

SECTION 23 25 00  
HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies cleaning and treatment of circulating HVAC water systems, including the following.
1. Cleaning compounds.
  2. Chemical treatment for closed loop heat transfer systems.
  3. Chemical treatment for open loop systems.

1.2 RELATED WORK

- A. Test requirements and instructions on use of equipment/system: Section 01 00 00, GENERAL REQUIREMENTS.
- B. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Piping and valves: Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Technical Services: Provide the services of an experienced water treatment chemical engineer or technical representative to direct flushing, cleaning, pre-treatment, training, debugging, and acceptance testing operations; direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 12 service calls and written status reports. During this period perform monthly tests of the cooling tower for Legionella pneumophila and submit reports stating Legionella bacteria count per millimeter. These tests shall be conducted in a certified laboratory and not by a technician in the field. Minimum service during construction/start-up shall be 8 hours.
- C. Field Quality Control and Certified Laboratory Reports: During the one year guarantee period, the water treatment laboratory shall provide not less than 12 reports based on on-site periodic visits, as stated in paragraph 1.3.B, sample taking and testing, and review with VA personnel, of water treatment control for the previous period. In addition to field tests, the water treatment laboratory shall provide certified laboratory test reports. These monitoring reports shall assess chemical treatment accuracy, scale formation, fouling and corrosion control, and shall contain instructions for the correction of any out-of-control condition.
- D. Log Forms: Provide one year supply of preprinted water treatment test log forms.

#### 1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data including:
  - 1. Cleaning compounds and recommended procedures for their use.
  - 2. Chemical treatment for closed systems, including installation and operating instructions.
  - 3. Chemical treatment for open loop systems, including installation and operating instructions.
- C. Water analysis verification.
- D. Materials Safety Data Sheet for all proposed chemical compounds, based on U.S. Department of Labor Form No. L5B-005-4.
- E. Maintenance and operating instructions in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

#### 1.5 APPLICABLE PUBLICATIONS

- A. The publication listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):  
70-05            National Electric Code (NEC)

### PART 2 - PRODUCTS

#### 2.1 CLEANING COMPOUNDS

- A. Alkaline phosphate or non-phosphate detergent/surfactant/specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system wetted metals without deleterious effects.
- B. All chemicals to be acceptable for discharge to sanitary sewer.
- C. Refer to Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING, PART 3, for flushing and cleaning procedures.

#### 2.2 CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS

- A. Inhibitor: Provide sodium nitrite/borate, molybdate-based inhibitor or other approved proprietary compound suitable for make-up quality and make-up rate and which will cause or enhance bacteria/corrosion problems or mechanical seal failure due to excessive total dissolved solids. Shot feed manually. Maintain inhibitor residual as determined by water treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.

- B. pH Control: Inhibitor formulation shall include adequate buffer to maintain pH range of 8.0 to 10.5.
- C. Performance: Protect various wetted, coupled, materials of construction including ferrous, and red and yellow metals. Maintain system essentially free of scale, corrosion, and fouling. Corrosion rate of following metals shall not exceed specified mills per year penetration; ferrous, 0-2; brass, 0-1; copper, 0-1. Inhibitor shall be stable at equipment skin surface temperatures and bulk water temperatures of not less than 121 degrees C (250 degrees F) and 52 degrees C (125 degrees Fahrenheit) respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.
- D. Pot Feeder: By-pass type, complete with necessary shut off valves, drain and air release valves, and system connections, for introducing chemicals into system, cast iron or steel tank with funnel or large opening on top for easy chemical addition. Feeders shall be 18.9 L (five gallon) minimum capacity at 860 kPa (125 psig) minimum working pressure.
- E. Sidestream Water Filter for Closed Loop Systems: Stainless steel housing, and polypropylene filter media with stainless steel core. Filter media shall be compatible with antifreeze and water treatment chemicals used in the system. Replaceable filter cartridges for sediment removal service with minimum 20 micrometer particulate at 98 percent efficiency for approximately five (5) percent of system design flow rate. Filter cartridge shall have a maximum pressure drop of 13.8 kPa (2 psig) at design flow rate when clean, and maximum pressure drop of 172 kPa (25 psig) when dirty. A constant flow rate valve shall be provided in the piping to the filter. Inlet and outlet pressure gauges shall be provided to monitor filter condition.

