SECTION 15503
RECIRCULATION AIR HANDLING UNITS - CLEANROOM

PART 1 - GENERAL

1.1 Related Documents

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

1.2 Summary

A. This Section specifies the requirements to furnish and install recirculation air handling units serving a controlled cleanroom environment, with the capacities, performance, and dimensions as shown on the contract drawings.

B. Work to be provided under this section includes furnishing, receiving, unloading, handling, erecting, installation, testing, and start-up of material equipment required for mechanical systems, complete in all respect as required by the contract documents.

C. The equipment specified in this Section is intended to assist in achieving a controlled Cleanroom environment. All materials, equipment, and fabrication methods shall be directed toward this objective. Care shall be used in the avoidance of paints, gaskets, seals, sealants, and other materials which outgas. Where outgassing is unavoidable, clearly identify products and base materials in all submittals. Substitutions of outgassing materials for materials of a different base content shall be provided at the Owner's request.

D. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for the referenced air-handling units.
1. Section 15050 – Piping Systems.
2. Section 15055 - Motors.
3. Division 15, Section 15106, “Chilled Water, Condenser, Water, Cooling Tower Water, Heating Hot Water, Condensate & Process Water piping, including Hydronic Specialties”.
4. Division 15, Section 15887, “HVAC Air Filters and Components.”
5. Division 15, Section 15990, “Testing, Adjusting, and Balancing.”
6. Division 16, Section 16441, “Disconnect Switches.”
7. Division 16, Section 16483, “Motor Control.”
8. Division 17, Section 17050, “I & C Basic Materials and Methods.”

E. In the event of conflict regarding requirements for the referenced air-handling units between this section and any other section, the most stringent provisions shall govern.

1.3 References

A. All products, materials, and installations included under this section shall adhere to and comply with all applicable codes, standards, ordinances, and regulations. Include with product data, information that certifies compliance with the following as applicable:
1. ANSI/AMCA 210-99, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
2. AMCA Standard 300-96, Reverberant Room Method for Sound Testing of Fans
3. ANSI/ARI 410-01, Forced-Circulation Air-Cooling and Air-Heating Coils

4. ANSI/ARI 430-99, Central Station Air Handling Units
5. ASTM A653-01, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
6. ASTM A167-99, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
7. ASTM B209-01, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
8. NFPA 70, National Electrical Code
9. NFPA 90A, Standard for the installation of Air conditioning and Ventilating Systems
10. NFPA 318, Standard for the protection of Cleanrooms
11. AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data."
12. AMCA 500 – (1991) Louvers, Dampers and Shutters.
13. UL 555S – (1996) “Leakage Rated Dampers for Use in Smoke Control Systems”.
14. UL 916 – (1994; “Bulletin 1994 and 1996, R 1996) Energy Management Equipment”.
15. UL 1995 – (1995) ”UL Standard for Safety Heating and Cooling Equipment”.

1.4 Submittals

A. General: Submit each item in this Article for approval according to the conditions of the Contract and General and Supplementary Conditions.

B. Product Data for each HVAC equipment listed in Section 1.2 A. and shall include the following:
1. Certified fan-performance curves with system operating conditions indicated.
2. Certified fan-sound power ratings.
3. Certified coil-performance ratings with system operating conditions indicated.
4. Motor ratings and electrical characteristics plus motor and fan accessories.
5. Material gages and finishes.
6. Filters with performance characteristics.
7. Dampers, including housings, linkages, and operators.
8. Smoke Detectors.
9. Equipment roof curb for flat equipment installation on sloping curb. Submit curb support details for A/E approval.

C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, and methods of field assembly, components, and location and size of each field connection.

D. Wiring diagrams detailing wiring for power and control systems, control interface differentiating between manufacturer-installed and field-installed wiring.

E. Coordination Drawings, including floor plans and sections drawn to scale. Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

F. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

G. Operating and Maintenance data: For air-handling units are to be included in the Operation and Maintenance (O&M) manuals as specified in General and Supplementary Conditions and Division 15 requirements.

