SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 3/28/2022

P A R T 1 - G E N E R A L

SCOPE

This section includes information common to two or more technical specification sections or items that are of a general nature, not conveniently fitting into other technical sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Protection of Finished Surfaces
- Sleeves and Openings
- Equipment Furnished By Others
- Provisions for Future
- Submittals
- Off Site Storage
- Certificates and Inspections
- Operating and Maintenance Data
- Training of Owner Personnel
- Record Drawings

PART 2 - PRODUCTS
- Identification
- Sealing

PART 3 - EXECUTION
- Cutting and Patching
- Building Access
- Equipment Access
- Coordination
- Identification
- Lubrication
- Sleeves and Openings
- Sealing and Fire Stopping
- Agency Training

RELATED WORK

Section 01 91 01– Commissioning Process
Section 23 05 13 - Common Motor Requirements for HVAC.
Section 23 33 00 - Air Duct Accessories.

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

Abbreviations of standards organizations referenced in other sections are as follows:

AABC	Associated Air Balance Council
ABMA	American Boiler Manufacturers Association
ADC	Air Diffusion Council
AGA	American Gas Association
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWS	American Welding Society

CGA	Compressed Gas Association
CTI	Cooling Tower Institute
EPA	Environmental Protection Agency
GAMA	Gas Appliance Manufacturers Association
IEEE	Institute of Electrical and Electronics Engineers
ISA	Instrument Society of America
MCA	Mechanical Contractors Association
MICA	Midwest Insulation Contractors Association
MSS	Manufacturer's Standardization Society of the Valve & Fitting Industry, Inc.
NBS	National Bureau of Standards
NEBB	National Environmental Balancing Bureau
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association. Inc.
UL	Underwriters Laboratories Inc.
ASTM E814	Standard Test Method for Fire Tests of Through-Penetration Fire Stops
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
UL1479	Fire Tests of Through-Penetration Firestops
UL723	Surface Burning Characteristics of Building Materials

QUALITY ASSURANCE

Refer to Division 1, General Conditions, Equals and Substitutions.

Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.

CONTINUITY OF EXISTING SERVICES

Do not interrupt or change existing services without prior written approval from the DFD Project Representative. When interruption is required, coordinate the down-time with the user agency to minimize disruption to their activities. Unless specifically stated, all work involved in interrupting or changing existing services is to be done during normal working hours.

PROTECTION OF FINISHED SURFACES

Refer to Division 1, General Requirements, Protection of Finished Surfaces.

Furnish one can of touch-up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch-up paint with other "loose and detachable parts" as covered in the General Requirements.

SLEEVES AND OPENINGS

Refer to Division 1, General Requirements, Sleeves and Openings.

SUBMITTALS

Refer to Division 1, General Conditions, Submittals.

Submit for all equipment and systems as indicated in the respective specification sections, marking each submittal with that specification section number. Mark general catalog sheets and drawings to indicate specific items being submitted and proper identification of equipment by name and/or number, as indicated in the contract documents.

Before submitting electrically powered equipment, verify that the electrical power and control requirements for the equipment are in agreement with the motor starter schedule on the electrical drawings. Include a statement on the shop drawing transmittal to the architect/engineer that the equipment submitted and the motor starter schedules are in agreement or indicate any discrepancies. See related comments in Section 23 05 13 in Part 1 under Electrical Coordination.

Include wiring diagrams of electrically powered equipment.

Submit sufficient quantities of shop drawings to allow the following distribution:

- Operating and Maintenance Manuals 2 copies

- Testing, Adjusting and Balancing Contractor 1 copy
- Division of Facilities Development 1 copy
- A/E 1 copy

OFF SITE STORAGE
Prior approval by DFD and the A/E will be needed. The contractor shall submit Storage Agreement Form AD-BDC-74 to DFD for consideration of off site materials storage.

Generally, ductwork, metal for making ductwork, duct lining, sleeves, pipe/pipe fittings and similar rough-in material will not be accepted for off site storage. For material that can be stored off site, no material will be accepted for off site storage unless shop drawings for that material have been approved.

CERTIFICATES AND INSPECTIONS
Refer also to Division 1, General Conditions, Permits, Regulations, Utilities and Taxes.

Obtain and pay for all required State installation inspections except those provided by the Architect/Engineer in accordance with code. Deliver originals of these certificates to the Division Project Representative. Include copies of the certificates in the Operating and Maintenance Instructions.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Records of tests performed a to certify compliance with system requirements
2. Certificates of inspection by regulatory agencies
3. Lubrication instructions, including list/frequency of lubrication
4. Copies of all approved shop drawings.
5. Manufacturer's wiring diagrams for electrically powered equipment
6. Temperature control record drawings and control sequences
7. Parts lists for manufactured equipment
8. Warranties
9. Additional information as indicated in the technical specification sections

TRAINING OF OWNER PERSONNEL
Instruct user agency personnel in the proper operation and maintenance of systems and equipment provided as part of this project; video tape all training sessions. Include not less than 4 hours of instruction, using the Operating and Maintenance manuals during this instruction. Demonstrate startup and shutdown procedures for all equipment. All training to be during normal working hours.

RECORD DRAWINGS
Refer to Division 1, General Requirements, Record Drawings.

In addition to the data indicated in the General Requirements, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

P A R T 2 - P R O D U C T S

IDENTIFICATION
STENCILS:
Not less than 1 inch high letters/numbers for marking pipe and equipment.

ENGRAVED NAME PLATES:
White letters on a black background, 1/16 inch thick plastic laminate, beveled edges, screw mounting, Setonply Style 2060 by Seton Name Plate Company or Emedolite- Style EIP by EMED Co., or equal by Marking Services, or W. H. Brady.

SEALING

NON-RATED PENETRATIONS:

Duct Penetrations:
Annular space between duct (with or without insulation) and the non-rated walls or floor opening shall not be larger than 2". Where existing openings have an annular space larger than 2", the space shall be patched to match existing construction to within 2" around the duct.

Where shown or specified, pack annular space with fiberglass batt insulation or mineral wool insulation. Provide 4" sheet metal escutcheon around duct on both sides of partition or floor to cover annular space.

P A R T 3 - E X E C U T I O N

CUTTING AND PATCHING
Refer to Division 1, General Requirements, Cutting and Patching.

BUILDING ACCESS
Arrange for the necessary openings in the building to allow for admittance of all apparatus. When the building access was not previously arranged and must be provided by this contractor, restore any opening to its original condition after the apparatus has been brought into the building.

EQUIPMENT ACCESS
Install all piping, conduit, ductwork, and accessories to permit access to equipment for maintenance and service. Coordinate the exact location of wall and ceiling access panels and doors with the General Contractor, making sure that access is available for all equipment and specialties. Access doors in general construction are to be furnished by the Mechanical Contractor and installed by the General Contractor.

COORDINATION
Verify that all devices are compatible for the surfaces on which they will be used. This includes, but is not limited to, diffusers, register, grilles, and recessed or semi-recessed heating and/or cooling terminal units installed in/on architectural surfaces.

Coordinate all work with other contractors prior to installation. Any installed work that is not coordinated and that interferes with other contractor's work shall be removed or relocated at the installing contractor's expense.

Cooperate with the test and balance agency in ensuring Section 23 05 93 specification compliance. Verify system completion to the test and balance agency (clean filters, duct systems cleaned, controls adjusted and calibrated, controls cycled through their sequences, etc.), ready for testing, adjusting and balancing work. Install dampers, flow measuring devices, gauges, temperature controls, etc., required for functional and balanced systems. Demonstrate the starting, interlocking and control features of each system so the test and balance agency can perform its work.

IDENTIFICATION
Identify equipment in mechanical equipment rooms by stenciling equipment number and service with one coat of black enamel against a light background or white enamel against a dark background. Use a primer where necessary for proper paint adhesion.

Where stenciling is not appropriate for equipment identification, engraved name plates may be used.

Use engraved name plates to identify control equipment.

LUBRICATION
Lubricate all bearings with lubricant as recommended by the manufacturer before the equipment is operated for any reason. Once the equipment has been run, maintain lubrication in accordance with the manufacturer's instructions until the work is accepted by DFD. Maintain a log of all lubricants used and frequency of lubrication; include this information in the Operating and Maintenance Manuals at the completion of the project.

SLEEVES AND OPENINGS

DUCT SLEEVES:
Duct sleeves are not required in non-rated partitions or floors.

SEALING

NON-RATED PENETRATIONS:

Duct penetrations through non-rated partitions shall require sheet metal escutcheons with fiberglass or mineral wool insulation fill for spaces that include laboratories, clean rooms, animal rooms, kitchens, cart wash rooms, janitor closets, toilet rooms, mechanical rooms, conference rooms, private consultation rooms, where ducts are exposed and where noted on drawings elsewhere.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

END OF SECTION

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SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 12/20/2023

P A R T 1 - G E N E R A L

SCOPE

This sections includes requirements for single and three phase motors that are used with equipment specified in other sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Operating and Maintenance Data
- Electrical Coordination
- Product Criteria

PART 2 - PRODUCTS
- Three Phase, Single Speed Motors

PART 3 - EXECUTION
- Installation

RELATED WORK

Section 01 91 01– Commissioning Process
Section 23 09 14 - Pneumatic and Electric Instrumentation and Control Devices for HVAC
Division 26 00 00 - Electrical

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

ANSI/IEEE 112	Test Procedure for Polyphase Induction Motors and Generators
ANSI/NEMA MG-1	Motors and Generators
ANSI/NFPA 70	National Electrical Code

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Include with the equipment which the motor drives the following motor information: motor manufacturer, horsepower, voltage, phase, hertz, rpm, full load efficiency. Include project wiring diagrams prepared by the contractor specifically for this work.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Lubrication instructions, including list/frequency of lubrication
2. Table noting full load power factor, service factor, NEMA design designation, insulation class and frame type for each motor provided

ELECTRICAL COORDINATION

Electrical drawings and/or specifications show number, and horsepower rating of all motors furnished by this Contractor, together with their actuating devices if these devices are furnished by the Electrical Contractor. Should any discrepancy in size, horsepower rating, electrical characteristics or means of control be found for any motor or other electrical equipment after contracts are awarded, Contractor is to immediately notify the

architect/engineer of such discrepancy. Costs involved in any changes required due to equipment substitutions initiated by this contractor will be the responsibility of this contractor. See related comments in Section 23 05 00 - Common Work Results for HVAC, under Shop Drawings.

Electrical Contractor will provide all power wiring and control wiring, except temperature control wiring.

Furnish project specific wiring diagrams to Electrical Contractor for all equipment and devices furnished by this Contractor and indicated to be wired by the Electrical Contractor.

PRODUCT CRITERIA

Motors to conform to all applicable requirements of NEMA, IEEE, ANSI, and NEC standards and shall be listed by U.L. for the service specified.

Select motors for conditions in which they will be required to perform; i.e., general purpose, splashproof, explosion proof, standard duty, high torque or any other special type as required by the equipment or motor manufacturer's recommendations.

Furnish motors for starting in accordance with utility requirements and compatible with starters as specified.

P A R T 2 - P R O D U C T S

THREE PHASE, SINGLE SPEED MOTORS

Use NEMA rated 230volt, three phase, 60 hertz motors for all motors 1/2 HP and larger unless specifically indicated.

Use NEMA general purpose, continuous duty, Design B , normal starting torque, T-frame or U-frame motors with Class B or better insulation unless the manufacturer of the equipment on which the motor is being used has different requirements. Use open drip-proof motors unless totally enclosed fan-cooled, totally enclosed non-ventilated, explosion-proof, or encapsulated motors are specified in the equipment sections.

Use grease lubricated anti-friction ball bearings with housings equipped with plugged/capped provision for relubrication, rated for minimum AFBMA 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at the end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

All open drip-proof motors to have a 1.15 service factor. Other motor types may have minimum 1.0 service factors.

All motors 1 HP and larger, except specially wound motors and inline pump motors 56 frame and smaller, to be high efficiency design with full load efficiencies which meet or exceed the values listed below when tested in accordance with NEMA MG 1.

FULL LOAD NOMINAL MOTOR EFFICIENCY BY MOTOR SIZE AND SPEED

MOTOR	-----Open Drip-Proof Motors------		
	-------Nominal Motor Speed-------		
HP	1200 rpm	1800 rpm	3600 rpm
1	82.5	85.5	77.0
1-1/2	86.5	86.5	84.0
2	87.5	86.5	85.5
3	88.5	89.5	85.5
5	89.5	89.5	86.5

P A R T 3 - E X E C U T I O N

INSTALLATION

Mount motors on a rigid base designed to accept a motor, using shims if required under each mounting foot to get a secure installation.

When motor will be flexible coupled to the driven device, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Using a dial indicator, check angular misalignment of the two shafts; adjust motor position as necessary so that the angular misalignment of the shafts does not exceed 0.002 inches per inch diameter of the coupling hub. Again using the dial indicator, check the shaft for run-out to assure concentricity of the shafts; adjust as necessary so that run-out does not exceed 0.002 inch.

When motor will be connected to the driven device by means of a belt drive, mount sheaves on the appropriate shafts in accordance with the manufacturer's instructions. Use a straight edge to check alignment of the sheaves; reposition sheaves as necessary so that the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so that the belt(s) can be added and tighten the base so that the belt tension is in accordance with the drive manufacturer's recommendations. Frequently recheck belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

Verify the proper rotation of each three-phase motor as it is being wired or before the motor is energized for any reason.

Lubricate all motors requiring lubrication. Record lubrication material used and the frequency of use. Include this information in the maintenance manuals.

END OF SECTION

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SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 03/08/2024

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for supports of all HVAC equipment and materials as well as piping system anchors. Included are the following topics:

RELATED WORK
Section 01 91 01– Commissioning Process
Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

REFERENCE STANDARDS
MSS SP-58 Materials, Design, Manufacture, Selection, Application, and Installation

QUALITY ASSURANCE
Refer to Division 1, General Conditions, Equals and Substitutions.

DESCRIPTION
Provide all supporting devices as required for the installation of mechanical equipment and materials. All supports and installation procedures are to conform to the latest requirements of the ANSI Code for pressure piping.