## 2.3 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Delivery and Storage: Deliver all chemicals in manufacturer's sealed shipping containers. Store in designated space and protect from deleterious exposure and hazardous spills.
- B. Install equipment furnished by the chemical treatment supplier and charge systems according to the manufacturer's instructions and as directed by the Technical Representative.
  - 1. Provide a by-pass line around water meters and bleed off piping assembly. Provide ball valves to allow for bypassing, isolation, and servicing of components.
  - 2. Bleed off water piping with bleed off piping assembly shall be piped from pressure side of circulating water piping to a convenient drain. Bleed off connection to main circulating water piping shall be upstream of chemical injection nozzles.
  - 3. Provide DN 25 (1 IN) Schedule 80 PVC piping for the flow assembly piping to the main control panel and accessories.
    - a. The inlet piping shall connect to the discharge side of the circulating water pump.
    - b. The outlet piping shall connect to the water piping serving the cooling tower downstream of the heat source.
    - c. Provide inlet PVC wye strainer and PVC ball valves to isolate and service main control panel and accessories.

4. Install PVC injection nozzles with corporation stops in the water piping serving the cooling tower downstream of the heat source.
  5. Provide Schedule 80 PVC piping for corrosion monitor rack per manufacturer's installation instructions. Provide PVC ball valves to isolate and service rack.
  6. Provide Schedule 80 PVC piping for erosion chemical feeder per manufacturer's installation instructions. Provide PVC ball valves to isolate and service feeder.
  7. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.
- C. Before adding cleaning chemical to the closed system, all air handling coils and fan coil units should be isolated by closing the inlet and outlet valves and opening the bypass valves. This is done to prevent dirt and solids from lodging the coils.
- D. Do not valve in or operate system pumps until after system has been cleaned.
- E. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the by-pass valves. Also, clean all strainers.
- F. Perform tests and report results in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- G. After cleaning is complete, and water PH is acceptable to manufacturer of water treatment chemical, add manufacturer-recommended amount of chemicals to systems.
- H. Instruct VA personnel in system maintenance and operation in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

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SECTION 23 31 00  
HVAC DUCTS, CASINGS AND SILENCERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Ductwork and accessories for HVAC including the following:
  - 1. Supply air, return air, outside air, exhaust, and relief systems.
  - 2. Exhaust duct with HEPA filters for Autopsy Suite, Negative Pressure Isolation Rooms, Positive Pressure Isolation Rooms and other locations as shown on the drawings.
- B. Definitions:
  - 1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
  - 2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
  - 3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
  - 4. Exposed Duct: Exposed to view in a finished room, exposed to weather.

1.2 RELATED WORK

- A. Fire Stopping Material: Section 07 84 00, FIRESTOPPING.
- B. Outdoor and Exhaust Louvers: Section 08 90 00, LOUVERS AND VENTS.
- C. Kitchen Hoods: Section 11 40 00, COMMERCIAL-KITCHEN HOODS.
- D. Fume Hoods: Section 11 53 13, LABORATORY FUME HOODS.
- E. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- F. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- G. Duct Insulation: Section 23 07 11, HVAC INSULATION
- H. Dryer Vents: Section 23 35 15, CLOTHES DRYER AND KITCHEN RANGE EXHAUST.
- I. Air Flow Control Valves and Terminal Units: Section 23 36 00, AIR TERMINAL UNITS.
- J. Duct Mounted Coils: Section 23 82 16, AIR COILS.