1.5 Qualiity Insurance

A. NFPA Compliance: Air-handling equipments and components shall be designed, fabricated, and installed in compliance with NFPA 90A, “Installation of Air Conditioning and Ventilating Systems.”

B. AMCA Compliance for centrifugal fans: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. ARI Certification: Air-handling units and their components shall be factory tested according to the applicable portions of ARI 430, “Central-Station Air-Handling Units,” and shall be listed and bear the label of the Air-Conditioning and Refrigeration Institute (ARI).

D. UL and NEMA Compliance: Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards.

E. Comply with NFPA 70 for electrical components devices and accessories installation.

F. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.
1. The Terms “Listed” and “Labeled”: As defined in the National Electrical Code (NEC), Article 100.
2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulations 1910.7.

G. Coordination: Coordinate layout and installation of central-station air-handling units with piping and ductwork and with other installations.

1.6 Delivery, Storage, and Handling

A. Deliver air-handling unit as a factory-assembled module with protective crating and covering.

B. Lift and support units with manufacturer’s designated lifting or supporting points.

1.7 Extra Materials/Spare Parts

A. Provide two sets of filters and belts for each unit.

1.8 Sequencing and Scheduling

A. Coordinate size and location of concrete housekeeping bases. Drill concrete expansion anchors into base. Anchor points in accordance with manufacturers’ instructions.

B. Coordinate size and location of structural-steel support members.

1.9 Product Handling, Delivery and Storage

A. Shipping: Where possible for shipping and installation, units shall be shipped fully assembled. Where units must be shipped in sections, units shall ship in the fewest number of sections to meet project requirements. Each section shall be prepared as follows:

1. The entire fan unit, casing, and other accessories with contact to clean air shall be preliminarily cleaned in the factory after final assembly with 10 percent isopropyl alcohol (IPA), 90 percent DI water, and industrial cleaning fluids to remove all oil, residue, and dust. After the unit has been cleaned, shrink wrap in a non-PVC protective plastic bag 5 mils thick and heat seal all joints. After shrink wrap, the unit shall be wrapped and sealed in a Visqueen sheet prior to movement onto framing members. The wrapping shall provide protection so that the unit can be transported and stored without contamination of the cleaned unit.
2. Each cleaned and bagged unit shall then be strapped on top of a full-sized wood base constructed of a minimum 4-inch by 4-inch framing members to allow shipment and handling, without damage to the casework. Shipping base and pallet frame shall be suitable for forklift pickup and moving. The outside of the package or crate shall be adequately marked or tagged to indicate its contents, including equipment name, contract name and number, approximate weight, any special precautions for handling, and recommended requirements for storage prior to installation.

B. Final Cleaning Method: This procedure shall be followed upon completion of all field installation to occur within the unit. Remove all adhesives and manufacturing residue with IPA or other solvents using a low-lint cotton Cleanroom wiper. Any solvents used other than IPA must be approved in advance, and any areas cleaned with these other solvents must be re-cleaned with IPA. Vacuum all exterior surfaces first from top working to the bottom. Follow by vacuuming the interior surfaces, again top toward bottom. Vacuum shall be cleanroom compatible HEPA-filtered type, or house vacuum with exhaust outside the cleaning area. Portable units shall be outside the cleaning area, with extended hoses. Follow vacuuming with cleaning of exterior and interior with cleaning solution. The exterior shall be cleaned first, from top working to bottom. Exterior cleaning of units installed on roofs shall consist of pressure washing for removal of construction and atmospheric dirt. After exterior cleaning, clean the interior, top surfaces first, followed by the sides and then the bottom. Cleaning shall be performed with PVA cleanroom sponges, with cleaning solutions contained in stainless steel working containers. Use polyester wipes for drying. Only distilled water shall be used to dilute cleaning solutions and to rinse sponges. Solutions and water shall be changed as soon as they are visibly dirty. Sponges shall be changed when the outer surface becomes abraded. Following cleaning, the unit shall be first 100 percent visually inspected for contamination. Next the units shall be wipe-tested in a minimum of three locations on each subassembly. No dirt shall show on the cleanroom wipe after three circular wipes of an approximate 1 square-foot area of each tested location. Areas failing the wipe test shall be re-cleaned.