Do not hang any mechanical item directly from a metal deck or run piping so it rests on the bottom chord of any truss or joist.

Support apparatus and material under all conditions of operation, variations in installed and operating weight of equipment and piping, to prevent excess stress, and allow for proper expansion and contraction.

Protect insulation at all hanger points; see Related Work above.

SUBMITTALS
Refer to division 1, General Conditions, Submittals and 01 33 00 Electronic Submittal Procedures.

Schedule of all hanger and support devices indicating shields, attachment methods, and type of device for each pipe size and type of service. Reference section 23 05 00.

All submittals are to comply with submission and content requirements specified in specification Section 01 91 01.

PART 2 - PRODUCTS

EQUIPMENT CURBS

Prefabricated Metal Curb:
Constructed of not less than 18 gauge galvanized steel reinforced so it is structurally capable of supporting the intended load with no penetrations through the curb flashing, inside and outside corner sections that are mitered and continuously welded, filled with 3 pound density rigid fiberglass insulation, integral deck mounting flange, nominal two inch wood nailer, galvanized steel counter flashing. Do not use built-in metal base flashings or cants. Use 18 inch high equipment curbs where the curb completely surrounds the perimeter of the equipment and there is no roof exposed to the weather.

PART 3 - EXECUTION

INSTALLATION

Install supports to provide for free expansion of the duct system. Support all duct from the structure using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. Fasten ceiling plates and wall brackets securely to the structure and test to demonstrate the adequacy of the fastening.

Trim steel hanger rods to within one inch of the final lock nut position. Hanger and support cutoff burrs shall be removed and sharp edges ground smooth.

Perform all welding in accordance with standards of the American Welding Society. Clean surfaces of loose scale, rust, paint or other foreign matter and properly align before welding. Use wire brush on welds after welding. Welds shall show uniform section, smoothness of weld metal and freedom from porosity and clinkers. Where necessary to achieve smooth connections, joints shall be dressed smooth.

HANGER AND SUPPORT SPACING

Place a hanger within 12 inches of each horizontal elbow, valve, strainer, or similar piping specialty item.

Support riser duct independently of connected horizontal duct.

SURFACE PREPARATION AND COATING SCHEDULE

Provide surface preparation and coating for the following:

- All structural steel supports, guides, anchors and pipe support hangers for steam, condensate and air distribution piping.

All surfaces of new support steel (guides, anchors, supports, excreta) shall be prepped and coated. Including but not limited to: front, back, sides, bolt holes, top, bottom and recesses.

All accessible surfaces of existing steel (guides, anchors, supports, excreta) shall be prepped and coated. Including but not limited to: front, back, sides, bolt holes, top, bottom and recesses.

Contractor shall provide temporary enclosures and heat for the field applied coating when surface temperatures are below coating manufacturers recommended temperatures of 50° F and at least 5° F above the dew point temperature.

Provide field coating at all field welds to include preparation in accordance with the manufacture's recommendations.

Provide surface preparation in accordance with the coating manufacturers recommendations.

EQUIPMENT CURBS

Secure bottom of support flat on roof deck. Secure equipment to curb in accordance with equipment manufacturer's instructions. Flashing and counter flashing by the Division 07 Contractor.

Fill the entire void space with compressible fiberglass insulation.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

END OF SECTION

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SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
BASED ON DFD MASTER SPECIFICATION DATED 11/09/2023

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for vibration isolation material for equipment, piping systems, and duct systems. Included are the following topics:

RELATED WORK
Section 01 91 01 - Commissioning Process
Section 23 34 00 - HVAC Fans
Section 23 33 00 - Air Duct Accessories

REFERENCE
Applicable provisions of Division 1 govern work under this section.

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

DESIGN CRITERIA
Isolate all motor driven mechanical equipment from the building structure and from the systems in which they serve to prevent equipment vibrations from being transmitted to the structure. Consider equipment weight distribution to provide uniform isolator deflections.

For equipment with variable speed capability, select vibration isolation devices based on the lowest speed.

Coordinate the selection of devices with the isolator and equipment manufacturers.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Include isolator type, materials of construction, isolator free and operating heights, and isolation efficiency based on the lowest operating speed of the equipment supported.

P A R T 2 - P R O D U C T S

MATERIALS
Use materials that will retain their isolation characteristics for the life of the equipment served. Use industrial grade neoprene for elastomeric materials.

Treat all isolators to resist corrosion. For isolation devices exposed to the weather or used in high humidity areas, hot dip galvanize steel parts, apply a neoprene coating on all steel parts, or use stainless steel parts; include limit stops to resist wind.

Provide pairs of neoprene side snubbers or restraining springs where side torque or thrust may develop.

Use isolators with a ratio of lateral to vertical stiffness not less than 1.0 or greater than 2.0.

VIBRATION ISOLATOR MANUFACTURERS
Mason Industries, Amber/Booth Co., Vibration Mounting & Controls, Kinetics Noise Control, or approved equal.

TYPE 4: RESTRAINED SPRING WITH NEOPRENE
Combination spring and neoprene with rib molded base similar to Type 3 mount above, but with a housing that includes vertical limit stops to prevent spring extension when weight is removed such that the installed and operating heights are the same. Maintain a minimum clearance of 1/2" around restraining bolts, and between the housing and the spring, so as not to interfere with the spring action. Design isolator so limit stops are out of contact during normal operation. Use height saving brackets when appropriate to the application.

TYPE 7: SPRING HANGER WITH NEOPRENE
Steel spring hanger located in a neoprene cup manufactured with a grommet to prevent short circuiting of the hanger rod. Neoprene cup shall contain a steel washer designed to properly distribute the load on the neoprene and prevent its extrusion. Design spring diameter and size hanger box lower hole sufficiently large to permit the hanger rod to swing through a 30° arc before contacting the hole perimeter and short circuiting the spring. Select spring so it has a minimum additional travel to solid equal to 50% of the rated deflection. Provide hanger with an eye bolt on the spring end and provision to attach the housing to the flat iron duct straps.

PERFORMANCE
Select vibration isolation devices as indicated below or to provide not less than 95% isolation efficiency, whichever is greater.

	Floor Span or Column Spacing							
	On Grade		**20 Feet**		**30 Feet**		**40 Feet**	
TYPE OF EQUIPMENT	Iso. Type	Min. Static Defl. In.	Iso. Type	Min. Static Defl. In.	Iso. Type	Min. Static Defl. In.	Min. Static Defl. In.	Iso. Type
Centrifugal Blowers:								
Roof mounted	Use type 4 mount with deflection from blower minimum deflection guide up to 0.75” deflection. Over 0.75” deflection, use type 4 S mount.							
Ductwork In Mechanical Equipment Rooms:	Use type 7 hanger with .75" minimum deflection for all ducts with a cross sectional area greater than 2.0 square feet and, where either the air velocity is great than 3500 fpm or, the pressure class is 4" water column or higher.							

BLOWER MINIMUM DEFLECTION GUIDE

		Required Deflection (Inches)		
Fan Speed (RPM)	On Grade	20' Floor Span	30’ Floor Span	40’ Floor Span
175-224	0.35	3.50	4.50	4.50
225-299	0.35	3.50	3.50	3.50
300-374	0.35	2.50	2.50	3.50
375-499	0.35	1.50	2.50	3.50
500 and over	0.35	0.75	1.50	2.50

P A R T 3 - E X E C U T I O N

INSTALLATION

Install vibration isolation devices for motor driven equipment in accordance with the manufacturer's installation instructions.

Do not allow installation practices to short circuit any isolation device.

PACKAGED AIR HANDLING UNITS, CUSTOM AIR HANDLING UNITS AND CENTRIFUGAL FANS

Attach horizontal thrust restraints at the centerline of thrust and symmetrically on either side of the unit. Thrust restraints are not required when the fan section in not isolated from the remainder of the air handling unit by means of duct flexible connections.

END OF SECTION

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 4/3/2023

P A R T 1 - G E N E R A L

SCOPE
This section includes air and water testing, adjusting and balancing for the entire project. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Description
- Pre-Installation Meeting and Scheduling
- Pre-Balance Conference
- Submittals

PART 2 - PRODUCTS
- Instrumentation

PART 3 - EXECUTION
- Preliminary Procedures
- Performing Testing, Adjusting and Balancing
- Deficiencies

RELATED WORK
Section 01 91 01– Commissioning Process
Section 23 05 00 Common Work Results for HVAC
Section 23 07 00 HVAC Insulation
Section 23 08 00 – Commissioning of HVAC
Section 23 09 14 Pneumatic and Electric Instrumentation and Control Devices for HVAC
Section 23 09 23 Direct Digital Control System for HVAC

REFERENCE
Applicable provisions of the General Conditions, Supplementary General Conditions and General Requirements in Division 1 govern work under this section.

REFERENCE STANDARDS
AABC	National Standards for Total System Balance, Sixth Edition, 2002.
ASHRAE	ASHRAE Handbook, 2007 HVAC Applications, Chapter 37, Testing Adjusting and Balancing.
NEBB	Procedural Standards for Testing Adjusting Balancing of Environmental Systems, Seventh Edition, 2005.
TABB	Tab Procedural Guide, First Edition, 2003.

DESCRIPTION
The Contractor will separately contract with an independent test and balance agency to perform all testing, adjusting, and balancing of air systems required for this project. Work related to the testing, adjusting, and balancing that must be performed by the installing mechanical contractor is specified in other section of these specifications.

Provide total mechanical systems testing, adjusting and balancing. Requirements include the balance of air, adjustment of new systems and equipment to provide design requirements indicated on the drawings, electrical measurement and verification of performance of all mechanical equipment, all in accordance with standards published by AABC, NEBB, or TABB.

Test, adjust and balance all air systems so that each room, piece of equipment or terminal device meets the design requirements indicated on the drawings and in the specifications.

Accomplish testing, adjusting and balancing work in a timely manner that allows partial occupancy of major buildings, occupancy of one building when the project involves many buildings, and completion of the entire

project in the time stated in the Instruction to Bidders and in accordance with the completion schedule established for this project.

Verify that provisions are being made to accomplish the specified testing, adjusting and balancing work. If problems are found, handle as specified in Part 3 under Deficiencies.

QUALITY ASSURANCE

Qualifications
An independent Firm specializing in the Testing and Balancing of HVAC systems for a minimum of 3 years. A Firm not engaged in the commerce of furnishing or providing equipment or material generally related to HVAC work other than that specifically related to installing Testing and Balancing components necessary for work in this section such as, but not limited to sheaves, pulleys, and balancing dampers.

A certified member of AABC or certified by NEBB or TABB in the specific area of work performed. Maintain certification for the entire duration of the project. If certification of firm or any staff performing work is terminated or expires during the duration of the project, contact DFD immediately.

Technicians on this project must have satisfactorily completed work on a minimum of (3) three projects of at least 50% in size, and of similar complexity. Size is defined as the quantity of each specific individual item requiring testing and balancing such as, but not limited to, equipment, devices, terminal devices, and grilles and diffusers.

Submit Qualifications of firm and project staff to DFD upon requested.

PRE-INSTALLATION MEETING AND SCHEDULING
The test and balance agency is required to attend a pre-installation meeting with all other project contractors before the construction process is started. The test and balance agency shall give the Mechanical Contractor a detailed schedule of testing and balancing tasks for incorporation into the project schedule.

PRE-BALANCE CONFERENCE
90 days prior to beginning testing, adjusting and balancing, schedule and conduct a conference with the Architect/Engineer, DFD's Project Representative and the mechanical system and temperature control system installing Contractors. Provide AE and Commissioning Provider (CxP) with a complete copy of the TAB plan for the project. The objective is final coordination and verification of system operation and readiness for testing, adjusting and balancing procedures and scheduling procedures with the above mentioned parties. Indicate work required to be completed prior to testing, adjusting, and balancing and identify the party responsible for completion of that work.

SUBMITTALS
Refer to division 1, General Conditions, Submittals. See also Related Work in this section.

Submit testing, adjusting and balancing reports bearing the seal and signature of the NEBB, AABC or TABB Certified Test and Balance Supervisor. The reports certify that the systems have been tested, adjusted and balanced in accordance with the referenced standards; are an accurate representation of how the systems have been installed and are operating; and are an accurate record of all final quantities measured to establish normal operating values of the systems.

Submission:

Distribute electronic copies of the Report to the DFD Project Representative, the Agency Contact, the Prime A/E, the DFD Project Manager, John Chapman (John.Chapman@wisconsin.gov), and Mike Casper (Mike.Casper@wisconsin.gov).

Format: Cover page identifying project name, project number and descriptive title of contents. Divide the contents of the report into the below listed divisions:

- General Information
- Summary
- Air Systems

Contents: Provide the following minimum information, forms and data:

General Information: Inside cover sheet identifying Test and Balance Agency, Contractor, Architect, Engineer, Project Name and Project Number. Include addresses, contact names and telephone numbers. Also include a certification sheet containing the seal and signature of the Test and Balance Supervisor.

Summary: Provide summary sheet describing mechanical system deficiencies. Describe objectionable noise or drafts found during testing, adjusting and balancing. Provide recommendations for correcting unsatisfactory performances and indicate whether modifications required are within the scope of the contract, are design related or installation related. List instrumentation used during testing, adjusting and balancing procedures.

The remainder of the report to contain the appropriate standard NEBB, AABC, or TABB forms for each respective item and system. Fill out forms completely. Where information cannot be obtained or is not applicable indicate same.

P A R T 2 - P R O D U C T S

INSTRUMENTATION

Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements to be in accordance with the requirements of NEBB, AABC, or TABB Standards and instrument manufacturer's specifications.

All instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by DD upon request. Calibration and maintenance of all instruments to be in accordance with the requirements of NEBB, AABC, or TABB Standards

P A R T 3 - E X E C U T I O N

DAILY REPORTS

Submit to DFD's Project Representative daily work activity reports for each day on which testing and balancing work is performed. Reports shall include description of day's activities and description of any system deficiencies.

PRELIMINARY PROCEDURES

Review preconstruction meeting report, applicable construction bulletins, applicable change orders and approved shop drawings of equipment, outlets/inlets and temperature controls.

