

DIVISION 23

SECTION 23 34 16

BOILER ROOM COMBUSTION AIR MAKEUP AND VENTILATION SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. For the Building No. 5 Boiler Plant, provide a boiler room combustion air makeup and ventilation system, including direct-driven makeup air units and belt-driven exhaust fans as specified herein, as shown on the Contract Drawings, and as needed for a complete and proper installation. The types of makeup air units and exhaust fans shall be as specified herein and as Scheduled on the Contract Drawings.
- B. The boiler room combustion air makeup and ventilation system shall be complete, including provision of all equipment, ductwork, piping, valves, fittings, appurtenances, materials, labor, accessories, specialties, variable frequency drives, electrical disconnect switches, automatic temperature controls, control wiring and devices, testing, adjusting, balancing and commissioning as necessary to provide a complete and fully operating system as specified under the Division 23 Specifications, and as shown on the Contract Drawings.

1.02 RELATED SECTIONS

- 1. Section 01 51 23 - Temporary Heating
- 2. Section 23 05 00 – Common Work Results For HVAC
- 3. Section 23 05 13 - Common Motor Requirements For HVAC Equipment
- 4. Section 23 05 23 - General Duty Valves For HVAC Piping
- 5. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment
- 6. Section 23 05 53 - Identification for HVAC Piping and Equipment
- 7. Section 23 05 93 - Testing, Adjusting and Balancing for HVAC
- 8. Section 23 07 00 - HVAC Insulation
- 9. Section 23 09 13 - Instrumentation and Control for HVAC
- 10. Section 23 09 14 - Natural Gas and CO Gas Leak Detection Equipment
- 11. Section 23 09 23 - Control Dampers
- 12. Section 23 09 24 - Steam Flow Meters
- 13. Section 23 22 13 - Steam and Condensate Heating Piping
- 14. Section 23 25 19 - Water Treatment for Steam System Feedwater
- 15. Section 23 31 13 - Metal Ducts
- 16. Section 23 33 00 - Air Duct Accessories
- 17. Section 23 34 16 - Boiler Room Combustion Air Makeup And Ventilation System
- 18. Section 23 51 00 - Chimney Liner
- 19. Section 23 51 16 - Prefabricated Breechings and Accessories
- 20. Section 23 51 23 - Gas Vents
- 21. Section 23 52 39 - Firetube Boilers
- 22. Section 23 53 12 - Vacuum Condensate Pumps

23. Section 23 53 13 - Boiler Feedwater Pumps

1.03 SUBMITTALS

A. Product Data

Submit manufacturer's product data for makeup air units and fans, including specifications, capacity ratings, motors, VFD's, electrical power requirements, fan performance curves with operating point clearly indicated, filters, non-freeze type steam heating coils, integral face-and-bypass-dampers and damper motor operators, filters, internal vibration isolation for MU units, MU unit cabinet casing construction and access sections and access doors coordinated with the locations of their associated architectural/structural maintenance access platforms, gages and finishes of materials, dimensions, weights, accessories furnished, suspension mounting installation details, and installation instructions. Coordinate with the specified requirements of Electrical Division 26, for provision of variable frequency drives for each MU Unit and EF Exhaust Fan.

B. Shop Drawings

Submit assembly-type shop drawings showing dimensions, required clearances, location, construction details, and field connection details.

C. Wiring Diagrams

Submit manufacturer's electrical requirements for power supply wiring to makeup air units and fan units. Submit manufacturer's wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field-installed.

D. Automatic Controls And Control Sequence Of Operation

Submit the Automatic Control Sequences Of Operation of MU Units and associated EF Exhaust Fans in strict conformance with the specified requirements of Section 230913, and as specified herein.

E. Submit for each makeup air unit and fan, complete performance curves showing Static Pressure vs CFM; HP vs CFM and Efficiency vs CFM. Curves shall show operation at the rated RPM and at 20% above and below the rated RPM. In addition, submit the noise rating in decibels (flat response without network), at the design operation point for each fan. Submit outlet velocity of makeup air units and the fans, and submit for the inline mixed-flow type fans the inlet and outlet sound power ratings for each of the eight octave bands, in units of dB re: 10⁻¹² Watts.

F. Furnish drawings indicating unit dimensions, required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.

- G. Submit performance report showing unit level performance data including: fan(s), motor(s), coil(s) and other functional components. Performance report shall also include unit casing performance.
- H. Submit operation and maintenance data, including instructions for lubrication, filter replacement, motor and drive replacement, and condensate pan cleaning; spare parts lists, and wiring diagrams.
- I. Submit air-handling unit performance ratings in accordance with ANSI/AHRI-430 (static pressure, airflow, fan speed, and fan brake horsepower).
- J. Submit makeup air unit static pressure profiles by component section.
- K. Submit coil ratings in accordance with AHRI-410 (capacities and pressure drops).
- L. Submit unweighted octave band MU Unit sound power for inlets and outlets rated in accordance with AHRI Standard 260. Provide eight data points, the first for the octave centered at 63 Hz, and the eighth centered at 8,000 Hz. Manufacturer shall not use sound estimates based on bare fan data (AMCA ratings), nor use calculations like the substitution method based on AHRI 260 tests of other MU unit products. Provide data for inlets and outlets as scheduled. Report unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.
- M. Submit MU Unit cabinet casing panel deflection at +/-8" WG, stated in terms of 'L/X' where 'L' is the casing panel length and 'X' is a constant provided by the AHU manufacturer.
- N. Submit MU Unit casing leakage rate at +/-8" WG, specified in terms of percentage of design airflow.
- O. Submit weight loads and distributions by component section.
- P. Submit product data for filter media, filter performance data, filter assembly, and filter frames.
- Q. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- R. Submit motor electrical characteristics.
- S. Maintenance Data

Submit maintenance instructions, including lubrication instructions, motor and drive replacement, and spare parts lists. Include this data, product data, Shop Drawings, and wiring diagrams in the maintenance manual in accordance with requirements of Division 1.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications

Firms regularly engaged in manufacture of packaged steam-heated makeup air units and inline mixed-flow fans, of capacities, types and sizes as scheduled and shown on the Contract Documents and as specified herein, whose products have been in satisfactory use in similar service for not less than 5 years.