C. Delivery: Receive and unload air handling units to installation site. Owner and Contractor shall inspect air-handling units when they are received and immediately report any damage or shortage. Any units arriving at the installation site damaged beyond field repair to new condition shall be rejected and must be returned to the manufacturer for rework or replacement.

D. Storage: Air handling units which cannot be installed immediately after delivery shall be stored in a safe, dry location as directed by the Owner

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable Manufacturers:
1. Huntair

2. Cleanpak
3. Pace
4. Approved equal

B. Units shall be constructed and shipped in modules suitable for receipt through 7'-6" wide by 8'-0" high dock doors. Modules shall be supplied with a longitudinal galvanized steel structural perimeter base section that shall serve as a housekeeping rail when unit is installed. Perimeter lifting lugs for overhead lifting shall be provided. Each section of the unit base shall contain a minimum 1-inch NPT drain to facilitate system wash-down. All drains shall be positively sealed with threaded caps secured to the unit base with chains.

C. Galvanized materials shall be treated with cold galvanizing organic zinc-rich coating containing 95% metallic zinc, by weight in the dried film to prevent rusting at all broken or sawed edges.

D. Insulation Requirements: NFPA 90A, flame spread rating not over 25 and smoke developed rating not higher than 50 when tested according to ASTM E-84.

E. Design and assemble units to require only the external connecting of electrical power, connection of individual module sections, and ductwork to provide complete and operable systems.
1. For motor power connections, provide a junction box on the exterior wall of the unit with conduit routed from the junction box to the motor disconnect.

F. Factory install all internal components, conduits, electrical conductors, junction boxes, tubing, and piping.

2.2 CASING

A. Units shall be constructed of sectionalized heavy-gage, mill galvanized steel or aluminum formed panels, rigidly reinforced. Bolts and screws shall be stainless steel or aluminum rivets. Casing panels shall be of standing seam construction with seams turned inward to provide a smooth flush exterior. A continuous bead of silicone caulking shall be applied between matching panel seams and, following assembly, on both the exterior and interior panel seams to produce an air-tight unit.

~~B.~~Panels shall be 2” thick with 16-gauge galvanized steel or aluminum outer liner and 3 lb density rigid board scrim-reinforced aluminum foil faced insulation. Insulation shall be secured to casing with waterproof adhesive and permanent fasteners.

C. Access doors shall be of double wall construction and be installed on lift-off type stainless steel hinges for all outward opening applications. Hinge pins shall be welded to base plate. Multiple handles shall be provided. Handles shall be epoxy coated or stainless steel and rated to meet 500 hour salt spray requirements. Internal latches shall be stainless steel. Doors shall open against pressure and clear all internal and external components.

D. Equipment Isolation:

1. For equipment located on the roof of the cleanroom or in EVA sensitive areas (EVA= Emissions, Vibrations and Acoustics), provisions need to be made to prevent the transmission of mechanical vibrations from the equipment to the support structure. When necessary, an effective structural isolation break (SIB) shall be provided.

2. Structural Isolation Breaks shall be provide at specified locations to reduce coupling between vibration-sensitive areas and areas containing vibration-producing equipment, such as fans and pumps.
3. Install isolators for fans, pumps and other such equipment associated with the equipment package. Unless otherwise allowed by the Vibration Consultant, no equipment of more than three horsepower is to be attached to the structure without suitable vibration isolation. Where piping connects to such equipment, provide flexible connectors
4. Passive mechanical equipment such as heat exchangers, storage tanks, and expansion tanks do not require vibration isolation from the building structure.
5. All rotating equipment shall operate at speeds less than 80% of their true critical speed.
6. Pumps, fans, and other rotating equipment shall be tested after installation and under operating conditions. Vertical and horizontal vibration shall not be greater than the levels indicated. The vibration shall be measured on the equipment bearing caps when the equipment is mounted on its vibration isolation mounts. If the equipment has an inertia base, the allowable vibration level is reduced by the ratio of the equipment weight alone to the equipment weight plus inertia base weight. A balance report will be provided for each item of equipment.