- K. Custom Air Handling Units: Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- L. Packaged Air Handling Units: Section 23 73 13, PACKAGED INDOOR CENTRAL STATION AIR-HANDLING UNITS.
- M. Return Air and Exhaust Air Fans: Section 23 34 00, HVAC FANS.
- N. Air Filters and Filters' Efficiencies: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- O. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- P. Duct Mounted Instrumentation: Division 25, INTEGRATED AUTOMATION.
- Q. Smoke Detectors: Section 28 31 00, FIRE DETECTION AND ALARM.

### 1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fire Safety Code: Comply with NFPA 90A.
- C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.
- E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.
- F. **Factory made slip-on connections will not be permitted.**

### 1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
  - 1. Rectangular ducts:
    - a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
    - b. Sealants and gaskets.
    - c. Access doors.

2. Round and flat oval duct construction details:

- a. Manufacturer's details for duct fittings.
- b. Sealants and gaskets.
- c. Access sections.
- d. Installation instructions.

- 3. Volume dampers, back draft dampers.
- 4. Upper hanger attachments.
- 5. Fire dampers, fire doors, and smoke dampers with installation instructions.
- 6. Sound attenuators, including pressure drop and acoustic performance.
- 7. Flexible ducts and clamps, with manufacturer's installation instructions.
- 8. Flexible connections.
- 9. Instrument test fittings.
- 10. Details and design analysis of alternate or optional duct systems.

- C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Moving and Conditioning Association (AMCA):
- 500D-98.....Laboratory Method of Testing Dampers for Rating
  - 500L-99 .....Laboratory Method of Testing Louvers for Rating
- C. American Society for Testing and Materials (ASTM):
- A167-99.....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
  - A653-01 .....Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process
  - A1011-02.....Standard Specification for Steel Sheet and Strip Hot rolled Carbon structural, High-Strength Low-Alloy and High Strength Low-Alloy with Improved Formability
  - B209-01 .....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
  - C1071-00.....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
  - E84-01 .....Standard Test Method for Surface Burning Characteristics of Building Materials
- D. National Fire Protection Association (NFPA):
- 90A-99.....Standard for the Installation of Air Conditioning and Ventilating Systems
  - 96-01.....Ventilation Control and Fire Protection of Commercial Cooking Operations
- E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
- 2nd Edition – 1995.....HVAC Duct Construction Standards, Metal and Flexible
  - 1st Edition, 1985.....HVAC Air Duct Leakage Test Manual

- F. Underwriters Laboratories, Inc. (UL):
- 33-93.....UL Standard for Safety Heat Responsive Links for Fire Protection Service
  - 181-96 .....UL Standard for Safety Factory-Made Air Ducts and Connectors
  - 555-02 .....Fire Dampers
  - 555S-02 .....Smoke Dampers