B. All makeup air units and exhaust fans as specified under this Section shall be the products of a single manufacturer.

C. Codes and Standards

1. AMCA Compliance: Provide fans bearing the AMCA Certified Ratings Seal. Sound rate centrifugal fans in accordance with AMCA 300: Test Code for Sound Rating Air Moving Devices.
2. ASHRAE Compliance: Test and rate fans in accordance with ASHRAE 51 (AMCA 210): Laboratory Methods of Testing Fans for Rating.
3. UL Compliance: Provide fan electrical components which have been listed and labeled by UL.
4. AMCA 99 – Standard Handbook
5. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes
6. AMCA 500 – Test Methods for Louvers, Dampers, and Shutters
7. AMCA 611-95 – Methods of Testing Airflow Measurement Stations for Rating
8. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
9. ANSI/UL 900 – Test Performance of Air Filter Units
10. AHRI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment
11. AHRI 410 – Forced-Circulation Air Cooling and Air Heating Coils
12. ANSI/AHRI 430 – Performance Rating of Central-Station Air Handling Units
13. ASHRAE 52.1/52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
14. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality

15. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
16. ASTM-C 1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.
17. NFPA 70 – National Electric Code (conductors, equipment and raceways)
18. NFPA 90A – Installation of Air Conditioning and Ventilation Systems
19. SMACNA – HVAC Duct Construction Standards
20. UL-181 – Mold Growth and Humidity Test
21. UL-1995 – Standard for Safety for Heating and Cooling Equipment

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans and makeup air units with factory-installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers.
- B. Handle makeup air units and fans carefully to avoid damage to components, enclosures, and finish. Do not install damaged equipment or components; replace and return damaged equipment and/or components to their manufacturer.
- C. Store makeup air units and fans in clean dry place and protect from weather and construction debris and traffic.
- D. Comply with manufacturer's rigging and installation instructions for unloading makeup air units and fans and moving them to final installation location.

1.06 SITE CONDITIONS

- A. Examine the Drawings, visit the site, and as may be applicable, take measurements to make sure that the equipment will fit in the spaces allocated, and that the equipment can be brought through the passages and the doors of the rooms. Fans and makeup air units too large to pass through these passages and doorways shall be shipped "knocked down" and assembled on site.

1.07 MAINTENANCE

- A. Furnish to NYCHA, one spare set of belts for each belt-driven fan, and provide additional pulleys and sheaves (drive-assemblies) upon completion of the final air balancing.
- B. Furnish to NYCHA two spare sets of MERV-8 filters for each MU makeup air unit.

1.08 WARRANTY

- A. All equipment installations shall be warranted by the installing Contractor for a minimum of 12-months after either the date of installation, or from the date of Acceptance of Substantial Completion By NYCHA, whichever occurs later.
- B. Provide Makeup Air MU Units with a factory warranty for at least 18 months from date of shipment. Warranty shall cover manufacturer defects. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician. Warranty shall include factory-provided integral controls, as specified.

1.09 SYSTEM STARTUP

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- B. Comply with manufacturer's published and approved start-up requirements to ensure safe and correct operation and integrity of warranty.

PART 2 - PRODUCTS

2.01 BELT-DRIVEN MIXED-FLOW INLINE EXHAUST FANS, EF-1 & EF-2:

- A. Provide belt-driven mixed-flow inline fans of sizes and arrangement, and of performance, capacities, characteristics, and with accessories as specified herein and as scheduled on the Contract Drawings. Fan performance shall be rated at STP standard atmospheric pressure and temperature conditions (density 0.075 Lbm/ft³).
- B. Fan shall be capable of accommodating static pressure and flow variations of +/- 15% of scheduled values.
- C. Each fan shall be belt-driven in AMCA arrangement #9.
- D. Fan shall be factory provided with lifting lugs.
- E. After fabrication all carbon steel components shall be cleaned and chemically treated by a phosphatizing process to insure proper removal of grease, oil and scale. Fan shall then be coated with a minimum of 2-4 mils thickness of Permator (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey. Coating shall exceed 1,000-hour salt spray under ASTM B117 test method.
- F. Fan housing shall be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
- G. Tubular fan housing shall be completely welded and coated with a minimum of 2-to-4 mils thickness of Permator (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey. No uncoated steel parts will be allowed.