Equipment Speed	Vibration Displacement (MILS) peak-to-peak
Under 600 rpm	**4**
600 to 1000 rpm	3
1000 to 2000 rpm	2
Over 2000 rpm	1

7. All vibration-isolation mounts shall be supplied by one of the following approved manufacturer's. Exception to this clause may be permitted in the case of internally isolated equipment with the explicit approval of the Contractor.
   a. Kinetics Noise and Control, Inc., Dublin, Ohio.
   b. Mason Industries, Inc., Hollis, New York.
   c. Amber/Boot Company, Houston, Texas.

2.3 FAN SECTION

A. Provide galvanized steel construction framed channel base for integral mounting of fan, motor and casing. Fan wheel, shaft, bearings, drives, and motor shall be mounted on a structural steel assembly which shall be isolated from the outer casing with factory installed 2-in. deflection spring isolators and vibration-absorbent fan-wall seal. Internally mounted motor shall be factory installed on slide rails having 2 adjusting screws. Provide a removable panel of adequate size to permit removal of the fan wheel, motor and drive.

B. Fans shall be direct-drive plenum or plug style, with backward curved airfoil section blades. Wheels shall be continuous welded all aluminum construction. Provide wire mesh protective wheel enclosure and heavy gauge wire inlet screen.

C. Fan wheels shall be keyed to shaft and be designed for continuous operation at the maximum rated fan speed and motor horsepower. Select fans and shafts to operate at least 25% below the first critical speed. Fan wheels and shafts shall be statically and dynamically balanced as an assembly. After final assembly, the entire unit shall be given final vibration test.

D. Bearings shall be self-aligning, pillow block re-greaseable ball types selected for an average life (AFBMA L-50) of 200,000 hours at design operating conditions. Bearings shall be equipped with Zerk fittings and lubrication lines extending through the unit casing. Shafts shall be solid steel, turned, ground and polished.

E. Motors shall be of voltage as shown on contract drawings, high efficiency type, for use with a Variable Frequency Drive. The fan motor shall be TEFC or TEAO with a minimum service factor of 1.15.

F. Variable frequency drive (VFD) provided by others. Provide conduit and conductors from fan motors to VFD mounting location if VFD is mounted on unit or through casing for remote VFD mounting.

G. Provide airflow measuring station as indicated on control drawings with signal transmitter mounted on unit casing outside.

2.4 COILS

A. Coils shall be of the cartridge type, removable from coil connection side of casing and supported in tracks over the entire length of the coil.

B. Chilled water coils shall be aluminum plate fins mechanically bonded to minimum 1/2" seamless copper tubing 0.02" minimum wall thickness. Headers shall be seamless copper with brazed coil connections. Coils shall be tested with 315 pounds air pressure under warm water and shall be suitable for operation at 250 psig working pressure. Coils shall be constructed for drainability. Casing shall be constructed of continuous galvanized steel compatible with slip out configuration. Provide alternate pricing for stainless steel casings.

C. Provide Dwyer Magnahelic Gauge complete with static pressure tips and accessories for indicating operational pressure drop of coil section. Gauges shall be mounted flush on outside of unit casing.

D. Condensate drain pan shall be stainless steel of double sloped construction with threaded drain connections on both sides and shall extend under the complete coil section of the unit.

2.5 AIR FILTERS

A. Air filters shall be provided with the unit. Minimum two sets of filters shall be provided: One set for construction phase, one set for system operation, second set of filters shall be installed after all ductwork is installed, cleaned and tested, and prior to final balancing.

B. Provide filters of make, size, arrangement, and efficiencies as scheduled on contract drawings.

C. Provide filter holding frames of minimum 16-gauge galvanized steel with vertical stiffeners, continuous gasket seal flange, and fasteners. Filter frames shall be installed and sealed to prevent any air leakage or bypass around the frames and arranged for front loading of the filters from the entering air plenum side.

D. Provide Dwyer Magnahelic gauge complete with static pressure tips and accessories for indicating the operating pressure drop of each filter bank. The indicating range of the gauge

shall be selected at twice the final resistance of the filter bank. Gauge shall be mounted flush on outside of unit casing.