## PART 2 - PRODUCTS

### 2.1 SHEET METAL WORK

#### A. General

1. All ducts and fittings shall be manufactured by a sheet metal fabrication company whose primary business experience is the manufacture of commercial and industrial quality ducts and fittings. Sheet Metal Contractor shall have adequate experience of building ductwork of the types required for this project as well as successful experience with projects of similar scope. Bids from sheet metal shops which do not meet the specified requirements shall not be acceptable.
  - a. Sheet Metal Accessories shall be provided as follows:
    - 1) Access Doors
    - 2) Flexible Connectors
    - 3) Flexible Ductwork
    - 4) Fire Dampers
    - 5) Fire/Smoke Dampers
    - 6) Smoke Dampers
    - 7) Automatic Dampers
    - 8) Balancing Dampers
2. Unless otherwise noted, all supply, return and exhaust air ductwork of all types shall be constructed of galvanized sheet metal based on the "Pressure Class" indicated in the "Minimum SMACNA Construction Standards" table found hereinafter.
3. The drawings are diagrammatic and indicate the arrangements of the principal apparatus, ductwork and piping and shall be followed as closely as possible. Because of the scale of the drawings, it is not possible to show all offsets, rises, drops, rises, fittings, accessories, etc. The Contractor shall carefully investigate the structure, finish conditions, and the work of other trades affecting the work and arrange ductwork, piping, equipment, accessories, etc. accordingly. Provide the best possible arrangement so as to provide the maximum headroom and access to apparatus while providing the minimum resistance to airflow. This work and any extra fittings and offsets required shall be included in the project without extra charge.
4. In addition to sheet metal ductwork provided under this Contract furnish and/or install accessories and devices furnished by others, including but not limited to smoke detectors. Provide and install miscellaneous sheet metal work including safing and mixing baffles.
5. All duct systems specified to be installed under this Contract, shall conform to the drawings, specifications, Standards, details and recommendations of the latest Edition of SMACNA "HVAC Duct Construction Standards - Metal and Flexible"; and "Round and Industrial Duct Construction Standards" (hereinafter referred to as Duct Manual).



Where the requirements under this Section exceed the requirements of the Duct Manual, the specification shall govern. Wherever the word "should" appears, replace with the word "shall".

6. The Sheet Metal Contractor shall submit duct fabrication standards and methods of installation, in compliance with SMACNA and these specifications, for review and approval by the Architect, clearly indicating the combination of metal gauges and reinforcement intended for use for each pressure classification. Duct fabrication shall not be allowed until a satisfactory review of this Standard has been performed. MERELY SUBMITTING COPIES OF THE SMACNA PRESSURE CLASS TABLES DOES NOT COMPLY WITH THIS REQUIREMENT.
7. All galvanized steel sheet metal shall conform to ASTM A653/A653M (G-90) having not less than 1.25 oz. of zinc on each side of each square foot of sheet. All other duct materials shall be as hereinafter specified as applicable to this Contract.
8. The Sheet Metal Contractor shall install all duct mounted smoke detectors.
9. The Sheet Metal Contractor shall furnish and install all plenums with automatic or manual dampers attached to louvers.
10. The Sheet Metal Contractor shall provide enclosures for all structural columns penetrating or contained within plenums.
  - a. This sheet metal enclosure shall match plenum construction for:
    - 1) Pressure class.
    - 2) Leakage class.
    - 3) Material.
11. There will be no supply and/or return air system ductwork internally lined unless otherwise noted.
12. The Sheet Metal Contractor shall clean and provide temporary caps on all ductwork during installation to prevent dust, dirt and debris from entering ducts during construction, including during shipping, handling and storage in the field.
13. All shop applied fabrication labels shall be applied to the exterior of the ducts. The Sheet Metal Contractor shall remove any material applied to the inside of the ducts before installation.
14. All inline fans shall have companion flanges intake and discharge for removal for servicing.
15. Seal all joints to air terminal boxes and air valves in the field, including reheat coils and sound attenuators.

## 2.2 DUCT CONSTRUCTION

### A. Duct Construction Schedule

1. Refer to Ductwork drawings for minimum SMACNA Construction requirements.

## 2.3 ADDITIONAL CONSTRUCTION REQUIREMENTS

### A. Minimum Requirements

1. The minimum gage for any steel duct shall be 26 gage except when specified heavier or required to be heavier gage by SMACNA Construction Schedules.
2. The minimum gage for black steel kitchen exhaust ductwork shall be 16 gage.
3. The minimum gage for stainless steel kitchen exhaust ductwork shall be 18 gage.