- H. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
- I. Mixed-flow fan housings shall include vanes to straighten airflow prior to exiting the fan discharge.
- J. Fans shall be factory provided with mounting system that allows for field rotation of the motor position. Bearing life shall not be reduced below specified level in different configurations. Fans shall accommodate suspension mounting without structural modifications to the fan.
- K. An access door shall be supplied for impeller inspection and service.
- L. OSHA compliant belt guard or motor cover shall be factory provided to completely cover the motor pulley and belt(s).
- M. Fan impeller shall be mixed-flow design. The impeller shall be electronically balanced both statically and dynamically to balance grade G6.3 per ANSI S2.19.
- N. Fan impeller shall be manufactured with contoured blade profiles. Impellers constructed of steel shall be coated with a minimum of 2-to-4 mils thickness of Permator (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey. Aluminum constructed impellers shall be mill finish.
- O. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
- P. Motors shall meet or exceed the minimum efficiency requirements of the 2020 New York City Energy Conservation Code, and the EISA (Energy Independence and Security Act) minimum required efficiencies. Motors shall be NEMA T-frame, 1800 RPM, Totally Enclosed Fan Cooled (TEFC) or Open Drip Proof (ODP) type, with a 1.15 service factor with across the line starting or 1.0 service factor when used with variable frequency drive (VFD) (as applicable).
- Q. Drive belts and sheaves shall be sized for 150% of the fan operating brake horsepower, and shall be readily and easily accessible for service, if required.
- R. Fan shaft shall be turned and polished steel that is sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class.
- S. Fan shaft bearings shall be Air Handling Quality. Bearings shall be heavy-duty grease lubricated, self-aligning ball or roller pillow block type.
- T. Air Handling Quality bearings shall be designed with low swivel torque to allow the outer race of the bearing to pivot or swivel within the cast pillow block. Bearings shall be 100% tested for noise and vibration by the manufacturer. Bearings shall be 100% tested to ensure the inner race diameter is within tolerance to prevent vibration.
- U. Bearings shall be selected for a minimum basic rating fatigue life (L-10) of 80,000 hours at maximum operating speed for each pressure class.
- V. Bearings shall have extended lube lines with Zerk fittings to allow for lubrication from the exterior of the fan.
- W. Manufacturers:

Subject to compliance with requirements, manufacturers offering belt-driven mixed-flow inline fans which may be incorporated in the work include, but are not limited to, the following, or approved equal:

Greenheck Corp. (Basis-of-Design)
Aerovent Corp.
Loren Cook Co.
New York Blower Co.
Twin City Fan Corp.

2.02 DIRECT-DRIVEN STEAM-HEATED MAKEUP AIR UNITS, MU-1, 2, 3 & 4:

- A. Manufacturer: Johnson Controls Corp. model "York Solution" (the basis-of-design model and manufacturer), or Trane Corp. model CSAA, or Temtrol model ITF, or approved equal.
- B. Makeup Air Units (MU) shall consists of a structural base, insulated casing, access doors, fans, motors, motor controls including VFD, coils, filters, face-and-bypass dampers and damper motor operators, controls, components and accessories, of capacities and electrical characteristics as scheduled and shown on the Contract Drawings, and as specified herein.
- C. Provide MU Units to meet the specified levels of performance and scheduled requirements including, but not limited to airflow, static pressure, heating capacity, electrical characteristics, sound, casing leakage, panel deflection and casing thermal performance.
- C. MU Units shall maintain structural integrity when casing wall panels are removed.
- D. Provide internal components and accessories as specified and scheduled. Components and accessories shall be installed by the MU Units' manufacturer in an ISO-9002 certified facility.
- E. Units shall be ship in one piece. Split units only where necessary for shipping and installation.
- F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.
- G. For MU Units' segments that must be broken-down (dismounted) to facilitate rigging and installation, such segments shall be disassembled and reassembled by the manufacturer's factory-trained and authorized service personnel.
- H. MU Units' Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.
- I. Ratings and Certifications:

1. MU Unit shall conform to AMCA 210 for fan performance ratings.
 2. MU Unit shall conform to E.T.L. standards. Unit shall be ETL listed.
 3. MU Unit sound ratings shall be reported in accordance with AHRI 260 for inlet and discharge sound power levels.
 4. MU Unit casing radiated sound ratings shall be reported in accordance with ISO 9614 parts 1&2 and ANSI S12.12.
 5. MU Unit shall conform to AHRI 410 for capacities, pressure drops, and selection procedures of air coils.
 6. MU Unit shall have airflow performance certified to ANSI/AHRI 430.
 7. Motors covered by the Federal Energy Policy Act (EPACT) shall meet EPACT requirements.
 8. MU Unit Face-And-Bypass Damper performance shall comply with AMCA 500.
 9. MU Units shall be ISO 9001 certified.
 10. MU Units shall be manufactured in an ISO 9002 certified facility.
 11. MU Units Filter media shall comply with ANSI/UL 900 listed Class I or Class II.
 12. MU Unit Control Wiring shall comply with NEC codes & ETL requirements.
- J. MU Units shall be provided with structural base rail under the full perimeter of the unit, formed from welded structural steel. Structural steel base rail shall be installed providing clearance for proper external trapping of drain pans and steam condensate. MU Units shall be provided with base rail and lifting lug system that does not require additional support for rigging. Factory-provide base rail lifting lugs at unit corners.
- K. MU Units cabinet casing construction shall not rely on the casing panels for structural integrity. Casing panels shall be 2" thick double-wall construction with thermal break. Thermal break shall be between interior and exterior liner of the panel assembly, and between the panel and casing framework. Provide casing with minimum thermal resistance (R-value) of 13 hr-ft²-°F/BTU. Exposed insulation is not acceptable. Casing panel insulation shall be injected polyurethane foam. Foam insulation shall be manufactured by EcoMate® or approved equal. Rigid foam board panels shall not be used. All exterior and interior casing panels (roof, wall, floor, access door) shall be made of G90 galvanized steel. Panel assembly shall meet UL standard 1995 for fire safety. Panel insulation shall comply with the requirements of NFPA 90A.