2.6 Sound Attenuators

A. Sound attenuators shall be factory installed where shown on contract drawings.

B. Provide sound attenuators of make, model, and performance as scheduled on contract drawings.

C. Coordinate and comply with all installation requirements of the original humidifier manufacturer.

2.7 Accessories

A. Plenum sections shall be suitable for installation between any 2 components to provide a transition space between sections. All service plenums shall be fitted with manually opened, hinged, full-height access doors, interior lights, exterior light switch, and 120V outlets.

B. Each unit shall have all light circuits and outlets connected to and served from a single junction box. Minimum conductor size shall be 12 AWG. All conductors shall be copper. Provide a minimum of one light per section and two separate lights in the fan motor section. All lights shall be common circuited to three-way switches, open each end of unit.

PART 3 - EXECUTION

3.1 Examination

A. Examine areas and conditions to receive equipment, for compliance with installation tolerances and other conditions affecting performance of central-station air-handling units.

B. Examine roughing-in of steam, hydronic, condensate drainage piping, and electrical to verify actual locations of connections before installation.

C. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 Installation

A. Install all HVAC equipment, such as air-handling units, fans, heaters & coils, level and plumb, according to manufacturer's written instructions.
   1. Roof-Mounted Units: Support on dedicated roof curbs. Secure units to roof as required to meet the building seismic category performance.

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. Install suspended fan coil units in accordance with manufacturer's and SMACNA requirements.

3.3 Housekeeping Bases (Not applicable, all units mounted on roof curbs)

3.4 Connections

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specified connection requirements:
1. Install piping adjacent to machine to allow service and maintenance.
2. Connect condensate drain pans using 1-1/4 inch NPS (DN32), Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
3. Hot- and Chilled-Water Piping: Conform to applicable requirements of Division 15 Section 15106, “Chilled Water, Condenser, Water, Cooling Tower Water, Heating Hot Water, Condensate & Process Water piping, including Hydronic Specialties.”. Connect to supply and return coil tappings with shutoff or balancing valve and union or flange at each connection.
4. Refrigerant Liquid (RL) and Refrigerant (gas) Suction (RS) tubing specification connecting Outdoor and Indoor AC units shall be as per Section 15125, “DX Refrigerant piping System & Accessories.

B. Duct installation and connection requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangements of ducts and duct accessories. Make final duct connections with flexible connections.

C. Electrical: Conform to applicable requirements of Division 16 Sections.
1. Connect fan motors to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. When manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.
2. Temperature control wiring and interlock wiring is specified in Division 17.
3. Temperature control wiring and interlock wiring for the Center for Nanophase Materials Science (CNMS) is specified in Division 15, Section 15950 “ Direct Digital Control System.”

3.5 Adjusting

A. Adjust damper linkages for proper damper operation.

3.6 Cleaning

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

3.7 Commissioning

A. Manufacturer’s Field Inspection: Engage a factory-authorized service representative to perform the following:
1. Inspect field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.

2. Prepare a written report on findings and recommended corrective actions.

B. Final Checks before Startup: Perform the following before startup:
1. Verify that shipping, block, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and those connections for piping, ductwork, and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
6. Set zone dampers to fully open position for each zone.
7. Set face-and-bypass dampers to full face flow.
8. Set outside-air and return-air mixing dampers to minimum outside-air setting.
9. Comb coil fins for parallel orientation.
10. Install clean filters.
11. Verify that manual and automatic volume control, and fire and smoke dampers in connected ductwork systems are in fully open position.

C. Starting procedures for central-station air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
   a. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Refer to Division 15, Section 15990 “Testing, Adjusting, and Balancing” for air-handling system testing, adjusting, and balancing.

3.8 Demonstration

A. Engage the services of a factory-authorized service representative to train operating and maintenance personnel as identified by the Construction Manager (CM) on procedures and schedules related to operations, startup, shutdown, troubleshooting, servicing and preventative maintenance.
1. Review data in the Operation and Maintenance (O&M) manuals. Refer to closeout requirements in General and Supplementary General Conditions.
2. Schedule training with Construction Manager (CM), with at least 7 days’ advance notice.

END OF SECTION 15503