4. The minimum thickness of any aluminum duct shall be 0.040".
  5. The minimum diameter of any tie rod shall be 1/2".
  6. The maximum tie rod spacing shall be 42" unless specifically engineered in accordance with the SMACNA Industrial Rectangular Duct Standard.
  7. When tie rods intersect, they shall be welded to each other.
  8. No ductwork shall be constructed to less than  $\pm 2$ " w.g. This means nothing is constructed to a standard between  $-2$ " w.g. and  $+2$ " w.g.
- B. All joints and seams in all ductwork and casings shall be sealed to SMACNA Seal Class "A". In finished areas, sealing compound shall be neatly applied to exposed ductwork and bands shall be provided over, to cover the sealant.
1. Some SMACNA constructions may not be suitable for the leakage classes specified even though they may meet the pressure class and should not be used.
  2. Seal class A Welded means all welded (i.e. transverse joints, longitudinal seams, spiral seams, fire dampers, volume dampers or any accessories) and in addition it means continuously welded.
  3. All sealants, adhesives and coatings shall be of approved kinds and qualities for each point of application, complying with recommendations for the use and storage.
  4. The method of installation and materials for sealing the ductwork shall be submitted by the Sheet Metal Contractor for review and approval by the Architect, as part of the ductwork construction standards and installation submittal.
- C. All longitudinal seams in all ductwork in excess of  $+2$ " w.g. or less than  $-2$ " w.g pressure class shall be made with formed Pittsburgh locks.
- D. Grooved seam/flat lock/pipe lock joining methods is restricted to 2" W.G. pressure class only.
- E. Button punch-snap lock seams are not to be used.
- F. Concealed stainless steel ductwork shall have an ASTM mill rolled No. 1 or No. 2 D finish. Exposed stainless steel ductwork shall have an ASTM mill rolled No. 2 B finish, or higher grade as required by the Architect, with all welds ground smooth and final brushed with stainless steel wire brushes. All welds on exposed stainless steel ductwork shall be free of stain, burn-through, or discoloration to the satisfaction of the Architect.
- G. Tie rods shall not be used in any plenum or large duct requiring internal access or use as an access pathway.
- H. All ductwork required to be removable shall be companion flanged SMACNA Type T-22 for ductwork constructed to SMACNA Metal Duct Standard and companion flanged in accordance with Industrial Standards for ductwork required to be constructed to Industrial Standards.
- I. Elbows
1. Radius elbows shall be used wherever possible. Where it is impossible or impractical to install a 1.5 times width to centerline radius of elbow (full radius elbow) lesser radii configurations shall be used, each with "radius-proportional" splitter vanes permanently installed within. No radius shall be less than 1.0 times the width. Provide square elbows in rectangular ducts with double thickness vanes with a minimum radius of 4 1/2". Square elbows may only be used when radius elbows will not fit and where specifically approved by the Architect prior to fabrication and/or as required by coordination shop drawings. All offsets shall be of the radius type.

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- J. Auxiliary drain pans.
1. Where indicated on the drawings, provide 1-1/2" deep auxiliary drain pans where indicated on the documents.
  2. Pans shall be 6" larger then equipment in all directions.
  3. Drains shall be piped to floor drains or utility sinks.
- K. Each duct mounted humidifier shall:
1. Be provided with a stainless steel drain pan
    - a. The minimum drain pan size when there are no obstructions shall be from 6 inches before leading face of the coil to a distance down stream from the leaving face to 6 inches beyond the humidifier manufactures absorption distance.
      - 1) Obstructions:
        - a) Coils.
        - b) Turning vanes.
        - c) Air cleaners.
        - d) Duct offsets greater then 15°.
        - e) Tie rods.
        - f) Anything in the air stream.
    - b. If obstructions are coils, eliminators, or evaporative media they may be located within the drain pan provided the drain pan extends to there drain pan requirements.
  2. Drain pan slope:
    - a. Pan shall slope at a minimum of 1/8 in. per foot from the horizontal towards the drain outlet.
    - b. Drain pan outlet shall be at the lowest point or points of the pan with sufficient size to prevent overflow under any normal expected operating condition.
    - c. Provide a seal trap in accordance with the contract detail and verify the trap will fit.
- L. Ducts Exposed to Weather
1. For all **supply and return** ducts exposed to weather, after all ducts and joints are sealed and tested as specified herein, apply all over and around the same areas of possible leakage (joints), an approved sealer system, so that ductwork outside the building shall be installed in a manner to result in less then 0.5 leakage class.
  2. Exposed **supply and return** ductwork shall be insulated and weather-protected by the Insulation Contractor after the installation is completed and tested.
- M. It is the intent of this specification to provide a duct system with minimum resistance to airflow. All take-offs shall be throated and transitions made as gradually as possible. Round take-offs from rectangular duct mains shall be made with bell-mouth connections of minimum 1" radius. "Bullhead" or sharp take-offs shall not be acceptable.