Check filters for cleanliness, dampers for correct positioning, equipment for proper rotation and belt tension, and temperature controls for completion of installation.

Notify DFD's Project Representative on a daily basis during balancing. Identify deficiencies preventing completion of testing, adjusting and balancing procedures. Do not proceed until systems are fully operational with all components necessary for complete testing, adjusting and balancing. Installing Contractors are required to provide personnel to check and verify system completion, readiness for balancing and assist Balancing Agency in providing specified system performance.

PERFORMING TESTING, ADJUSTING AND BALANCING

Perform testing, adjusting and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards except as may be modified below.

Unless specifically instructed in writing, all work in this specification section is to be performed during the normal workday.

Cut insulation, ductwork and piping for installation of test probes to the minimum extent necessary for adequate performance of procedures. Patch using materials identical to those removed, maintaining vapor barrier integrity and pressure rating of systems.

Measure and record system measurements at the fan to determine total flow. Adjust equipment as required to yield specified total flow at terminals. Proceed taking measurements in mains and branches as required

for final terminal balancing. Perform terminal balancing to specified flows balancing branch dampers, deflectors, extractors and valves prior to adjustment of terminals.

Measure and record static air pressure conditions across fans.

Adjust outside air, and exhaust air dampers for design conditions at both the minimum and maximum settings and record both sets of data.

Adjust register, grille and diffuser vanes and accessories to achieve proper air distribution patterns and uniform space temperatures free from objectionable noise and drafts within the capabilities of the installed system.

Provide fan and motor drive sheave adjustments necessary to obtain design performance. Provide drive changes specifically noted on drawings, if any. If work of this section indicates that any drive or motor is inadequate for the application, advise the owner's project representative by giving the representative properly sized motor/drive information (in accordance with manufacturers original service factor and installed motor horsepower requirements); Confirm any change will keep the duct/piping system within its design limitations with respect to speed of the device and pressure classification of the distribution system. Required motor/drive changes not specifically noted on drawings or in specifications will be considered an extra cost and will require an itemized cost breakdown submitted to owner's project representative. Prior authorization is needed before this work is started.

Final air system measurements to be within the following range of specified cfm:

Fans	0% to +10%
Return/exhaust grilles, registers	0% to -10%

Contact the temperature control Contractor for assistance in operation and adjustment of controls during testing, adjusting and balancing procedures. Cycle controls and verify proper operation and setpoints. Include in report description of temperature control operation and any deficiencies found.

Permanently mark equipment settings, including damper positions, control settings, and similar devices allowing settings to be restored. Set and lock memory stops.

Leave systems in proper working order, replacing belt guards, closing access doors and electrical boxes, and restoring temperature controls to normal operating settings.

Coordinate and assist CxP with all verification activities defined within section (01 91 01) including providing all required sampling date necessary for the commissioning process.

Verify and record, in the T&B Report, values of damper positions and fan speeds for all characterization curves required in the 23 09 93 control sequences.

DEFICIENCIES

Division 23 00 00 contractor to correct any installation deficiencies found by the test and balance agency that were specified and/or shown on the Contract Documents to be performed as part of that division of work. Test and balance agency will notify the DFD's Project Representative of these items and instructions will be issued to the Division 23 00 00 contractor for correction of the deficient work. All corrective work to be done at no cost to the State of Wisconsin. Retest mechanical systems, equipment, and devices once corrective work is complete as specified.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 Commissioning of HVAC in accordance with the procedures defined for functional performance testing in Section 01 91 01. Notify the A/E and commissioning provider 5 business days prior to performing functional performance testing so that they may witness.

END OF SECTION

SECTION 23 08 00
COMMISSIONING OF HVAC
BASED ON DFD MASTER SPECIFICATION DATED 01/17/17

P A R T 1 - G E N E R A L

SCOPE
This section includes commissioning forms for construction verification and functional performance testing. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Submittals

PART 2 - PRODUCTS
- (Not Used)

PART 3 – EXECUTION

Commissioning Forms

CV-23 09 14	Control Wiring and Devices
CV-23 09 23	Local Control Panels
CV-23 31 00	Ductwork and Casings
CV-23 33 00	Control Dampers
CV-23 34 00	Centrifugal Fans
CV-23 37 13	Diffuser, Grilles and Registers

Functional Performance Test Forms

FPT-23 05 93	Testing Adjusting and Balancing
FPT-23 34 00	HVAC Fans

RELATED WORK
Section 01 91 01– Commissioning Process

REFERENCE
Applicable provisions of Division 1 shall govern work under this section.

SUBMITTALS
Reference the General Conditions of the Contract for submittal requirements.

Reference Section 01 91 01 Commissioning Process for Construction Verification Checklist and Functional Performance Test submittal requirements.

P A R T 2 – P RO D U C T S

(Not Used)

P A R T 3 – E X E C U T I O N

COMMISSIONING FORMS
Commissioning forms are to be filled in as work progresses by the individuals responsible for installation and shall be completed for each installation phase.

Provide a description of the work completed since the last entry, the percentage of the total work completed for the system for that area and the step of installation or finalization.

Circle Yes or No for each commissioning form item. If the information requested for an item does not apply to the given stage of installation for the system, list it as “N/A”. Explain all discrepancies, negative responses or N/A responses in the negative responses section.

Once the work is 100% complete and the responses to each item are complete and resolved for a given commissioning forms group, mark as complete, initial and date in the spaces provided.

Provide copies of the commissioning forms to the commissioning agent 2 days prior to construction progress meetings.

CV-23 09 14 – Control Wiring and Devices

Equipment Identification/Tag: ______
Location:________________________

A) WIRING INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) All cabling identified at both ends according to Section 23 09 14.
2) A minimum of 5’ of cable provided in DDC panel for all electronic input/output devices, sensors, relays and interlocking wiring to allow for termination by the DDC Contractor.
3) All high voltage and low voltage wiring (includes low voltage cable) installed in metal conduit, Electrical Non-metallic Tubing (ENT), or Electrical Metallic Tubing (EMT), as scheduled per specifications.
4) All conduit installed and supported in accordance with electrical sections (Division 26) of this specification and the National Electrical Code.
5) Bushings installed at all conduit terminations.
6) Conduit is a minimum of 1/2 " for low voltage control wiring and pipe fill does not exceed 40%.
7) Control panels serving equipment fed by emergency power also served by emergency power.
8) "Hand/off/auto" selector switches installed on systems where automatic interlock controls are specified and "hand/off/auto" selector switches are not supplied with the equipment controlled.
9) All equipment requiring maintenance is accessible (valves, junction boxes, etc.).

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

B) CONTROL DEVICES INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)	11)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE					INITIALS:					DATE:				

Question Details

1) Thermometers installed at each point of temperature transmission (sensors) and control, except reheat coils, unless the drawings indicate a thermometer is to be installed.
2) Room thermostats and sensors installed at the location and height indicated on the drawings and aligned with light switches and humidistats.
3) Any room thermostats or sensors mounted on an exterior wall mounted on a thermally insulated sub-base.
4) Where thermostats or sensors are mounted on exterior walls or in any location where air transfer will affect the measured temperature or humidity the conduit and any other opening that will effect the measurement are sealed.
5) Guards provided on thermostats in entrance hallways, other public areas, or in locations where thermostat is subject to physical damage.
6) For horizontal steam or hot water coils, low limit thermostat elements distributed (serpentine) horizontally across the coil to cover every square foot of coil.
7) For integral face and bypass coils the low limit thermostat elements are installed on the leaving face of the heating coil inside the damper enclosure.
8) Straightening vanes installed upstream of air flow measuring stations where required per manufacturers recommendations.
9) Where flow meters are located more than five feet above the floor or where they cannot be read due to equipment location, provide remote mounting of the flow meter display and programming controls four to five feet above finished floor.
10) For VFD installations, a separate current switch provided in parallel with the VFD motor status relay when a bypass starter is provided on the VFD to prove motor status in the bypass mode.
11) All control devices and boxes mounted on insulated ductwork are mounted over the insulation.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:		

Question Details

1) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
2) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.
3) All wiring is properly labeled with control ID number of circuit within ½" of device and terminal connection.
4) All control devices with the exception of dampers, valves, and terminal unit devices labeled with permanent printed labels that correspond to control drawings.
5) Temperature control wiring and tubing junction and pullboxes identified utilizing spray painted green covers.
6) Pressure and/or differential set points of pressure sensors re-adjusted after final balancing is completed.
7) Threshold settings for current switch adjusted to indicate belt or coupling loss after final balancing.
8) As-built control drawings of all systems served by each local panel provided in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 09 23 – Local Control Panels

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Voltage / Phase / Frequency (V / - /Hz)			/ /	/ /
5	# of Controllers				
6	UPS Manufacturer				
7	UPS Model				
8	UPS Serial Number				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	All components/accessories present.			YES	NO
3	Unit tags affixed.			YES	NO
4	Manufacturer's ratings readable/accurate.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
C	*INSTALLATION*				
1	Unit secured as required by manufacture and specifications requirements.			YES	NO
2	Unit display located 60" above finished floor level.			YES	NO
3	Adequate clearance around unit for service.			YES	NO
4	Conduit feeds are aligned with openings and accommodate seismic motion.			YES	NO
5	Panel mounted near controlled equipment/system on vibration free wall or free-standing support.			YES	NO
6	Unit is level, plumb and square.			YES	NO
7	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
D	*WIRING*				
1	Unit is adequately grounded for intended use.			YES	NO
2	All connections are terminated properly.			YES	NO
3	All electrical connections are tight.			YES	NO
4	All cables are permanently labeled relative to use.			YES	NO
5	Circuit breaker for panel installed and labeled within panel.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
E	*WIRING-DEVICES*				
1	All connections are terminated properly.			YES	NO
2	A minimum of 5' spare cabling and/or tubing provided for all controller terminations to panel.			YES	NO
3	All electrical connections are tight.			YES	NO
4	Shutdown toggle switch provide for each air handling unit controller contained within panel (if applicable).			YES	NO
5	All cables are permanently labeled relative to use.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Group/Item	Group/Task Description			Response	
F	*STARTUP*				
1	All points given address and list provided in panel.			YES	NO
2	All switches and circuit breakers have been manually tested.			YES	NO
3	Fuses have been installed in all controllers and switches (if applicable).			YES	NO
4	All toggle and HOA switches checked and fully operational.			YES	NO
5	Point-to-point communication test conducted and all points found to be acceptable.			YES	NO
6	Record drawings and instructions noted within specifications provided in panel enclosure.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 31 00 – Ductwork and Casings

Equipment Identification/Tag: ______
Location:________________________

A) GENERAL DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:				

Question Details

1) Ductwork is clean and free of damage prior to installation.
2) Ductwork is installed in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, 2nd Edition, 1995.
3) Where two different metal ducts meet, the joint is installed in such a manner that metal ducts do not contact each other by using proper seal or compound.
4) No reductions to duct to less than six inches in any dimension and/or aspect ratio greater than 8:1 are present.
5) Duct is pitched toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.
6) All equipment and systems requiring maintenance are accessible (valves, junction boxes, etc.).
7) All seams, joins and penetrations sealed in accordance with SMACNA seal class "A" standards, except transfer ductwork with pressure classification below 2”.
8) All duct openings sealed to maintain duct system cleanliness.
9) Ductwork supported in accordance with SMACNA HVAC Duct Construction Standards, except secure wire method is not utilized.
10) Sheet metal thickness complies with the requirements of Section 23 21 00.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

C) KITCHEN, DUST COLLECTION & GENERAL EXHAUST DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:	

Question Details

1) Bracing and reinforcement provided to the outside of the kitchen ductwork to prevent breathing, rattling, vibration or sagging of duct.
2) Ductwork supports provided at intervals no greater than 5' for kitchen ductwork, and no fasteners or hangers penetrate duct.
3) Horizontal kitchen ductwork is pitched back to hood at 1 inch per foot.
4) Grease tight access doors of the same material and thickness as the duct and as large as possible, up to 24 inches in any dimension provided on duct sides of all kitchen ductwork at each change in direction, not less than every 10 lineal feet of duct, including risers, and not less than 1-1/2 inches from the bottom of the duct.
5) Exhaust ductwork is pitched to drain back to equipment or exhaust grille.
6) Water tight drain pan provided at all low points or at locations where moisture may collect, with drain pan piped to nearest floor drain.
7) Access doors and clean out doors provided on duct sides of dust collection exhaust ductwork at each change in direction, at junctions with vertical ducts, at devices requiring periodic inspection and maintenance, and not less than every 10 lineal feet of duct, including risers.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

E) DUCT ACCESSORIES INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below)									
				1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:				

Question Details

1) Turning vanes installed in all rectangular, mitered elbows in accordance with SMACNA standards and/or manufacturer's recommendations.
2) Fire dampers installed in sleeves with retaining angles on both sides of rated partition, with ductwork connections meeting manufacturer requirements.
3) Where it is necessary to set dampers out from the rated wall, install a sleeve extension encased in two hour rated fire proofing insulation. Install an access door at each fire damper, located to permit resetting the damper or replacing the fusible link.
4) Access doors provided in size, location and quantity specified under contract documents, including before and after all duct mounted coils.
5) Pressure relief doors provided on VAV systems to protect ductwork damage in the case of equipment or controls malfunction.
6) Flexible duct connections provided for all connections to rotating or vibrating equipment, including air handling units (unless unit is internally isolated), fans, or other motorized equipment.
7) Flexible duct connections in corrosive environments or fume exhaust systems, provided with a double layer of the Teflon coated fabric.
8) Manual volume dampers are constructed with continuous shafts according to SMACNA Duct Construction Standards Fig. 2-12 and Fig. 2-13.
9) Manual volume damper blades are two gauges thicker than the surrounding duct according to SMACNA Duct Construction Standards Fig. 2-12 and Fig. 2-13.
10) Manual volume damper handles are extended beyond the surface of external duct insulation according to Section 23 33 00.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

F) FLEXIBLE DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:				DATE:		