- L. Insulation system provided shall be resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338. Encapsulate insulation with sheet metal so that air does not contact insulation. Solid lined double-walled panels insulated with injected foam shall be hermetically sealed at each corner and around their entire perimeter to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall.
- M. MU Unit shall conform to ASHRAE Standard 111 Class 6 for casing leakage no more than 1% of design airflow at 1.25 times design static pressure up to a maximum of +8 inches w.g. in positive pressure sections and -8 inches w.g. in negative pressure sections down to a minimum of 50 CFM measurable leakage or 5,000 design CFM.
- N. Provide MU Unit wall panels and access doors that deflect no more than $L/240$ when subjected to 1.5 times design static pressure up to a maximum of +8 inches WG in positive pressure sections and -8 inches WG in negative pressure sections. 'L' is the panel-span length and ' $L/240$ ' is the deflection at panel midpoint. Provide MU Unit floors and roofs that deflect no more than $L/240$ when subjected to a 300 lb static load at mid-span. 'L' is the panel-span length and ' $L/240$ ' is the deflection at panel midpoint.
- O. Provide double wall access doors that meet requirements specified for the MU Units casing. Provide industrial-style stainless steel hinges that permit 180 degrees of door swing. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or "paw" latches are not acceptable. Provide each door with a single handle linked to multiple latching points or a separate handle for each latching point. Doors serving access segments shall have an interior latch handle. Provide access doors with a locking hasp to accommodate a lockout device. Access doors shall be located to provide clearance for pipe insulation, connectors, and accessories. Space shall allow a minimum of 90 degrees of door swing.
- P. Provide double-pane viewing windows. Windows shall be a non-condensing type consisting of a desiccant dehumidification layer. Minimum dimension shall be 3" x 8".
- Q. Steam Heating Coils shall meet or exceed performance scheduled on drawings. Steam Heating Coils shall be provided with performance certified in accordance with AHRI Standard 410 for coil capacity and pressure drop, wherever applicable. Coils circuits shall be designed such that the fluid velocity is within the range of certified rating conditions at design flow.
- R. Steam Heating Coils casing section shall accommodate full-face or reduced-face coils as scheduled. Face and bypass coil segments shall be provided with factory installed face-and-bypass dampers.
- S. Steam Heating Coils shall be built in their own full-perimeter frame. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. Casing

and support members shall not block finned area. Individual Steam Heating Coils shall be removable from the side of the MU Units.

- T. A single intermediate vertical coil support shall be provided on Steam Heating Coils with a finned length greater than 62." Two vertical supports shall be provided on coils with a finned length greater than 100," and three vertical supports on Steam Heating Coils with a finned length greater than 141."
- U. Gap between Steam Heating Coils stub-out connection and MU Units casing, shall be insulated with a spool-shaped sleeve grommet. Adhesive rings applied to the casing walls shall not be acceptable.
- V. Steam heating coils shall be capable of sustaining operation at up to 50 psig pressure and a corresponding saturated steam temperature of 298° F. Factory test steam coils with 325 psig compressed air under water. Dehydrate and seal coils prior to shipping.
- W. Steam heating coils shall be of "non-freeze" type construction, provided with a tube outer diameter (OD) of 1" and an inner distribution tube of 5/8" O.D. Circuit coils for gravity drain of condensate without trapping. Steam shall discharge in the direction of condensate flow to ensure even heat transfer across each tube.
- X. Steam coil headers shall be made of seamless copper or brass tubing. Pipe connections shall be steel or red brass. Header connections (tubes and piping connections) shall be silver-brazed or TIG welded. Continuous aluminum or copper fins shall be provided for coils with die-formed fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.010-inch thick.
- Y. MU Units shall be provided with fans as scheduled on the Contract Drawings. The fan section shall be provided with an access door on the drive side of the fan. Fans shall be provided with an inlet screen in the inlet of fan housing, and a cage on the discharge of the fan housing. The fan and motor assembly shall be mounted on a common adjustable base. This common base shall attach to factory-provided internal spring vibration isolators, rated for 1-inch deflection, which shall mount to the MU Unit's structural base-frame support channels. These channels shall span the MU Unit's floor and mount directly to the MU Unit's frame.
- Z. Bearings shall be of either the sealed permanently lubricated type, or of the serviceable type to facilitate periodic relubrication. Bearings requiring relubrication shall be factory provided with grease lines extended from the bearing to zerk-fittings mounted in an accessible location on the fan-support bracket on the motor drive side of the fan, or to the exterior of the unit [primary access side].
- AA. MU Unit fans shall be provided with bearings complying with ANSI/AFBMA 9 for fatigue life ratings and with an average life L10 of at least 200,000 hours, as scheduled.