- N. In addition to SMACNA requirements, ductwork in return systems without boxes, ductwork in supply systems without boxes, ductwork in exhaust systems without boxes, ductwork in any Constant Volume System and/or ductwork downstream of VAV, supply, return or exhaust boxes or valves shall be provided with:
1. Volume dampers in all branch takeoffs and in all main branches and ducts of all ductwork systems (supply, return and exhaust) for properly regulating and balancing airflow to all terminal outlets, for all duct sizes, whether shown on the drawings or not.
    - a. Provide manual adjustable rectangular opposed blade dampers with factory installed locking hand quadrants extended 2" for all dampers installed in externally insulated duct.
  2. Provided with a means for remote adjustment
    - a. All balancing dampers that are:
      - 1) Inaccessible for adjustment, including those isolated by mechanical obstructions (e.g. piping, conduit, cable trays, other ductwork, etc.).
      - 2) Above drywall ceilings
      - 3) Above plaster ceilings
      - 4) Where specified
      - 5) Where noted on the drawings.
  3. Remote operators
    - a. Cable remote Operators shall be installed within the neck of the air device for access through the removable core of the air device.
      - 1) Provide Cable Control kit for remote, internally mounted, worm gear operator volume dampers.
        - a) Provide stainless steel cable and control wire.
    - b. Wireless remote balancing damper
      - 1) The adjustment mechanism hardware and installation shall in all cases conform to the project governing building codes.
      - 2) The Contractor shall provide air balancing dampers in primary and branch zones and serving individual air devices as indicated and/or specified in the contract documents.
        - a) Balancing dampers shall be located upstream from air outlets a *minimum* of six feet.
          - (1) In no instance shall any damper be installed:
            - (a) At supply diffuser necks
            - (b) At linear diffuser plenum inlets.
        - b) Ceiling access doors for balancing damper access shall not be allowed at any location without prior written approval of the architect.

- c) All balancing dampers that are inaccessible for adjustment, including those isolated by mechanical obstructions (e.g. piping, conduit, cable trays, other ductwork, etc.) shall be provided with a means for remote adjustment.
  - d) The damper-controller shall have a built-in test mechanism that, prior to installing the ceilings that will quickly and positively verify:
    - (1) That the installed dampers work correctly.
    - (2) With a clear visual indication at the controller.
  - e) The contractor shall indicate on the as-built duct drawings:
    - (1) The final location of all inaccessible air balancing dampers
    - (2) All remote connector locations.
  - f) The remote damper adjustment mechanism shall be the wireless controlled.
  - g) Total enclosure of components and cables
  - h) All above-ceiling components shall be plenum-rated with a minimum UL94-5VA classification.
    - (1) Power/signal cables to the actuators shall be easily extendable in "daisy chain" fashion in increments up to 150 feet.
  - i) When merging several actuators power/signal cables for control from a common location, remote panels shall be provided in the node capacity required, and with each tagged to its respective damper.
    - (1) When panels are located in public view, the look and finishes shall be approved by the architect.
- O. All rectangular dampers shall be opposed blade and each shall be controlled by an approved galvanized locking quadrant indicating the damper position, as detailed on the drawings.
- 1. Volume dampers installed into ductwork that is specified to be externally insulated shall have extended activator/handle rods with extension bracket such that adjustment of the damper handle will not disturb the insulation.
- P. Submit the sheet metal shop drawings to the Balancing Contractor of the project for his review and placement of dampers with the final balancing procedures and requirements in mind.
- 1. Coordinate the location and areas with the Balancing Contractor, and fabricate the ductwork system accordingly.
  - 2. Provide any and all balancing dampers required by the balancing contractor at no additional cost.
- Q. In addition to SMACNA requirements, all round ductwork, if used in lieu of rectangular supply and/or return/exhaust systems shall conform to SMACNA.
- 1. The use of flat oval ductwork shall be acceptable only with prior written approval of the Architect. **Note:** Flat oval shall not be used under negative pressure.
  - 2. Round duct shall be manufactured of spiral lock seam. Ductwork up to 12"Ø and 2" w.g. pressure class can be manufactured with longitudinal lock seams.
  - 3. All tees shall be conical.