Question Details

1) Flexible ductwork is clean and free from damage prior to installation.
2) Flexible duct used for final connections of air inlets and outlets at diffuser, register, and grille locations only.
3) Where flexible duct is used, it is installed with the minimum length required to make the final connections, but no greater than 5 feet in length, and no more than one (1) 90° bend.
4) Inner jacket of flexible duct secured in place with stainless steel metal band clamp.
5) Insulation vapor barrier jacket secured in place with steel or nylon draw band.
6) Flexible ductwork does not penetrate walls.
7) Individual sections of flexible ductwork are of one piece construction.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

G) FINALIZATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)	10)
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
				YES NO	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**	**YES NO**
❑ CHECKLIST GROUP COMPLETE				**INITIALS:**					**DATE:**				

Question Details

1) All penetrations through fire rated wall assemblies have been sealed per specification requirements.
2) All penetrations through non-rated wall assemblies have been sealed per specification requirements for given space type.
3) Each fire damper manually tested for proper operation and any defective dampers repaired or replaced. Access doors labeled “FIRE DAMPER” according to IMC requirements.
4) Fire/smoke damper linkages coordinated with operators so dampers are closed when the air system is not operating.
5) All dirt and foreign matter removed from the entire duct system and diffusers, registers, grilles and the inside of air-handling units cleaned before operating fans.
6) Duct systems with cleaned with high power vacuum machines where systems have been used for temporary heat, air-conditioning, or ventilation purposes during construction.
7) All ductwork leakage tested in accordance with test methods described in Section 5 of SMACNA HVAC Air Duct Leakage Test Manual, with test pressure equal to the duct pressure class.
8) Leakage rate does not exceed more than 5% of the system air quantity for low pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
9) Leakage rate does not exceed more that 1% of the system air quantity for high pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.
10) Ductwork randomly tested for structural integrity and deflection limits do not exceed those listed in accordance with Chapter 7 of SMACNA HVAC Duct Construction Standards, 3.0 Performance Requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

CV-23 33 00 – Control Dampers

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Height / Width (in / in)			/	/
5	Capacity (fpm / in W.C.)			/	/
6	Actuator Manufacturer				
7	Actuator Model				
8	Control Air Pressure (psig) (if applicable)				
9	Voltage (V) (if applicable)				
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	All components/accessories present.			YES	NO
3	Unit tags affixed.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Manufacturer's ratings readable/accurate.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
C	*HANGING*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Unit is level.			YES	NO
3	Adequate clearance around unit for service.			YES	NO
4	All components accessible for maintenance.			YES	NO
5	Unit labeled and is easy to see.			YES	NO
6	Access door provided at unit for inspection of linkages and actuator.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
D	*CONTROLS INSTALLATION*				
1	Damper actuator installed and wiring/tubing terminated properly.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	
E	*STARTUP*				
1	Damper open/close sequence verified and acceptable.			YES	NO
2	Operation of end switch verified and acceptable (if applicable).			YES	NO
3	Damper opens and closes smoothly.			YES	NO
4	Control wiring labeled per specification requirements.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**		**DATE:**	

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 34 00 – Centrifugal Fans

Equipment Identification/Tag: _____
Location:_____

Group/Item	Group/Task Description			Submitted	Delivered
A	*MODEL VERIFICATION*				
1	Manufacturer				
2	Model				
3	Serial Number				
4	Fan Type				
5	Capacity / Static Pressure (cfm / in. w.g.)			/	/
6	Motor Power / Speed (hp / rpm)			/	/
7	NEMA Nominal Efficiency				
8	Voltage / Phase / Frequency (V / - / Hz)			/ /	/ /
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
B	*PHYSICAL CHECKS*				
1	Unit is free from physical damage.			YES	NO
2	Openings are sealed with plastic.			YES	NO
3	All components present.			YES	NO
4	Installation and startup manual provided.			YES	NO
5	Unit tags affixed.			YES	NO
6	Manufacturer's ratings readable/accurate			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
C	*INSTALLATION*				
1	Unit secured as required by manufacturer and specifications.			YES	NO
2	Equipment location coordinated with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances.			YES	NO
3	Unit is totally isolated (without rigid contact) from structure, ductwork or other stationary equipment or devices.			YES	NO
4	Shipping bolts have been removed (if applicable).			YES	NO
5	Adequate clearance around unit for service.			YES	NO
6	All components accessible for maintenance.			YES	NO
7	Drain pipe extended to collection pan (grease laden roof exhaust fans ONLY).			YES	NO
8	Drain connection reduced down to ½" fitting and left open (non-grease laden roof exhaust fans ONLY).			YES	NO
9	Unit labeled and is easy to see.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
D	*DUCTWORK*				
1	Adequate locations available for testing and balancing of unit.			YES	NO
2	Inlet and outlet ductwork are free of transitions and/or obstructions for ductwork length or distance specified by manufacturer.			YES	NO
3	All dampers and sensors are accessible (access panels).			YES	NO
4	Flexible duct connections of proper material installed.			YES	NO
5	All dampers close tightly and stroke fully and easily.			YES	NO
6	Ductwork is clean and free of debris.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
E	*ELECTRICAL*				
1	Local disconnect installed in accessible and visible location.			YES	NO
2	Each motor terminal box is connected with a minimum 12", maximum 36" piece of flexible conduit to a fixed junction box.			YES	NO
3	Motor NEMA Nominal Efficiency complies with Section 23 05 13.			YES	NO
4	Motor rotation is in correct direction.			YES	NO
5	All electrical connections are tight.			YES	NO
6	All electrical components are grounded.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
F	*CONTROLS INSTALLATION (if applicable)*				
1	Remote start and stop wiring installed and communication verified.			YES	NO
2	Remote status wiring installed and communication verified.			YES	NO
3	Remote alarm wiring installed and communication verified.			YES	NO
4	Thermostat wiring installed and communication verified.			YES	NO
5	Damper actuators installed and calibration verified.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
G	*MECHANICAL STARTUP*				
1	Unit is clean.			YES	NO
2	Fan and motor lubricated and aligned.			YES	NO
3	Belt sheaves have been properly aligned per the specifications (if applicable).			YES	NO
4	Fan belts have proper tension and are in good condition (if applicable).			YES	NO
5	Protective shrouds for fan and belts in place and secure.			YES	NO
6	System starts and runs without any unusual noise or vibration.			YES	NO
7	Manufacturer's startup checklist completed and attached.			YES	NO
8	All damage to unit finish is repaired.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Group/Item	Group/Task Description			Response	
H	*CONTROLS STARTUP (if applicable)*				
1	Remote start/stop from BAS verified and acceptable.			YES	NO
2	Interlock with associated unit/system verified and acceptable.			YES	NO
3	Temperature control sequence verified and acceptable.			YES	NO
❑ **CHECKLIST GROUP COMPLETE**		**INITIALS:**	_____	**DATE:**	_____

Negative Responses

Group/ Item	Date Found	Found By	Reason for Negative Response	Resolved	Date Resolved	Resolution
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		
				YES / NO		

CV-23 37 13 – Diffuser, Grilles and Registers

Equipment Identification/Tag: ______
Location:________________________

A) GENERAL DUCTWORK INSTALLATION CHECKS

Date	Description of Work Performed	% Complete	Initials	Questions (See details below) 1)	2)	3)	4)	5)	6)	7)	8)	9)
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
				YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO	YES NO
❑ CHECKLIST GROUP COMPLETE				INITIALS:					DATE:			

Question Details

1) Diffusers, grilles and registers installed as shown in contract documents.
2) Where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser, equalizing grids are furnished.
3) Connections between ductwork drops and diffusers, grilles and registers sealed airtight.
4) Unused portions of linear slot diffusers and linear bar diffusers and grilles are blanked off.
5) Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, inside of duct is painted with flat black paint to reduce visibility.
6) In clean rooms and animal holding rooms, space between diffusers, registers and grilles and ceiling or wall to be air and watertight using clear, non-hardening, microbiological resistant silicone sealant compatible with ceiling or wall surfaces.
7) All diffusers, grilles and registers temporary sealed at end of work day to maintain duct system cleanliness.
8) All mars and blemishes are repaired.
9) Throw pattern and direction adjusted per contract document requirements.

Negative Responses

Group/ Item	Date Found	Found By	Location	Reason for Negative Response	Resolved	Date Resolved	Resolution
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		
					YES / NO		

FPT-23 05 93 – Testing, Adjusting and Balancing Verification Test

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____

Objectives
This test is performed to verify the accuracy of the testing, adjusting and balancing completed for the facility.

Instrumentation
AABC or NEBB specified equipment with specified accuracies.

Sampling Methodology
1. Major equipment air flow (i.e. AHU's, fans, etc.): Sample air flow performance of 100 % of all major equipment shown in the construction documents for all sample points indicated.

Procedure
For each of the sample points listed under the results section, re-test the point in accordance with the procedures detailed within specification section 23 05 93. Verify procedures utilized concur with these documents and record findings in the results section below. In addition, for each point tested record the measured value and verify the result is within 10% of the original value recorded and within the specified tolerances of the design setting for the point.

Sample 100% of Terminal devices if 20% of devices sampled fall outside of either specified tolerance range of the completed Testing, Adjusting and Balancing Verification Test Results Table found in form FPT – 23 05 93, located in section 01 91 01.

Sample 100% Lab and Vivarium devices if 20% of devices sampled fall outside of either specified tolerance range of the completed Testing, Adjusting and Balancing Verification Test Results Table found in form FPT – 23 05 93, located in section 01 91 01.

Functional Performance Test

23 05 93 Testing Adjusting and Balancing Verification Test

Results

Sample Point Name	Procedure Compliant	Design	T&B Report Final Reading	Commission Test	Tolerance Within 10% of T & B Report Final Reading	Within Tolerance Specified in 23 05 93	Notes
Fan – CFM	□ YES □ NO				□ YES □ NO	□ YES □ NO	
Fan - ESP	□ YES □ NO				□ YES □ NO	□ YES □ NO	
Grille – CFM	□ YES □ NO				□ YES □ NO	□ YES □ NO	
Grille – CFM	□ YES □ NO				□ YES □ NO	□ YES □ NO	
Grille – CFM	□ YES □ NO				□ YES □ NO	□ YES □ NO	
Louver – CFM	□ YES □ NO				□ YES □ NO	□ YES □ NO	
Louver - ESP	□ YES □ NO				□ YES □ NO	□ YES □ NO	

Diffusers and grilles with adjustable throw patterns adjusted to match contract documents? YES NO
Final ductwork control static pressure setpoint recorded? YES NO

Conclusion

Acceptable Criteria: All points listed are within listed tolerances of design and original recordings and were recorded in accordance with TAB plan and/or NEBB standards.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Witnesses

Name	Signature

FPT-23 34 00 - HVAC Fans

Equipment Identification/Tag: _____
Location: _____

Test Duration
Date: _____ Start Time: _____ End Time _____

Estimated Duration: _____
Cx Provider(s): _____
_____
_____
_____

Applicable Equipment: _____
_____

Objectives
This test is performed to investigate the functionality of HVAC fan with associated system.

Instrumentation

Instrument	Accuracy	Measurement
N/A	N/A	N/A

Stated Sequence
To be defined by A/E and commissioning provider at completion of construction documents.

Sampling Set
All units and all sequences, except fans controlled exclusively by interlock and/or switch which are to be verified under construction verification.

Procedure
1. Remote Start/Stop
    a. Verify fan is in occupied mode. If not override system into occupied mode.
    b. Override "on" command to "off".
    c. Verify unit de-energizes.
    d. Return "on" command to normal operation.
    e. Verify unit is energized.
    f. Return system to normal operation.
2. Thermostatically Controlled (Exhaust Applications)
    a. Record temperature setpoint of system/zone.
    b. Record current temperature of system/zone.
    c. If fan is on, adjust temperature setpoint to be 10º above current system/zone temperature.
    d. Verify fan is de-energized and allow to stabilize for 10 minutes.
    e. Return system to normal operation.
    f. If fan is off, adjust temperature setpoint to be 10º below current system/zone temperature.
    g. Verify fan is de-energized and allow to stabilize for 10 minutes.
    h. Return system to normal operation.

Results
Remote Start/Stop:
Unit is energized and de-energized when commanded by building automation system? YES NO

Thermostatically Controlled (Exhaust Applications):
Initial Temperature Setpoint: _____
System/Zone Temperature: _____
Adjusted Temperature Setpoint: _____

Fan is energized or de-energized in response to increases and decreases of temperature setpoint? YES NO

Conclusion
Acceptable Criteria: Unit is energized when called upon by BAS. Unit is energized and de-energized in response to fluctuations in system or zone temperatures.

Comments:

Observations:

Final Status: ❑ Accepted ❑ Not Accepted

Relevant Trend Data
Fan run status, system/zone temperature, system static pressure, blade pitch

Witnesses

Name	**Signature**

SECTION 23 09 14
PNEUMATIC AND ELECTRIC INSTRUMENTATION AND CONTROL DEVICES FOR HVAC
BASED ON DFD MASTER SPECIFICATION DATED 5/6/2024

P A R T 1 - G E N E R A L

SCOPE
This section includes control system specifications for all HVAC work as well as related control for systems found in other specification sections. Included are the following topics:

PART 1 - GENERAL
- Scope
- Point List
- Related Work
- Reference
- Work Not Included
- Quality Assurance
- Reference Standards
- System Description
- Submittals
- Demolition
- Design Criteria
- Operation and Maintenance Data
- Material Delivery and Storage

PART 2 - PRODUCTS
- Control Dampers
- Sensor Guards
- Temperature Control Panels
- Current Status Switches
- Carbon Monoxide (CO) Sensor
- Nitrogen Dioxide (NO2) Sensor
- Emergency Shutdown Switches
- Power Supplies

PART 3 - EXECUTION
- Installation
- Wire Conduit and Tubing Installation Schedule
- Control Dampers
- Control System Instrumentation
- Room Sensors
- Temperature Control Panels
- Current Status Switches
- Preconstruction Review Meeting
- Construction Verification
- Functional Performance Testing
- Agency Training

POINT LIST (Section 23 09 15)

RELATED WORK
Section 01 91 01– Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC - Coordination
Section 23 09 15 - Direct Digital Control Input/Output Point Summary Tables
Section 23 09 23 - Direct Digital Control System for HVAC
Section 23 09 93 - Sequence of Operation
Section 23 33 00 - Ductwork Accessories - for control damper installation

Division 23 - HVAC - Equipment provided to be controlled or monitored
Division 26 - Electrical - Installation requirements & Equipment provided to be controlled or monitored
Division 28 - Electronic Safety and Security

REFERENCE
Applicable provisions of Division 1 govern work under this section.