- BB. Fans shall be of the "direct-driven" type.
- CC. Fan motors shall be built in accordance and comply with the latest standards of the NEMA and IEEE, and shall conform with the minimum energy efficiency requirements of the 2020 NYCECC. Fan motors shall be provided with a minimum service factor of 1.15, NEMA design ball bearing type, rated for continuous duty at full load in a 104°F [40°C] ambient, open drip proof (ODP) type, and suitable for use in variable frequency application per NEMA MG-1 Part 30.
- DD. Manufacturer shall factory-provide MU Units with UL or ETL listed fan-motor disconnects and associated components. Disconnects shall comply with applicable provisions of the National Electric Code. Fused or non-fused fan-motor disconnects shall be provided in NEMA 1 enclosures. Disconnects shall be mounted on the primary access side of the supply fan section. Disconnect shall be suitable for use as an OSHA lockout/tagout disconnect when applied in accordance with part IV, Department of Labor OSHA 29 CFR Part 1910, Control of Hazardous Energy Source (lockout/tagout): final rule. Disconnect handles shall be lockable in the "off" position with up to three padlocks. Switch mechanism shall be directly lockable in the "off" position via padlock when door is open. Disconnects shall be provided with integral ground lug. Provide two (2) #14 ground wires on 16A to 100A disconnects. Auxiliary contacts shall be provided as specified.
- EE. Manufacturer shall factory-provide MU Units with UL or ETL listed VFDs and associated components, as specified herein. The MU Units are designed to operate as "constant volume" air handling units. MU Unit VFD's shall be used only to facilitate ease of initial balancing and shall not be used to modulate MU unit capacity during operation. VFDs shall comply with applicable provisions of the National Electric Code. VFDs shall be mounted in a dedicated NEMA 1 compartment located on the primary access side of its associated fan section and wired VFD to motor. After unit installation, VFD shall be started and programmed by a factory trained and factory employed and authorized service technician. Unit(s) shall be provided with VFD Fused main disconnect.
- FF. VFD's shall be provided with harmonic distortion feedback protection, including Equivalent 5% impedance input line reactor and Integral RFI/EMI filtering to meet EMC EN61800-3 for First Environment
- GG. VFD's shall be provided with a user interface including the following features:
1. Thirty (30) Character multi-lingual alphanumeric display
 2. Parameter set-up and operating data
 3. Display data shall include:
 - a) output frequency (Hz)
 - b) speed (RPM)
 - c) motor current
 - d) calculated % motor torque
 - e) calculated motor power (kW)

- f) DC bus voltage
- g) output voltage
- h) heat sink temperature
- i) elapsed time meter (re-settable)
- j) kWh (re-settable)
- k) input / output terminal monitor
- l) PID actual value (feedback) & error
- m) fault text
- n) warning text
- o) scalable process variable display

HH. VFD's shall be provided with the following protection circuits:

- 1. over current
- 2. ground fault
- 3. over voltage
- 4. under voltage
- 5. over temperature
- 6. input power loss of phase
- 7. loss of reference/feedback
- 8. adjustable current limit regulator

II. VFD's shall be UL 508C approved for electronic motor overload (12t).

JJ. VFD's shall be provided with features for high input transient protection and surge suppression, including:

- 1. 4 MOV's ahead of diode bridge
- 2. 120 Joule rated 1600V diode module
- 3. Compliant with UL 1449 / ANSI 61.4

KK. VFD's shall be provided with the following communication features:

- 1. Two programmable analog inputs
- 2. Six programmable digital inputs
- 3. Two programmable analog output
- 4. Three programmable digital relay outputs
- 5. Modbus RTU Communications protocol
- 6. Adjustable filters on analog inputs and outputs
- 7. Input speed signals, including 4-20 mA and 0-10 VDC
- 8. Accel/Decel contacts [floating point control]

9. Auto restart [customer selectable and adjustable]
 10. Start/Stop options shall include 2 wire dry contact closure, application of input power, and application of reference signal (PID sleep/wake-up).
 11. Integrated control interface for Siemens FLN, Johnson N2, Modbus RTU, BACnet MS/TP or LONWorks over RS-485.
- LL. VFD's shall be capable of perform the following functions:
1. Pre-magnetization on start
 2. DC braking/hold at stop
 3. Ramp or coast to stop
 4. Seven preset speeds
 5. Three critical frequency lockout bands
 6. Start function shall include ramp, flying start, automatic torque boost, and automatic torque boost with flying start
- MM. In addition to motor power terminals, MU units shall be provided with an independent power terminal for convenience receptacles and lights. On the supply fan section, a 120 Volt convenience receptacle shall be provided.
- NN. MU Units shall be provided with flat filter sections consisting of 2-inch thick pleated throwaway 30% efficiency / MERV-8 filters and frames as scheduled on the contract Drawings. Side loading filters for filter segments located upstream of coil sections shall be provided with an access door on the drive side through which filters can be easily loaded. Performance of installed filtration system shall be certified via a DOP test and classified as UL Class 1 when tested in accordance with UL Standard 586. Flush mounted, factory installed differential pressure gage on the drive side of unit shall be provided to measure pressure drop across filters. Manufacturer shall provide fully functional gauges, complete with tubing.
- OO. MU Units shall be factory provided with integral Face-and-Bypass Dampers, tested in accordance with AMCA 500. Dampers shall have airfoil blades, extruded vinyl edge seals, and flexible metal compressible jamb seals. Dampers shall have a maximum leakage rate of 4 CFM/square foot at 1" w.g., and shall comply with ASHRAE 90.1. Damper blades shall be of opposed-blade configuration. Damper blades shall be fabricated of ether galvanized steel or aluminum.

2.03 BOILER ROOM COMBUSTION AR MAKEUP AND VENTILATION SYSTEM CONTROL SEQUENCE OF OPERATION: MU-1, 2, 3 & 4 AND EF-1 & 2:

- A. The four makeup air unit supply fans shall be provided with VFD's with integral H-O-A switches, indexed to "Automatic" mode. The MU Units are designed to operate as "constant volume" air handling units, as specified. MU Unit VFD's

shall be used only to facilitate ease of initial balancing and shall not be used to modulate MU unit capacity during operation.