QUALITY ASSURANCE
Installing contractor must be a manufacturer's branch office or an authorized representative of a Direct Digital Control (DDC) equipment manufacturer that provides engineering and commissioning of the DDC equipment. Submit written confirmation of such authorization from the manufacturer. Indicate in letter of authorization that installing contractor has successfully completed all necessary training required for engineering, installation, and commissioning of equipment and systems and that such authorization has been in effect for a period of not less than three years. DDC equipment may or may not be required to be installed by this contractor as part of the project, but the intent of this quality assurance specification is to ensure that the installing contractor has the capabilities to engineer, install, and commission the field devices supplied under this section for temperature control.

REFERENCE STANDARDS

ANSI B16.22	Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings
ANSI/ASTM B32	Specification for Solder Metal
ASTM B75	Seamless Copper Tube
ASTM D1693	Environmental Stress-Cracking of Ethylene Plastics
ASTM D 635	Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
AMCA 500-D	Laboratory Method of Testing Dampers for Rating

SYSTEM DESCRIPTION

System is to be electric/electronic.

SUBMITTALS
Include the following information:

Manufacturer’s data sheets indicating model number, pressure/temperature ratings, capacity, methods and materials of construction, installation instructions, and recommended maintenance. General catalog sheets showing a series of the same device is not acceptable unless the specific model is clearly marked.

Schematic flow diagrams of systems showing fans, and other control devices. Each control device provided under this Section shall be uniquely labeled. Duplicate labeling may be used within similar mechanical systems. Label each device with setting or adjustable range of control. Indicate all wiring, clearly, differentiating between factory and field installed wiring. Wiring should be shown in schematics that detail contact states, relay references, etc. Diagrammatic representations of devices alone are not acceptable.

Details of construction, layout, and location of each temperature control panel within the building, including instruments location in panel and labeling. Also include on drawings location of mechanical equipment controlled (room number), horsepower and flow of motorized equipment (when this data is available on plans), locations of all remote sensors and control devices (either by room number or column lines).

Schedule of control dampers indicating size, leakage rating, arrangement, pressure drop at design airflow, and number and size of operators required.

A complete description of each control sequence for equipment that is not controlled by direct digital controls. Direct digital controlled equipment control sequences will be provided by the DDC control contractor.

Prior to request for final payment, submit record documents which accurately record actual location of control components including panels, thermostats, wiring, and sensors. Incorporate changes required during installation and start-up.

The user agency may choose to review the submittals and record control drawings to ensure they are in compliance with the contract documents.

All submittals are to comply with submission and content requirements specified in specification Section 01 91 01.

DESIGN CRITERIA
Size all control apparatus to properly supply and/or operate and control the apparatus served.

Provide control devices subject to corrosive environments with corrosion protection or construct them so they are suitable for use in such an environment.

Provide devices exposed to outside ambient conditions with weather protection or construct them so they are suitable for outdoor installation.

Use only UL labeled products that comply with NEMA Standards. Electrical components and installation to meet all requirements of the electrical sections (Division 26) of project specifications.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

In addition to the general content specified under GENERAL REQUIREMENTS supply the following additional documentation:

1. Lubrication instructions, including list/frequency of lubrication
2. List indicating types and grades of oil and/or grease, packing materials, normal and abnormal tolerances for devices, and method of equipment adjustment.
3. Table noting full load power factor, service factor, NEMA design designation, insulation class and frame type for each motor provided
4. A complete set of record control drawings.

MATERIAL DELIVERY AND STORAGE
Provide factory shipping cartons for each piece of equipment and control device. This contractor is responsible for storage of equipment and materials inside and protected from the weather.

P A R T 2 - P R O D U C T S

CONTROL DAMPERS
Provide control dampers shown on the plans and as required to perform the specified functions. Dampers shall be rated for velocities that will be encountered at maximum system design and rated for pressure equal or greater than the ductwork pressure class as specified in Section 23 31 00 of the ductwork where the damper is installed.

Use only factory fabricated dampers with mechanically captured replaceable resilient blade seals, stainless steel jamb seals and with entire assembly suitable for the maximum temperature and air velocities encountered in the system.

Dampers in galvanized ductwork shall be constructed of galvanized steel and/or aluminum.

All dampers, unless otherwise specified, to be rated at a minimum of 180º F working temperature. Leakage testing shall be certified to be based on latest edition of AMCA Standard 500-D and all dampers, unless otherwise specified, shall have leakage ratings as follows:

Damper Class	Differential Pressure	Leakage
Class IA	1" w.g.	$\leq$3 CFM/ft^2

Leakage rate dampers for differential pressures that they will encounter at maximum system design pressures.

Steel framed dampers: Nailor models 2010 & 2020; Greenheck models VCD-33 & VCD-42; Johnson Controls model VD-1630; Ruskin Models CD60 & CD40; other approved equal.

Aluminum frame and blade dampers: Nailor models 2010EAF & 202EAF; Greenheck model VCD-43; Ruskin model CD50; Arrow model AFD-20; other approved equal.

Dampers used for directed mixing of airstreams, i.e., outside air and return air, to be parallel blade type and sized for an air velocity of 1800 to 2000 fpm with the damper blades shall be arranged so that the air

streams are directed at one another to facilitate mixing. Dampers used for throttling or modulating applications other than air stream mixing to be opposed blade type. Two position dampers may be parallel or opposed blade type.

Dampers used for isolation on the discharge of centrifugal fans shall have damper blades perpendicular to the fan shaft to minimize system effect. Dampers mounted with blades vertically shall be designed for vertical blade orientation.

Dampers for applications other than fume exhaust to have frames of not less than 16 gauge galvanized steel or 12 gauge extruded aluminum. Blades to be two-ply steel airfoil of not less than 2 x 20 gauge galvanized steel (14 gauge equivalent) or extruded aluminum airfoil, with stainless steel, acetal, Celcon, bronze, or nylon bearings. Maximum allowable blade width is 8 inches. Use plated steel linkage hardware.

General exhaust dampers: Ruskin model CD80AF; Greenheck model HCD-230; or approved equal.

Maximum damper width is 48 inches; where required width exceeds 48 inches, use multiple damper sections. Inside frame free area shall be a minimum of 90% of total inside duct area.

Multiple width damper sections shall utilize jack shaft linkages unless noted below. Sections over 144 inches wide shall be actuated from two locations on the jack shaft. Double width damper sections for two-position operation may be actuated without jack shafts if each damper section is actuated separately. Dampers that have multiple width and multiple vertical sections shall have a jackshaft for each vertically stacked set of dampers and be provided with crossover linkages between jack shafts to transfer uneven loading.

Jack shafts shall be extended outside of the ductwork for external actuator mounting. Provide bearings on the point of exit for support of damper shafts to prevent wear on the shaft and the ductwork. If locating actuators out of the air stream is impossible, obtain mounting location approval from the designer unless the contract documents indicate in air stream mounting is acceptable. actuator.

Provide weatherproof NEMA 4 enclosures (Belimo N4 option or equal, Belimo ZS-100 or ZS-150 are not acceptable) that have removable covers that have clasps or machine screws (no sheet metal screws) and that do not require removing fasteners from the ductwork to prevent actuator failure or freeze-up when mounting in locations exposed to harsh environments or outdoor locations.

Size operators for smooth and positive operation of devices served, and with sufficient torque capacity to provide tight shutoff against system temperatures and pressure encountered. For electric modulating actuation, use fully proportional actuators with zero and span adjustments. For two-position electric actuation use 24 VAC for DDC controlled actuators, 120 VAC actuators may be used for hardwire interlocking. See 23 09 15 for specific type of input signal required. Actuator stroke times shall match the requirements of the DDC controllers provided under 23 09 23, and/or the specific system requirements for proper operation. All electric actuators will be provided with overload protection to prevent motor from damage when stall condition is encountered. For all two position isolation dampers that are controlled by the DDC system, provide actuators that are powered open and closed and do not utilize the actuator fail position spring for DDC commanded operation unless specified. This is to prevent fast closure by the spring return. Dampers wired to fan power can utilize the actuator fail position spring to actuate the damper.

Where control sequences require damper position indication or interlock, provide damper end switches integral to the damper actuators with form “C” contacts. Damper end switches shall have adjustable positions that can be set for proving the damper open, closed, or both depending on the specified application. End switch contact ratings shall be suitable for application. Where multiple banks of dampers are provided and not physically interlocked, end switches shall be provided for each bank of dampers and wired together to prove all dampers are in the position to be indicated. End switches shall not contain mercury.

All power required for electric actuation shall be provided by this contractor if it is not able to be directly provided from the DDC controller.

Provide operators with linkages and brackets for mounting on device served.

SENSOR **GUARDS**

For locations that are subject to physical abuse, provide metal guard, Johnson Controls GRD10A-601, Shaw Perkins Series 16 or equal.

TIME CLOCKS

UL listed, digital, 7-day, minimum of 10 on/off programs per day, holiday programming, automatic daylight savings switchover, and minimum of seven-day battery back-up.

CURRENT STATUS SWITCHES

Provide a current sensor with adjustable threshold and digital output with LED display, equal to a Veris model H-708/H-904. Threshold adjustment must be by a multi-turn potentiometer or set by multiprocessor that will automatically compensate for frequency and amperage changes associated with variable frequency drives. When used on variable speed motor applications, use a current sensor that will not change state due to varying speeds. Current switches with integral relays shall not be used for start/stop and status motor applications.

CARBON MONOXIDE (CO) & NITROGEN DIOXIDE (NO2) SENSORS; SUPERVISORY CONTROLLER

Furnish and install BACnet Honeywell Analytics E3Point, or equivalent, networkable Dual-Gas with CO and NO2 sensors and 4-20mA output signals. CO sensor range shall be 0-250 ppm with +/-3% accuracy of full scale at 25 Deg. C. and a resolution of 1 ppm. NO2 sensor range shall be 0-10 ppm with a +/-3% accuracy of full scall at 25 Deg. C. and a resolution of 0.1 ppm. Sensor shall be certified to ANSI/UL 61010-1 requirements. Contractor shall provide and include in the O&M's factory calibration certificates for each sensor cartridge.

The sensors shall be supervised by a compatible supervisory controller, basis of design BASnet Honeywell Analytics model 301C. Unit and accessories shall include, at minimum, 3 alarm levels and visual displays, 4-20 mA output signal and an audible alarm. Sensors shall be installed per manufacturers recommended heights.

Provide reduced voltage transformers as required for operation from 120 V. Include startup and commissioning services by the manufacturer's authorized representative.

EMERGENCY SHUTDOWN SWITCHES

Emergency HVAC Shutdown Switch: Kele ST120SL-RP1-HS or WPS-RP2-HS or equal. Switch shall be a momentary contact switch with raised lid to access switch. Labeling shall be provided to indicate the switch is for Emergency HVAC Shut-Down.

POWER SUPPLIES

Provide all required power supplies for transducers, sensors, transmitters, and relays. All low voltage transformers shall have a resettable secondary circuit breaker and be listed as class 2 power supplies. All transformer assemblies in enclosures shall have isolated high and low voltage compartments with separate removeable covers for connections.

P A R T 3 - E X E C U T I O N

INSTALLATION

Install system with trained mechanics and electricians employed by the control equipment manufacturer or an authorized representative of the manufacturer. Where installing contractor is an authorized representative of the control manufacturer, such authorization shall have been in effect for a period of no less than three years.

Install all control equipment, accessories, wiring, and piping in a neat and workmanlike manner. All control devices must be installed in accessible locations. This contractor shall verify that all control devices furnished under this Section are functional and operating the mechanical equipment as specified in Section 23 09 93.

Label all control devices except for terminal unit devices with permanent printed labels that correspond to control drawings. Labeling for each device shall be unique within each mechanical system. Temperature control junction and pull boxes shall be identified utilizing spray painted green covers. Other electrical system identification shall follow the 26 05 53 specification. For control devices mounted above accessible ceilings, label the ceiling tile grid at the ceiling tile that is to be removed for access to the control device.

The label shall be pre-printed using clear polyester tape with black bold 28 size font for ceilings under 12 feet. For ceilings over 12 feet high, use bold 40 size font. For accessible ceilings, use an arrow to point at ceiling tile to be removed for access.

All control devices and electrical boxes mounted on insulated ductwork shall be mounted over the insulation. Provide mounting stand-offs where necessary for adequate support. Cutting and removal of insulation to mount devices directly on ductwork is not acceptable. This contractor shall coordinate with the insulation contractor to provide for continuous insulation of ductwork.

Mounting of electrical or electronic devices shall be protected from weather if the building is not completely enclosed. This Contractor shall be solely responsible for replacing any equipment that is damaged by water that infiltrates the building if equipment is installed prior to the building being enclosed.

Provide all electrical relays and wiring, line, and low voltage, for control systems, devices, and components. Install all high voltage and low voltage wiring (includes low voltage cable) in metal conduit, Electrical Non-metallic Tubing (ENT), or Electrical Metallic Tubing (EMT), as scheduled below and hereafter referred to generically as conduit except above accessible ceilings as noted below. See Wire and Air Piping Conduit Installation Schedule below for specific conduit or tubing to be used. All raceways, enclosures, fittings, and associated supports shall be provided and installed according to the requirements set forth in Division 26, NFPA 70 (NEC) and Chapter SPS 316 of the Wisconsin Administrative Code. All conduits shall be routed parallel and/or perpendicular to walls and adjacent piping. Raceways shall be located to maintain headroom and working clearance around equipment and devices that require inspection and service.

In general, support all raceways from the building structure. No component of a raceway system shall be secured to corrugated metal roof deck. Do not impose on the installations of other trades. Securing conduit, rods, straps, hangers, etc. to suspended ceiling components, electrical raceways, plumbing piping, fire protection sprinkler piping, HVAC piping or ductwork, or their associated support systems, will not be accepted.