- B. The two exhaust fans shall be provided with VFD's with integral H-O-A switches, indexed to "Automatic" mode. The exhaust fans are designed as specified herein, to operate in either "100%-speed mode" or "50%-speed mode", via their VFD's.
- C. Each EF exhaust fan shall be provided with a discharge duct mounted two-position motorized isolation damper, as shown on the Contract drawings. Whenever the EF exhaust fan is started, its respective associated discharge motorized damper shall automatically open. Whenever the EF exhaust fan motor starter is de-energized, its respective associated discharge motorized damper shall automatically close.
- D. The four MU Units are each associated with two façade outdoor air intake louver mounted two-position motorized combustion and ventilation air intake dampers, as shown on the Contract Drawings. Whenever a makeup air unit is started, its respective associated pair of motorized intake air dampers shall automatically open. Whenever a makeup air unit motor starter is de-energized, its respective associated pair of motorized intake air dampers shall automatically close.
- E. At any time, the boiler plant lead/lag control system is specified to designate each of the four boiler-burners as the "Lead Boiler", "1st Lag Boiler", "2nd Lag Boiler" and "3rd Lag Boiler, respectively, and those designations are to be automatically rotated, on pre-programmed regular time intervals, to equalize runtime wear among the four boiler-burners. Each of the four Makeup Air (MU) Units shall be automatically interlocked to operate in unison with each of the four respective associated boiler-burners, as specified hereinbelow.
- F. The Temperature Controls Contractor (TCC) shall provide a lead/lag sequencer for the two EF exhaust fans that shall, at any time, automatically assign each of the two EF exhaust fans the designations of "Lead Exhaust Fan", and "Lag Exhaust Fan", respectively. The Lead/Lag designations of the two EF exhaust fans shall be automatically switched, alternately, once each week, so as to equalize runtime wear between the two EF exhaust fans.
- G. When the outdoor ambient temperature is above 65°F dry-bulb (adj.), as sensed by the master outdoor-air dry-bulb temperature sensor, wall-mounted on the North façade of Building No. 5, at elevation 10-feet above grade with sun-shield, the system shall be automatically indexed to the "summer mode". During the "summer mode", makeup air units MU-1, 2, 3 & 4 and exhaust fans EF-1 & 2 shall be off and their control circuits shall be de-energized.
- H. Upon a drop in outdoor ambient temperature below 60°F dry-bulb (adj.), as sensed by the master outdoor-air dry-bulb temperature sensor, and with all four boiler-burners, B-1, B-2, B-3 & B-4 momentarily "off-line", the makeup air units control circuits shall be automatically energized and enabled, the Lead Makeup

Air Unit (ie., the makeup air unit associated with the designated "Lead Boiler") shall automatically start and shall operate continuously at 100% speed, and the Lead Exhaust Fan shall automatically start and shall operate at 100% speed.

- I. Each of the four MU Units shall be automatically interlocked to operate in unison with each of the four respective associated boiler-burners, so that whenever a boiler-burner is started (whether via the boiler plant's lead/lag control system or via manual intervention), its respective associated makeup air unit shall automatically start. Upon a call for a boiler-burner to start, its respective associated makeup air unit shall automatically start. (Note here that the "Lead Makeup Air Unit" would already be required to be operating indexing of the system to the "winter mode" even before the "Lead Boiler" receives a call to fire from the boiler plant lead/lag controller.) Upon proof of makeup air unit startup, via a current sensing switch at the makeup air unit VFD, the boiler-burner control circuit shall then be allowed to start firing the boiler-burner.
- J. During the "winter mode" of operation:
 1. Upon a call for the "Lead Boiler" to start firing, via the boiler-plant's lead-lag controller, the "Lead Makeup Air Unit" shall continue to operate at 100%-Speed, and the "Lead Exhaust Fan" shall continue to operate and its VFD shall be automatically indexed to operate at 50%-Speed. The "Lag Exhaust Fan" shall be Off.
 2. Upon a call for the "First-Lag Boiler" to start firing, via the boiler-plant's lead-lag controller, the "First-Lag Makeup Air Unit" shall automatically start and shall operate at 100%-Speed, and the "Lead Exhaust Fan" VFD shall be automatically indexed to operate at "100% speed". The "Lag Exhaust Fan" shall remain "Off".
 3. Upon a call for the "Second-Lag Boiler" to start firing, via the boiler-plant's lead-lag controller, the "2nd Lag Makeup Air Unit" shall automatically start and shall operate at 100%-Speed, and the "Lag Exhaust Fan" shall automatically start with its VFD automatically indexed to operate at 50%-Speed.
 4. Upon a call for the "Third-Lag Boiler" to start firing, via the boiler-plant's lead-lag controller, the "3rd Lag Makeup Air Unit" shall automatically start and the "Lag Exhaust Fan" VFD shall be automatically indexed to operate at 100% speed.
 5. Upon a call for the "3rd Lag Boiler" to stop firing, via the boiler-plant's lead-lag controller, the "3rd Lag Makeup Air Unit" motor starter shall be automatically de-energized, and the "Lag Exhaust Fan" shall continue to operate with its VFD automatically indexed to operate at 50%-Speed.

6. Upon a call for the "2nd Lag Boiler" to stop firing, via the boiler-plant's lead-lag controller, the "2nd Lag Makeup Air Unit" motor starter shall be automatically de-energized, and the "Lag Exhaust Fan" shall automatically shut-down.
 7. Upon a call for the "1st Lag Boiler" to stop firing, via the boiler-plant's lead-lag controller, the "First-Lag Makeup Air Unit" motor starter shall be automatically de-energized, and the "Lead Exhaust Fan" VFD shall be automatically indexed to operate at 50%-Speed. The "Lag Exhaust Fan" shall remain "Off".
 8. Upon a call for the "Lead Boiler" to stop firing, via the boiler-plant's lead-lag controller, the "Lead Makeup Air Unit" shall continue to operate, and the "Lead Exhaust Fan" VFD shall continue to operate and shall be automatically indexed to operate at "100%-Speed".
- K. By design of the combustion air makeup ventilation system's air flow balance, a net positive pressurization will be maintained in the boiler room during the winter heating mode. During periods of boiler operation at less than 100% firing rates of on-line (firing) boilers, associated increases in the positive pressurization of the boiler room space shall be maintained within a preset limit by means of relief of excess supply air ventilation via a roof curb mounted ventilation relief air hood with inlet duct mounted manually adjustable counterweighted barometric relief air damper. Counterweight adjustment of the barometric relief air damper shall be manually adjusted to limit the positive pressure within the boiler room to a maximum of 0.10-inch WG.
- L. During the "winter mode", the makeup air units two-way modulating steam coil temperature control valve shall automatically modulate in sequence with the modulating face-and-bypass damper, to maintain 60°F (adj.) discharge air temperature, as sensed by the makeup air units steam preheat coil discharge air temperature sensor. The steam preheat control modulating temperature control valve and integral face-and-bypass dampers shall always be subject to override control of the low-limit freeze-protection discharge temperature controller, to maintain a low-limit freeze-protection discharge air temperature of 40°F.
- M. Low-Limit Freeze-Protection Controller: The makeup air units steam preheat coil discharge air stream mounted freeze protection thermostat with serpentine capillary sensing bulb shall be wired into the supply fan motor VFD and exhaust fan motor VFD's to override the normal operating discharge air temperature control of the face-and-bypass dampers and the modulating steam coil temperature control valve, and to automatically shut-down the supply fan and associated exhaust fans upon reaching its low-limit setpoint of 40°F (adj.). At the same time a local alarm signal shall be sent to the MU Units DDC controller and an alarm shall be displayed on the local MU Unit mounted operator display device. Once shut-down via the low-limit freeze-protection safety control, manual reset of the freeze protection thermostat shall be required to return the MU Unit to normal operation.

- N. Upon receipt of a fire alarm signal, the makeup air (MU) units shall automatically shut down via the Fire Alarm Control System. All control wiring from the Fire Alarm System to the MU units VFD's shall be provided as specified under Division 26, Fire Alarm/Electrical.
- O. There are four (4) duct-mounted smoke detectors, mounted in the discharge ductwork of each of the four (4) MU makeup air units in the Boiler Room of Bld'g. #5. All wiring to and from the smoke detectors shall be provided as specified under Div. 26 Fire Alarm/Electrical. Upon detection of smoke, as sensed by any one of the four (4) duct-mounted smoke detectors, the respective associated makeup air (MU) unit shall automatically shut down via the Fire Alarm Control Panel (FACP). Once shutdown via the FACP, after the fire alarm signal is cleared, the MU units shall require manual restart before resuming normal operation.
 - 1. Upon receipt of a fire alarm shutdown signal to any single makeup air (MU) unit via the FACP, the respective associated boiler-burner control circuit shall be automatically de-energized and disabled by an override shutdown control signal to be provided as specified under the Mechanical Div. 23. Once a boiler-burner is shutdown via the override shutdown signal and after the fire alarm signal is cleared and the respective associated makeup air (MU) unit has resumed normal operation, the boiler-burner control circuit shall be automatically re-enabled and re-energized.
- P. The Contractor shall coordinate the automatic temperature control and interlocking requirements for the (4) makeup air units (MU) and the (2) exhaust fans (EF) with the specified requirements of Section 23 53 29, "Firetube Boilers", for provision of seamless, fully coordinated, integrated and coherent interfaces and interlocks between the boiler plant lead/lag controller and the (4) makeup air units (MU) and the (2) exhaust fan (EF) units. The Contractor shall provide any control relays, sets of auxiliary contacts, interlocking control wiring and control power transformers and low-voltage 120-Volt or 24-Volt power sources as may be necessary to provide the automatic interlocking control interfaces as required under the control sequences of operation, as specified herein and under other Sections of Div. 23.

PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine areas and conditions under which makeup air units and fans are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to NYCHA.

3.02 INSTALLATION

- A. Install makeup air units and fans in the locations shown on the Drawings in

accordance with manufacturer's installation instructions, and with recognized industry practices, to ensure that makeup air units and fans comply with requirements.

B. Access

Provide access and service space around and over makeup air units and fans as indicated, but in no case less than that recommended by manufacturer.

C. Suspension Mounting Support And Vibration Isolation of Fans

Provide four (4), 3/8-inch diameter, galvanized steel threaded-rod suspension hangers, hex-nuts and lock-washers, with four (4) spring type vibration isolators of 2.0-inches rated deflection, for suspension mounting of fans from the underside of the building structural framing. Provide necessary supplemental galvanized steel support members for rigid attachment to the underside of building structural steel framing, for attachment and suspension of hanger rods. Fans shall be suspended only from the underside of building structural steel framing. The use of insert-anchor-bolts into the underside of the existing concrete slab above, will NOT be permitted.

D. Suspension Mounting Support of Makeup Air Units

Provide four (4), 3/8-inch diameter, galvanized steel threaded-rod suspension hangers, hex-nuts and lock-washers, for suspension mounting of makeup air units from the underside of the building structural framing. Provide necessary supplemental galvanized steel support members for rigid attachment to the underside of building structural steel framing, for attachment and suspension of hanger rods. Makeup air units shall be suspended only from the underside of building structural steel framing. The use of insert-anchor-bolts into the underside of the existing concrete slab above, will NOT be permitted.