Conduit shall be a minimum of 1/2 " for low voltage control provided the pipe fill does not exceed 40%.

Minimum low voltage wiring gauge to be 18 AWG for outputs and 20 AWG for inputs. All low voltage wiring to be stranded.

Low voltage wiring can be run without conduit above accessible lay-in tile ceilings. All wiring in mechanical rooms, above inaccessible hard ceilings, exterior locations, and in any exposed areas, and in all other locations shall be installed in conduit. Wire for wall sensors shall be installed in conduit concealed in the wall. Wiring for radiation valves shall be installed in conduit concealed in the wall. For retrofit installations, all wiring for sensors and valves shall be installed in conduit concealed in new walls. Sensor wiring for existing walls shall be installed without conduit and concealed in the wall (fished) where possible. If running wire concealed in the existing wall is not possible, install in surface raceway as specified or if not specified, consult with the AE for raceway type and color to be provided.

Where low voltage wiring is installed free-air, installation shall comply with the following:

- Wiring shall utilize the cable tray wherever possible.

- Wiring shall run at right angles and be kept clear of other trades work.

- Wiring shall be supported utilizing "J" or "Bridal-type" steel mounting rings anchored to ceiling concrete, piping supports, walls above ceiling or structural steel beams. Mounting rings shall be of open design (not a closed loop) to allow additional wire to be strung without being threaded through the ring. For mounting rings that do not completely surround the wire, attach the wire to the mounting ring with a strap.

- At HVAC terminal units only, where the wiring serves a specific device; e.g., controller, actuator, transmitter, etc. associated with the unit, the j-hooks or Bridal rings required to support the wiring, may be secured to the rods or straps that support the ductwork or piping that serves the unit. Wall penetrations shall be sleeved.

- Supports shall be spaced at a maximum 4-foot interval unless limited by building construction. If wiring "sag" at mid-span exceeds 6-inches; another support shall be used.

- Wall penetrations shall be sleeved, and fire stopped as specified.

- Wiring shall not be supported from existing cabling, existing tubing, plumbing or steam piping, ductwork, any component of a suspended ceiling, or electrical or communications conduit.

Install all shutdown switches furnished under this Section where specified or shown on the plans. Boiler kill switches shall be wired to each boiler safety circuit and an auxiliary contact shall be wired to a DDC binary input. Emergency HVAC shutdown switches shall be wired to DDC binary inputs for shutdown of all HVAC equipment serving the building.

All wiring in control panels shall be terminated on a terminal strip. Wire nuts are not acceptable. A maximum of two wires shall be terminated under any one terminal.

Utilizing a control panel as a raceway for wiring to another control panel is prohibited.

After completion of installation, test and adjust control equipment. Submit data showing set points and final adjustments of controls.

WIRE AND AIR PIPING CONDUIT AND TUBING INSTALLATION SCHEDULE

The following conduit schedule shall apply to both polyethylene tubing and wire in conduit where conduit is specified for air tubing or wiring. Conduit and tubing referenced below shall meet specifications in Section 26 05 33 and as defined below.

Air piping shall be run in independent conduit without wiring. In no cases shall wiring and air piping share a conduit, raceway, or cable tray.

Where air piping and wiring share a trough or wire management system above a control panel, code required separation shall be provided.

Conduit other than that specified below for specific applications shall not be used.

Underground Installations within Five Feet (1.5 m) of Foundation Wall: Rigid steel conduit.

Underground Installations More than Five Feet (1.5 m) From Foundation Wall: Rigid steel conduit. Plastic-coated rigid steel conduit. Schedule 40 PVC conduit.

Under Slab on Grade Installations: Schedule 40 PVC conduit.

Exposed Outdoor Locations: Rigid steel conduit.

Concealed in Concrete and Block Walls: Rigid steel conduit. Schedule 40 PVC conduit. Electrical Nonmetallic Tubing (ENT).

Concealed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical Metallic Tubing (EMT).

Exposed Dry Interior Locations: Rigid steel conduit. Intermediate metal conduit. Electrical metallic tubing.

Exposed Dry Interior Locations for Control Devices with Conduit Connections: EMT or Flexible Metal Conduit (FMC). Minimum length shall be one foot (300 mm); maximum length shall be three feet (900 mm). Minimum size FMC of 3/8".

Exposed Dry Interior Locations for Control Devices without Conduit Connections: Where HVAC equipment control panels or devices do not provide for the direct connection of conduits, exposed wiring may be extended to complete the final connections in dry locations, providing it does not exceed 18 inches in length.

CONTROL DAMPERS

All control dampers furnished by the control manufacturer are to be installed by the Mechanical Contractor under the coordinating control and supervision of the Control Contractor in locations shown on plans or where required to provide specified sequence of control.

Damper end switches, where required, shall be integral to the actuator that is mounted to the damper drive shaft or auxiliary shaft attached to a damper drive blade. End switches shall be adjusted to prove the

damper the position opposite the fail position of the damper actuator unless the control sequence requires a different position to be proven to accomplish the specified control sequence.

Coordinate installation with the sheetmetal installer to obtain smooth duct transitions where damper size is different than duct size. Blank off plates will not be accepted.

Each operator shall serve a maximum damper area of 36 square feet. Where larger dampers are used, provide multiple operators.

TEMPERATURE CONTROL PANELS

Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. All control panel openings shall be plugged. Conduits and other penetrations on the top of the cabinets shall be sealed on the exterior of the cabinet with silicone caulk to resist water penetration. One control panel may accommodate more than one major mechanical system in same equipment room. Provide permanent printed labeling for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

Provide as-built control drawings of all systems served by each local panel in a location adjacent to or inside of panel cover. Provide a protective cover or envelope for drawings.

CURRENT STATUS SWITCHES

Provide for each fan or pump specified or shown on point list. Set threshold adjustment to indicate belt or coupling loss. Readjust threshold for proper operation after final balancing is completed

PRECONSTRUCTION REVIEW MEETING

This contractor shall attend a meeting or meetings as required prior to construction to review the control system on the project. The meeting attendees shall consist of the AE of Record, DFD, CxP, User Agency, Section 23 09 14 Contractor, and the Division 23 Contractor. All sequences covered within specification section 23 09 93 and related system configurations and devices shall be reviewed in detail and any corrections to the sequences and mechanical systems shall be made through the DFD construction change process.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

For commissioning of control systems, the following items shall be complete by the contractor prior to functional performance testing:

- Completed functional performance tests written by the commissioning agent shall have been reviewed at the controls Preconstruction Review Meeting.
- All point to point checkout for each input/output shall be complete and documented.
- All changes to the design need to be incorporated prior to testing.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01.

END OF SECTION

SECTION 23 09 93
SEQUENCE OF OPERATION FOR HVAC CONTROLS
BASED ON DFD MASTER SPECIFICATION DATED 3/28/2022

P A R T 1 - G E N E R A L

SCOPE
This section includes control sequences for HVAC equipment as well as equipment furnished by others that may need monitoring or control. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Description of Work
- Submittals
- Operation and Maintenance Data
- Design Criteria

PART 2 - PRODUCTS
- Not Applicable

PART 3 - EXECUTION
- General Control
- Mechanical Ventilation Control
- Installation Checklists & Functional Performance Testing

RELATED WORK
Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01– Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 09 14 - Pneumatic and Electric Controls
Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC – Coordination

Division 23 - HVAC - Equipment provided to be controlled or monitored.
Division 26 - Electrical - Equipment provided to be controlled or monitored.
Division 28 - Electronic Safety and Security

REFERENCE
The A/E must properly coordinate the necessary power wiring.
Section 23 09 14 work includes furnishing and installing all field devices, including electronic sensors for the equipment, and all related field wiring, interlocking control wiring between equipment, sensor mounting, etc., that is covered in that section.

Motorized control dampers and actuators, thermowells (temperature sensing wells), automatic control valves and their actuators are also covered in Section 23 09 14.

DESCRIPTION OF WORK
Control sequences are hereby defined as the manner and method by which automatic controls function. Requirements for each type of operation are specified in this section.

Operation equipment, devices and system components required for automatic control systems are specified in other Division 23 control sections of these specifications.

All temperature, humidity, and pressure sensing, and all other control signal transportation for the control sequences shall be furnished under Section 23 09 14. All electronic, and electric input/output signals shall be extended under Section 23 09 14, with adequate lead length for termination within the appropriate control panel.

Sequences for equipment controlled by electric self-contained controls are accomplished by hardware provided under Section 23 09 14.

SUBMITTALS
Refer to Division 1, General Conditions, Submittals, Section 23 05 00 and Section 23 09 14 for descriptions of what should be included in the submittals.

Shop drawings shall be provided by contractor(s) providing equipment under Section 23 09 14. The contractor providing the 23 09 14 equipment shall provide a complete narrative of the sequence of operation for equipment that is controlled directly from that equipment. The narrative of the sequence of operation shall not be a verbatim copy of the sequences contained herein but shall reflect the actual operation as applied by the contractor.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA
Reference Section 23 09 14.

P A R T 2 - P R O D U C T S

Not applicable to this Section – reference Section 23 09 14 for product descriptions.

P A R T 3 - E X E C U T I O N

GENERAL:

SETPOINTS:
All setpoints indicated in the control specification are to be adjustable. The setpoints shall be readily available to be modified in the mechanical system software system summary (either textual or graphic based) and under the same software level as hardware points. Some less used setpoints may be provided on a lower software level, if requested by the user Agency for clarity. The setpoints indicated herein are only specified as a calculated starting point (or initial system operation). It is expected that setpoint adjustments and control loop tuning shall be required to provide optimum system operation based on requirements of the building. The control contractor shall work with the balancing contractor and the user Agency to provide the final system setpoint adjustments and control loop tuning after the system is in operation and building is in use. Document all final setpoints on the as-built control drawings. Any questions regarding the intended operation of the HVAC equipment and control systems shall be referred to the HVAC design engineer through the appropriate construction communication process. The following setpoints should be used as initial setpoints unless otherwise specified in the individual control sequences or instructed by the user Agency. If the contractor fails to check with the user Agency for final setpoints, they shall adjust setpoints at no additional cost.

CO ppm Fan Enable Setpoint: 35 ppm
CO ppm audible & Visual Alarm Minimum Setpoint: 50 ppm
NO2 ppm Fan Enable Setpoint: 1 ppm
NO2 ppm Audible & Visual Alarm Minimum Setpoint: 5 ppm

ANTI-CYCLING:
Timers shall be set as specified or as needed to prevent damage or excessive wear to the equipment. Unless otherwise specified in the individual control sequences, fans and pumps shall have a minimum runtime on timers of 15 minutes (adj.) and off timers of 5 minutes (adj.)or the recommended timers by the manufacturer. Safeties shall override runtime timers.

DEADBANDS:
Provide deadbands for all control loops to prevent constant hunting of output signals to controlled devices. Deadbands shall be set to provide adequate control around setpoint as follows unless otherwise specified in the individual control sequences:

CO ppm Fan Control: 0 ppm
NO2 ppm Fan Control: 0 ppm

ALARMS:
Provide all alarmed points with adjustable time delays to prevent nuisance tripping under normal operation and on equipment start-up. For all commanded outputs that have status feedback, provide an alarm that shall

indicate the commanded output is not in its commanded state. Provide alarms on all points as indicated on point charts.

For devices that have form "C" contacts available for alarm monitoring, use closed contacts for the Normal condition and open contacts on Alarm condition. This shall provide a level of supervision by detecting a break in the wiring.

EQUIPMENT START/STOP FAILURE STATES:
All start/stop points for equipment shall utilize normally open contacts unless called out specifically in the individual control sequences.

CURRENT STATUS SWITCHES:
When current switches are used for proving fan or pump status, they shall be set up so that they will detect belt or coupling loss by the reduction in current draw on loss of coupled load. The current switch calibration shall be repeated by the 23 09 14 contractor after the balancer is complete. Current switches shall be provided for each motor on multiple fan air handling units and status provided individually to the local control system for each motor.

DAMPER INTERLOCKS FOR FANS WITH STARTERS:
For fan systems with magnetic starters and shutoff dampers specified with end switches, the damper interlock shall be hardwired in such a way that the damper shall open if the fan starter hand / off / auto switch is in the hand or in the auto position and being called to start. After the damper end switch has proven the damper open, a hardwire interlock from the end switch to the starter holding coil for the fan shall cause the fan to start. For fan systems that are ducted in parallel, see specific sequence for fan system on interlock requirements.

SENSORS:
All devices and equipment including terminal units, specified to be controlled in a control sequence by a thermostat or sensor, shall be provided with a sensor, whether or not the device is indicated on the plans. Consult the HVAC design engineer for the thermostat or sensor location.

DAILY SCHEDULING
Provide scheduling of EF-1 runtime as listed below.

CONTROLLED VARIABLE REQUIREMENTS
All controlled variables, i.e., CO concentration, NO2 concentration, etc., shall be wired directly to the controller in which the software PID loop or other similar software loop resides.

MECHANICAL VENTILATION CONTROL:

GENERAL:
The ventilation system is a constant volume supply fan.
The ventilation system is controlled by the local ventilation control panel and CO & NO2 sensors.
The ventilation system is equipped with the following:

Exhaust fan with starter.
Outside air damper furnished by ATC. (Refer to specification 23 09 14)
Exhaust air damper furnished by ATC. (Refer to specification 23 09 14)
Actuators furnished by ATC. (Refer to specification 23 09 14)

FAN CONTROL:

Start/Stop:
The ventilation control panel shall start the exhaust fan.

Current Status Switch:
Provide for exhaust fans and set up as described under GENERAL, Current Switch Setup, in this Section.

Damper Status End Switches:
Provide for both the Outside Air and Exhaust Air dampers. Interlock with EF-1 run command. Alarm and display with a luminaire on the front of VCP-1 when individual damper status does not match the command.

The control panel shall be furnished and installed by the Controls Contractor and function as described below. It is intended that VCP-1 contains a dedicated BACnet DDC controller(s) which shall perform the primary logic and control functions to operate the associated HVAC equipment. VCP-1 shall include an emergency fan off light indicator and fan status on/off light indicators, EF-1 & damper operation failure light indicators, gas detected for ventilation light indicator for CO & NO2 gasses, manual pushbutton EF-1 enable/disable, necessary relays, scheduler, etc. to accomplish the control sequences listed below.