E. Electrical Wiring

Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26. Ensure that rotation is in direction indicated and intended for proper performance. Do not proceed with centrifugal fan start-up until wiring installation is acceptable. Interlock wiring between fan units; and between fans and field-installed control devices. Provide control wiring between field-installed controls, indicating devices, and fan motor starters.

F. Controls

1. Provide automatic controls as specified under the "Instrumentation And Control For HVAC" Section 23 09 13 and as specified under this Section of the Contract Specifications.
2. The Contractor shall coordinate the automatic temperature control and interlocking requirements for the (4) makeup air units (MU) and the (2) exhaust fans (EF) with the specified requirements of Section 23 53 29, "Firetube Boilers", for provision of seamless, fully coordinated, integrated and coherent interfaces and interlocks between the boiler plant lead/lag controller and the (4) makeup air units (MU) and the (2) exhaust fan (EF) units. The Contractor shall provide any control relays, sets of auxiliary contacts, interlocking control wiring and control power transformers and low-voltage 120-Volt or 24-Volt power sources as may be necessary to provide the automatic interlocking control interfaces as required under the control sequences of operation, as specified herein and under other Sections of Div. 23.

G. Ductwork And Piping Connections

Refer to the Piping, Ductwork and Accessories Sections of the Contract Specifications. Provide flexible connections on inlet and outlet duct connections.

- H. Coordinate all trades to ensure that the installation of makeup air units and fans are not in conflict with the work performed of other trades.
- I. One complete set of filters shall be provided for testing, balancing, and commissioning of makeup air units. Provide a second complete set of filters at time of transfer to NYCHA.

3.03 MU UNITS INSTALLATION INSPECTION PRIOR TO STARTUP

- A. Enlist the services of the manufacturer's factory-trained and factory-employed authorized service technician to perform an inspection of MU units and their installation, prior to startup. Technician shall inspect and verify the following as a minimum:
 1. Damage of any kind
 2. Level installation of unit
 3. Proper reassembly and sealing of unit segments at shipping splits.
 4. Tight seal around perimeter of unit at the roof curb
 5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
 6. Completion and tightness of electrical, ductwork and piping
 7. Tight seals around wiring, conduit and piping penetrations through MU Units casing.

8. Supply of electricity from the building's permanent source
 9. Integrity of condensate trap for positive or negative pressure operation
 10. Condensate traps charged with water
 11. Removal of shipping bolts and shipping restraints
 12. Tightness and full motion range of damper linkages operate manually
 13. Complete installation of control system including end devices and wiring
 14. Cleanliness of MU Units interior and connecting ductwork
 15. Proper service and access clearances
 16. Proper installation of filters
 17. Filter gauge set to zero
- B. Resolve any non-compliant items prior to unit start-up.

3.04 INSPECTION AND ADJUSTMENT OF MU UNITS FAN ASSEMBLY PRIOR TO STARTUP

- A. Enlist the services of the manufacturer's factory-trained and factory-employed authorized service technician to perform an inspection of the MU Units fan assembly subsequent to general MU Units inspection and prior to startup. Technician shall inspect and verify the following as a minimum:
1. Fan isolation base and thrust restraint alignment
 2. Tight set screws on bearings and fan
 3. Tight fan bearing bolts
 4. Tight motor base and mounting bolts
 5. Blower wheel tight and aligned to fan shaft
 6. Fan discharge alignment with discharge opening
 7. Fan bearing lubrication
 8. Free rotation of moving components rotate manually
- B. Manufacturer shall dynamically balance fan/motor/base assembly.
1. Balance constant volume fan assemblies at design RPM.
 2. Balance variable volume fan assemblies from 10% to 100% of design RPM.
 3. Take filter-in measurements in the horizontal and vertical axes on the drive and opposite-drive sides of fan shafts.
 4. Constant speed fan vibration limits: filter-in measurements shall not exceed 4 mils.

5. Variable speed fan vibration limits: filter-in measurements shall not exceed 7 mils.
6. Manufacturer shall hi-pot test wiring intended to carry voltages greater than 30VAC.

3.05 MU UNITS MANUFACTURER'S STARTUP SERVICE AND OWNER TRAINING

- A. Enlist the services of the Manufacturer's factory-trained and factory-employed authorized service technician to supervise and perform startup of the MU Units. Technician shall perform the following steps as a minimum:
 1. Energize the unit disconnect switch
 2. Verify correct voltage, phases and cycles
 3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
 4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
 5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.
- B. Provide a minimum of 4 hours of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician. Training shall include MU Units controls, VFD, and MU Units.
- C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.
- D. For MU Units that are provided as specified with a factory-mounted variable frequency drive (VFD), enlist the services of the VFD manufacturer's factory-trained and factory-employed authorized service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.
- E. Submit a startup test report summarizing any problems found and remedies performed.

3.06 FIELD QUALITY CONTROL

- A. Upon completion of installation of makeup air units and fans, and after motor has been energized with normal power source, test equipment to demonstrate compliance. Where possible field correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment which cannot be satisfactorily corrected.

3.07 ADJUSTING AND CLEANING

- A. Start-up, test, and adjust makeup air units and fans in presence of manufacturer's authorized representative, and perform Testing, Adjusting and Balancing of the fan system in accordance with the specified requirements of Section 23 05 93 of the Contract Specifications.

- B. Clean unit interior of MU Units prior to operating. Remove tools, debris, dust and dirt. Clean exterior prior to transfer to NYCHA.

END OF SECTION

SAMPLE

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