Minimum Ventilation: VCP-1 shall energize EF-1 twice daily for a period of 2 1/2 hours each time, once in the morning and once in the afternoon. Time-of-day activation periods and duration shall be programmable from VCP-1.

Gas Detection Ventilation: When any level of concentration of carbon monoxide or nitrogen dioxide is detected via the gas detection sensors, VCP-1 shall operate EF-1 and illuminate a light located on the panel which indicates a call for ventilation. Ventilation shall be de-energized when CO or NO2 have not been detected for a programmed period of time (adjustable). EF-1 will be programmed to have a minimum runtime (adjustable) to avoid short cycling.

Manual Ventilation Control: A pushbutton shall be provided at the VCP-1 to initiate manual “On” operation of EF-1 ventilation. When initiated by the manual control pushbutton, the EF-1ventilation equipment shall operate for a period of 120 minutes (adjustable) or until the pushbutton supplied for the "Stop" command is initiated.

All equipment located in the cold storage shall be capable of operating in -15 Deg. F ambient temperatures.

SAFETIES:
General:
All safeties shall be hard wired to the exhaust fan starters or VFD safety circuits. Starters shall not function in the “Hand” or “Auto” and VFD’s shall be disabled if they are indexed to the “Auto” or “Hand” position in either the VFD or bypass modes.

UNIT SHUTDOWN:
Whenever the ventilation system is indexed off, the exhaust fans shall stop. On a failure of the exhaust fan, an alarm shall be sent through VCP-1. Whenever the exhaust fan is off for any reason the following shall occur:

The outside air dampers and exhaust air dampers shall close.

FUNCTIONAL PERFORMANCE TESTING
Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

END OF SECTION

SECTION 23 31 00
HVAC DUCTS and CASINGS
BASED ON DFD MASTER SPECIFICATION DATED 06/19/2020

P A R T 1 - G E N E R A L

SCOPE

This section includes specifications for all duct systems used on this project. Included are the following topics:

RELATED WORK

Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC
Section 23 08 00 – Commissioning of HVAC
Section 23 33 00 – Air Duct Accessories

REFERENCE

Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

ANSI SS-EN 485-2	Aluminum and Aluminum Alloys-Sheet, Strip and Plate-Part 2: Mechanical Properties
ASTM B209	Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM A90	Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
ASTM A167	Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A623	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A527	Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
ASTM 924	Standard Specification for General Requirements for Sheet Steel, Metallic-coated by the Hot-dip Method
ASTM C 1071	Specification for Fibrous Glass Duct Lining Insulation

ASTM C 411	Test Method for Hot Surface Performance of High Temperature Thermal Insulation
ASTM E 84	Test Method for Surface Burning Characteristics of Building Materials
ASTM C 1338	Test Method for Determining Fungal Resistance of Insulation Materials and Facings
ASTM G 21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
ASTM C 916	Standard Specification for Adhesives for Duct Thermal Insulation
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
UL 181	Standard for Safety for Factory Made Air Ducts and Air Connectors.
NAIMA	Fibrous Glass Duct Liner Standard

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Include manufacturer's data and/or Contractor data for the following:

- Fabrication and installation drawings.
- Schedule of duct systems including material of construction, gauge, pressure class, system class, method of reinforcement, joint construction, fitting construction, and support methods, all with details as appropriate.
- Duct sealant and gasket material.
- Duct liner including data on thermal conductivity, air friction correction factor, and limitation on temperature and velocity.

DESIGN CRITERIA
Construct all ductwork to be free from vibration, chatter, objectionable pulsations and leakage under specified operating conditions.

Use material, weight, thickness, gauge, construction and installation methods as outlined in the following SMACNA publications, unless noted otherwise:

- HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005
- HVAC Air Duct Leakage Test Manual, 2nd Edition, 2012
- HVAC Systems - Duct Design, 4th Edition, 2006

Use products which conform to NFPA 90A, possessing a flame spread rating of not over 25 and a smoke developed rating no higher than 50.

DELIVERY, STORAGE AND HANDLING
Promptly inspect shipments to ensure that Ductwork is undamaged and complies with the specification.

Protect Ductwork against damage.

Protect Ductwork by storing inside or by durable, waterproof, above ground packaging. Do not store material on grade. Protect Ductwork from dirt, dust, construction debris and foreign material. Where end caps/packaging are provided, take precautions so caps/packaging remain in place and free from damage.

Offsite storage agreements do not relieve the contractor from using proper storage techniques.

Storage and protection methods must allow inspection to verify products.

P A R T 2 - P R O D U C T S

GENERAL
All sheet metal used for construction of duct shall be 24 gauge or heavier except for round and spiral ductwork and spiral duct take-offs 12" and below may be 26 gauge where allowed in SMACNA HVAC Duct Construction Standards, Metal and Flexible, 3rd Edition, 2005.

Duct sizes indicated on plans are net inside dimensions; where duct liner is specified, dimensions are net, inside of liner.

DUCTWORK PRESSURE CLASS

Minimum acceptable duct pressure class, for all ductwork except transfer ductwork, is 2 inch W.G. positive or negative, depending on the application. Transfer ductwork minimum acceptable duct pressure class is 1 inch W.G. positive or negative, depending on the application. Duct system pressure classes not indicated on the drawings to be as follows:

	Calc. S.P. in	Pressure Class in
Exhaust air ducts	-	2
Outside air ducts	-	2

MATERIALS

Galvanized Steel Sheet:

Use ASTM A 653 galvanized steel sheet of lock forming quality. Galvanized coating to be 1.25 ounces per square foot, both sides of sheet, G90 in accordance with ASTM A90. Provide "Paint Grip" finish or galvanneal sheet metal for ductwork that will be painted.

Where any duct surface is scratched, marred, or otherwise damaged, paint with PVC aerosol spray.

All couplings shall be slip-joint construction with a minimum 2 inches insertion length. Seal all couplings with sealants as specified.

LOW PRESSURE DUCTWORK (Maximum 2 inch pressure class)

Fabricate and install ductwork in sizes indicated on the drawings and in accordance with SMACNA recommendations, except as modified below.

Construct so that all interior surfaces are smooth. Use slip and drive or flanged and bolted construction when fabricating rectangular ductwork. Use spiral lock seam construction when fabricating round spiral ductwork. Sheet metal screws may be used on duct hangers, transverse joints and other SMACNA approved locations if the screw does not extend more than 1/2 inch into the duct.

Use elbows and tees with a center line radius to width or diameter ratio of 1.5 wherever space permits. When a shorter radius must be used due to limited space, install single wall sheet metal splitter vanes in accordance with SMACNA publications, Type RE 3. Where space will not allow and the C value of the radius elbow, as given in SMACNA publications, exceeds 0.31, use rectangular elbows with turning vanes as specified in Section 23 33 00. Square throat-radius heel elbows will not be acceptable. Straight taps or bullhead tees are not acceptable.

Where rectangular elbows are used, provide turning vanes in accordance with Section 23 33 00.

Provide expanded take-offs or 45 degree entry fittings for branch duct connections with branch ductwork airflow velocities greater than 700 fpm. Square edge 90-degree take-off fittings or straight taps will not be accepted.

Button punch snaplock construction will not be accepted on aluminum ductwork.

Round ducts may be substituted for rectangular ducts if sized in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission of the Architect/Engineer.

Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

DUCT SEALANT

Manufacturer: 3M 800, 3M 900, H.B. Fuller/Foster, Hardcast, Hardcast Peal & Seal, Lockformer cold sealant, Mon-Eco Industries, United Sheet Metal, or approved equal. Silicone sealants are not allowed in any type of ductwork installation.

Install sealants in strict accordance with manufacturer's recommendations, paying special attention to temperature limitations. Allow sealant to fully cure before pressure testing of ductwork, or before startup of air handling systems.

GASKETS
2 Inch Pressure Class And Lower:
Soft neoprene or butyl gaskets in combination with duct sealant for flanged joints.

P A R T 3 - E X E C U T I O N

INSTALLATION
Verify dimensions at the site, making field measurements and drawings necessary for fabrication and erection. Check plans showing work of other trades and consult with Architect in the event of any interference.

Make allowances for beams, pipes or other obstructions in building construction and for work of other contractors. Transform, divide or offset ducts as required, in accordance with SMACNA HVAC Duct Construction Standards, Figure 4-7, except do not reduce duct to less than six inches in any dimension and do not exceed an 8:1 aspect ratio. Where it is necessary to take pipes or similar obstructions through ducts, construct easement as indicated in SMACNA HVAC Duct Construction Standards, Figure 4-8, Fig. E. In all cases, seal to prevent air leakage. Pipes or similar obstructions may not pass through high pressure or fume exhaust ductwork.

Test openings for test and balance work will be provided under Section 23 05 93.

Provide frames constructed of angles or channels for dampers or other devices installed in duct systems, and make all connections to such equipment including equipment furnished by others. Secure frames with gaskets and screws or nut, bolts and washers.

Install duct to pitch toward outside air intakes and drain to outside of building. Solder or seal seams to form watertight joints.

Where two different metal ducts meet, the joint shall be installed in such a manner that metal ducts do not contact each other by using proper seal or compound.

Install all motor operated dampers and connect to or install all equipment furnished by others. Blank off all unused portions of louvers, as indicated on the drawings, with 1-1/2 inch board insulation with galvanized sheet metal backing on both sides.

Do not install ductwork through dedicated electrical rooms or spaces unless the ductwork is serving this room or space.

Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

Provide adequate access to ductwork for cleaning purposes.

Provide temporary capping of ductwork openings to prevent entry of dirt, dust and foreign material.

Protect diffusers, registers and grilles with plastic wrap or some other approved form of protection to maintain dirt and dust free and to prevent entry of dirt, dust and foreign material into the Ductwork.

During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

DUCTWORK SUPPORT
Support ductwork in accordance with SMACNA HVAC Duct Construction Standards, Figure 5-5, except supporting ductwork with secure wire method is not allowed.

Stainless steel air-craft cable hanging systems are allowed on round ductwork under 12 inches diameter if installed utilizing two fasteners with two cable loops. Support with 3/32 inch, 7 x 7, stainless steel air-craft cable, with matching serrated spring loaded wedge mechanism fasteners rated for actual load. Comply with the manufacturer's installation instructions.

LOW PRESSURE DUCT (Maximum 2 inch pressure class)
Seal all ducts, except for transfer ducts, in accordance with SMACNA seal class "A"; all seams, joints, and penetrations shall be sealed.

Install a manual balancing damper in each branch duct and for each diffuser or grille. The use of splitter dampers, extractors, or grille face dampers will not be accepted for balancing dampers.

Hangers must be wrapped around bottom edge of duct and securely fastened to duct with sheet metal screws or pop rivets. Trapeze hangers may be used at contractor's option.

CLEANING
Remove all dirt and foreign matter from the entire duct system and clean diffusers, registers, grilles and the inside of fans before operating.

Clean duct systems with high power vacuum machines where systems have been used for temporary heat, air-conditioning, or ventilation purposes during construction. Protect equipment that may be harmed by excessive dirt with filters, or bypass during cleaning.

LEAKAGE TEST
Test all ductwork in accordance with test methods described in Section 4 of SMACNA HVAC Air Duct Leakage Test Manual. Do not insulate ductwork until it has been successfully tested. Test pressure shall be equal to the duct pressure class.

If excessive air leakage is found locate leaks, repair the duct in the area of the leak, seal the duct, and retest.

Leakage rate shall not exceed more than 5% of the system air quantity for low pressure ductwork, determined in accordance with Appendix C of the SMACNA HVAC Air Duct Leakage Test Manual.

Submit a signed report to the Division's Construction Representative, indicating test apparatus used, results of the leakage test, and any remedial work required to bring duct systems into compliance with specified leakage rates.

STRUCTURAL TEST
Random test all ductwork per DFD direction. Do not insulate ductwork until it has been successfully tested. Test pressure shall be equal to the duct pressure class.

Deflection limits shall not exceed those listed in accordance with Chapter 11 of SMACNA HVAC Duct Construction Standards, 3.0 Performance Requirements.

Submit a signed report to the Division's Construction Representative, indicating test apparatus used, results of the structural test, and any remedial work required.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

APPENDIX

DUCT LEAKAGE TEST REPORT

State of Wisconsin Department of Administration	**DFD Project Number:_____**
Division of Facilities Development	**Date Submitted:_____**

Project	**Name:**_____		
	Location:_____		
	Contractor:_____		
System	**Fan No:**_____	**Leakage Class (C_L):**_____	
Data	**Fan Design CFM:**_____	**Duct Pressure Class (P_C):**_____	
		Test Pressure (P_T):_____	
Test			
Equipment	**Manufacturer:**_____	**Model No:**_____	**Serial No:**_____

For large systems, use the reverse side for a simple sketch of the entire duct system. Then use letter designations to indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Note that due to normal construction sequencing it is usually necessary to test risers separately prior to enclosing chases.

Design Data					**Field Test Data**							
			Allowable Leakage		**Diameter**		**Pressure (in. wc.)**					
Duct Section	**Duct Shape**	**Duct Surface (Ft^2)**	**Leakage Factor ($P^{.65}C_L$)**	**CFM for Section**	**Tube (D_1)**	**Orifice (D_2)**	**In Duct (P)**	**Across Orifice (P_{drop})**	**Date**	**Performed By**	**Observed By**	**Actual CFM**
TOTAL												

DUCT STRUCTURAL TEST REPORT

State of Wisconsin **DFD Project Number:_____**
Department of Administration
Division of Facilities Development **Date Submitted:_____**

Project **Name:_____**
Location:_____
Contractor:_____

System Data **Fan No:_____**
Description of Test Method:_____
_____
_____

Test Equipment **Manufacturer:_____** **Model No:_____** **Serial No:_____**

Indicate the various duct sections being tested at one time. Also use the reverse side for test comments.

Design Data								Field Test Data						
Duct Test Location	Ductwork Shape		Duct Pressure Class	Allowable Ductwork Wall Deflection		Allowable Joint/ Reinforcement Deflection		Pressure (in. wc.) In Duct	Measured Ductwork Wall Deflection		Measured Joint/ Reinforcement Deflection		Per-formed By/ Date	Wit-nessed By/ Date
	H	W		H	W	H	W		H	W	H	W		

END OF SECTION

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SECTION 23 33 00
AIR DUCT ACCESSORIES
BASED ON DFD MASTER SPECIFICATION DATED 02/17/2022

P A R T 1 - G E N E R A L

SCOPE

This section includes accessories used in the installation of duct systems. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Shop Drawings
- Operation and Maintenance Data

PART 2 - PRODUCTS
- Manual Volume Dampers
- Turning Vanes
- Control Dampers
- Flashings
- Duct Flexible Connections
- Sound Attenuators
- Louvers

PART 3 - EXECUTION
- Manual Volume Dampers
- Turning Vanes
- Control Dampers
- Flashings
- Duct Flexible Connections
- Louvers
- Construction Verification

RELATED WORK

Section 23 05 48 – Vibration and Seismic Controls for HVAC Piping and Equipment
Section 23 08 00 – Commissioning of HVAC
Section 23 31 00 – HVAC Ducts and Casings

REFERENCE

Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

NFPA 90A	Standard for Installation of Air Conditioning and Ventilating Systems
SMACNA	HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition, 2005
UL 214	
UL 555 (6th edition)	Standard for Fire Dampers and Ceiling Dampers
UL 555S (4th edition)	Leakage Rated Dampers for Use in Smoke Control Systems

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions

SHOP DRAWINGS

Refer to division 1, General Conditions, Submittals.

Submit for all accessories and include dimensions, capacities, ratings, installation instructions, and appropriate identification.

Include certified test data on dynamic insertion loss, self-noise power levels, and aerodynamic performance of sound attenuators.

Submit manufacturer's color charts where finish color is specified to be selected by the Architect/Engineer.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

P A R T 2 - P R O D U C T S

MANUAL VOLUME DAMPERS
Manufacturers: Ruskin, Vent Products, Air Balance, or approved equal.

Dampers must be constructed in accordance with SMACNA Fig. 7-4, Fig. 7-5, and notes relating to these figures, except as modified below.

Reinforce all blades to prevent vibration, flutter, or other noise. Construct dampers in multiple sections with mullions where width is over 48 inches. Use rivets or tack welds to secure individual components; sheet metal screws will not be accepted. Provide operators with locking devices and damper position indicators for each damper; use an elevated platform on insulated ducts. Provide end bearings or bushings for all volume damper rods penetrating ductwork constructed to a 3" w.c. pressure class or above.

TURNING VANES
Manufacturers: Aero Dyne, Anemostat, Barber-Colman, Hart & Cooley, or approved equal.

Construct turning vanes and runners for square elbows in accordance with SMACNA Fig. 4-3 and Fig. 4-4 except use only airfoil type vanes. Construct turning vanes for short radius elbows and elbows where one dimension changes in the turn in accordance with SMACNA Chart 4-1 and Fig. 4-9.

CONTROL DAMPERS
Control dampers are specified in section 23 09 14.

FLASHINGS

Provide flashing to completely weatherproof connection of ductwork to louvers. Flashing to be constructed of material similar to louver material.

Flashing and counterflashing for roof curbs will be provided by others.

Flashing and curbs for duct and pipe penetrations of roof assemblies to be in accordance with details.

DUCT FLEXIBLE CONNECTIONS
Material to be fire retardant, be UL 214 listed, and meet the requirements of NFPA 90A.

Connections to be a minimum of 3 inches wide, crimped into metal edging strip, and air tight. Connections to have adequate flexibility and width to allow for thermal expansion/contraction, vibration of connected equipment, and other movement.

General Applications:
Use coated glass fiber fabric for all applications. Material for inside applications other than corrosive environments, fume exhaust, or kitchen exhaust to be double coated with neoprene, air and water tight, suitable for temperatures between -10°F and 200°F, and have a nominal weight of 30 ounces per square yard.

LOUVERS

Louver Provided by Division 23 Contractor:
Manufacturers: Airolite K6776, Industrial Louvers 658, American Warming and Ventilating LE-31, Construction Specialties 6177, Ruskin ELF6350DMP or approved equal.

Similar to Airolite Type K6776, extruded aluminum alloy not less than 12 gauge (.081" thick), 6063 series frame and blades, all-welded assembly, 35 degree or 45 degree blades with water baffle, 6 inches thick. Provide with bird screen of ½" x ½" mesh aluminum in 12 gauge aluminum frame and an aluminum sill. Locate the bird screen inside of the louver unless noted otherwise.

Louver to bear the AMCA certified ratings seal for both air performance and water penetration, having a free area not less than 50% based on a 48" x 48" section, a water penetration less than 0.1 oz/square foot under AMCA test at 1000 feet per minute, and an intake pressure drop less than 0.20 inches of water at 1000 feet per minute.

Finish to be anodized or Kynar 500 in a custom color to be selected by the Architect. Furnish sufficient paint in the same color as the louver to paint the outer surface of panels over unused portions of louvers and to paint the interior portion of ductwork visible through the louvers.

P A R T 3 - E X E C U T I O N

MANUAL VOLUME DAMPERS
Install manual volume dampers in each branch duct and for each grille, register, or diffuser as far away from the outlet as possible while still maintaining accessibility to the damper. Install so there is no flutter or vibration of the damper blade(s).

TURNING VANES
Install turning vanes in all rectangular, mitered elbows in accordance with SMACNA standards and/or manufacturer's recommendations.

Install double wall, airfoil, 2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity less than 2000 fpm. Install double wall, airfoil, 4-1/2 inch radius vanes in ducts with vane runner length 18" or greater and air velocity 2000 fpm or greater.

If duct size changes in a mitered elbow, use single wall type vanes with a trailing edge extension. If duct size changes in a radius elbow or if short radius elbows must be used, install sheetmetal turning vanes in accordance with SMACNA Chart 4-1 and Figure 4-9.

CONTROL DAMPERS
Install dampers in locations indicated on the drawings, as detailed, and according to the manufacturer's instructions. Install blank-off plates or transitions where required for proper mixing of airstreams in mixing plenums. Provide adequate operating clearance and access to the operator. Install an access door adjacent to each control damper for inspection and maintenance.

FLASHINGS
Flashing for roof curbs, equipment supports or rails located on roof, will be installed by others.

DUCT FLEXIBLE CONNECTIONS
Install at all duct connections to rotating or vibrating equipment, including air handling units (unless unit is internally isolated), fans, or other motorized equipment in accordance with SMACNA Figure 7-8. Install thrust restraints to prevent excess strain on duct flexible connections at fan inlets and outlets; see Related Work.

For applications in corrosive environments or fume exhaust systems, use a double layer of the Teflon¿ coated fabric when making the connector.

LOUVERS
Furnish louvers to the General Prime Contractor for mounting in exterior walls. Connect outside air intake duct to the louver, sealing all connections air and water tight.

Provide bird screen on inside of active louver area where none is provided with louvers. Where louvers are equipped with inside birdscreen, remove screen at all locations where duct connections are not made.

Install insulated metal panel on unused portion of louver. Panels must be sealed weathertight to louver assembly with flashing as required for proper drainage to outside of building. Paint outside surface of panel to match louver prior to installation. Where ductwork is visible through louver when viewed from outside the building, paint inside of duct to match louver color.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION

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SECTION 23 34 00
HVAC FANS
BASED ON DFD MASTER SPECIFICATION DATED 04/05/2017

P A R T 1 - G E N E R A L

SCOPE
This section includes specifications for fans that are not an integral part of a manufactured device. Included are the following topics:

RELATED WORK
Section 01 91 01– Commissioning Process

Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
Section 23 08 00 – Commissioning of HVAC

REFERENCE
Applicable provisions of Division 1 govern work under this Section.

REFERENCE STANDARDS

AMCA 203	AMCA Fan Application Manual - Troubleshooting
AMCA 210	Laboratory Method of Testing Fans for Rating
AMCA 300	Reverberant Room Method for Sound Testing of Fans
NFPA 90A	Standard for the Installation of Air Conditioning and Ventilating Systems
NFPA 96	Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations
UL 762	Power Roof Ventilators For Restaurant Exhaust Appliances

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

SHOP DRAWINGS
Refer to division 1, General Conditions, Submittals.

Include dimensions, capacities, fan curves, materials of construction, ratings, weights, motors and drives, sound power levels, appropriate identification and vibration isolation for all equipment. Sound power levels to be based on tests performed in accordance with AMCA Standard 300.

Submit color selection charts for equipment where applicable.

Fan curves shall indicate the relationship of CFM to static or total pressure for various fan speeds. Brake horsepower, recommended selection range, and limits of operation are to also be indicated on the curves. Indicate operating point on the fan curves at design air quantity and indicate the manufacturer's recommended drive loss factor for the specific application. Tabular fan performance data is not acceptable.

OPERATION AND MAINTENANCE DATA

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

DESIGN CRITERIA

Tested and certify all fans in accordance with the applicable AMCA test code.

Each fan and motor combination shall be capable of delivering 110% of air quantity scheduled at scheduled static pressure. The motor furnished with the fan shall not operate into the motor service factor when operating under these conditions.

Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA Publication 203, Appendix L.

Where inlet and outlet ductwork at any fan is changed from that shown on the drawings, provide any motor, drive and/or wiring changes required due to increased static pressure or baffling necessary to prevent uneven airflow or improve mixing.

All internal insulation and other components exposed to the airstream are to meet the flame spread and smoke ratings contained in NFPA 90A.

All roof mounted equipment to be provided with curbs or equipment stands in accordance with specification in Section 23 05 29.

P A R T 2 - P R O D U C T S

GENERAL

Use fan size, class, type, arrangement, and capacity as scheduled.

Furnish complete with motors, wheels, drive assemblies, bearings, vibration isolation devices, and accessories required for specified performance and proper operation. All single phase motors to have inherent thermal overload protection.

Provide variable pitch sheaves for drives 3 hp and smaller, fixed pitch sheaves for drives 5 hp and larger. Design all drives for 150% of motor rating.

Statically and dynamically balance all fans so they operate without objectionable noise or vibration.

Use AMCA Type A spark resistant construction for all fans handling flammable or explosive vapors.

POWER ROOF EXHAUST FANS

Manufacturers: Carnes, Greenheck, Penn, Jenn-Air, Cook, ACME, S&P or approved equal.

Provide upblast unit, as scheduled, with aluminum housing, non-overloading type centrifugal wheel, inlet cone, factory mounted and wired motor and disconnect switch, and bird screen.

Electrical Contractor will provide disconnect switches and thermal overload protection for units with three phase motors.

Upblast units to have motor, bearings, and drives completely enclosed and isolated from the exhaust air stream with ventilation provided by outside air.

P A R T 3 - E X E C U T I O N

INSTALLATION

Install as shown on the drawings, as detailed, and according to manufacturer's installation instructions. On units provided with a drain connection, reduce drain connection down to ½" fitting and leave open.

Install thrust restraints in accordance with the requirements of Section 23 05 48.

CONSTRUCTION VERIFICATION ITEMS

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 01 91 01 in accordance with the procedures defined for construction verification checklists.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01.

END OF SECTION

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SECTION 23 37 13
DIFFUSERS, REGISTERS & GRILLES
BASED ON DFD MASTER SPECIFICATION DATED 7/11/2023

PART 1 - GENERAL

SCOPE

This section includes specifications for air terminal equipment. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Submittals
- Design Criteria

PART 2 - PRODUCTS
- Manufacturers
- Registers and Exhaust Grilles

PART 3 - EXECUTION
- Installation
- Construction Verification Items

RELATED WORK

Section 01 91 01 - Commissioning Process
Section 23 08 00 - Commissioning of HVAC
Section 23 31 00 - HVAC Ducts and Casings
Section 23 33 00 - Air Duct Accessories
Section 23 05 93 - Testing, Adjusting and Balancing for HVAC

REFERENCE

Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
UL 181 - Factory-Made Air Ducts and Connectors.
ARI-ADC Standard 880.

QUALITY ASSURANCE

Refer to division 1, General Conditions, Equals and Substitutions.

SUBMITTALS

Refer to division 1, General Conditions, Submittals.

Furnish submittal information including, but not limited to, the following:

- Manufacturer's name and model number
- Identification as referenced in the documents
- Capacities/ratings
- Materials of construction
- Sound ratings
- Dimensions
- Finish
- Color selection charts where applicable
- Manufacturer's installation instructions
- All other appropriate data

DESIGN CRITERIA

All performance data shall be based on tests conducted in accordance with Air Diffusion Council (ADC) Test Code 1062 GRD 84.

PART 2 - PRODUCTS

MANUFACTURERS
Acceptable manufacturers for specific products are listed under each item.

REGISTERS AND EXHAUST GRILLES
Carnes R, Greenheck XG-4000, Krueger 880, Metal Aire 4000, Nailor 51DH, Price 520 (supply) and 530 (return/exhaust), Shoemaker 900, Titus 300 (supply) and 350 (return/exhaust).

Aluminum unless otherwise indicated, with frame type appropriate to installation.

Register and grille sizes as shown on drawings and/or as scheduled.

White, baked enamel finish or powder coat finish, unless otherwise indicated.

Screw holes on surface counter sunk to accept recessed type screws.

Fixed blade (0 or 45 degree) core return and exhaust registers and grilles.

PART 3 - EXECUTION

INSTALLATION
Install grilles, registers and diffusers as shown on drawings and according to manufacturer's instructions.

Furnish diffusers with equalizing grids where it is not possible to maintain minimum 2 duct diameter straight duct into diffuser. Equalizing grids shall consist of individually adjustable vanes designed for equalizing airflow into diffuser neck and providing directional control of airflow.

Unless otherwise indicated, size ductwork drops to diffusers or grilles to match unit collar size.

Seal connections between ductwork drops and diffusers/grilles airtight.

Where diffusers, registers and grilles cannot be installed to avoid seeing inside duct, paint inside of duct with flat black paint to reduce visibility.

CONSTRUCTION VERIFICATION
Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01.

END OF SECTION