4. All laterals shall be straight.
5. All taps through 10" diameter in size shall have a machine drawn entrance and all fittings shall have longitudinal seams, continuous-welded. Both sides of all welds shall be primed with zinc chromate.
6. All tap entrances shall be free of weld build-up.
7. Elbows in diameters 3" through 10" shall be 2-section stamped or pleated elbows. Larger elbows shall be gored construction. Elbows shall be fabricated to a centerline radius of 1.5 times the diameter. All gored elbows shall be fabricated according to the following schedule:

<u>Elbows</u>	<u># of Gores</u>
Up to 35°	2
36° to 71°	3
Over 71°	5

8. All field joints in diameters through 48" shall be made with a 2" long slip-fit or sleeve coupling provided assembly is not hindered. Ductwork over 48", and for all sizes where disassembly and removal is required, shall be joined with Vanstone or shop fabricated flanges.
9. All flanges and taps into spiral ducts shall be factory or shop fabricated and installed as hereinbefore specified. Shipment of loose flanges or taps for field installation shall be avoided.
10. All access doors for round duct shall be furnished by the access door manufacturer. Round duct access doors shall be of low leakage sandwich type suitable for systems up to 8" pressure, positive or negative. Round duct access doors shall be insulated.
11. Unless specifically noted otherwise or required by special constraints, all elbows on ductwork changing direction from vertical to horizontal shall be 1.5 times radius.

R. Intake, Relief and Exhaust Plenums

1. In addition to SMACNA requirements for duct construction by pressure class, sheet metal plenums connected to louvers shall meet the following exterior enclosure wind requirements as installed.
  - a. Design of plenums shall incorporate the wind load requirements of Section 01 83 16.13, EXTERIOR ENCLOSURE WIND REQUIREMENT.
  - b. Provide analysis data and calculations for the plenum support system signed and sealed by the qualified Professional Engineer responsible for their preparation.

2.4 SPECIAL EXHAUST SYSTEMS

- A. Canopy hoods shall be fabricated of 18 gauge welded 304 stainless steel with No. 2B finish. Canopy hoods shall have all welds ground and polished with stainless steel wire brushes. Welds shall be free of stains, burns or discoloration. Transition to the duct connection shall be a maximum angle of 45°. Duct work shall extend down to mounting height of hood.
- B. Exhaust stacks above roof shall be fabricated of minimum 18 gauge G90 galvanized steel, unless exhaust system required by Duct Construction Table to be fabricated of stainless steel. Galvanized steel exhaust stacks shall be primed and painted, with color as selected by the Architect. Stainless steel stacks shall be welded with a No. 2B finish. Unless noted otherwise, stacks above roof shall be supported using guy wires attached to roof in accordance with details, and as specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

## 2.5 SHOP APPLIED DUCT LINER

- A. Duct liner is not permitted.

## 2.6 ACCESS DOORS

- A. Provide access doors and frames in all supply, exhaust and return ductwork as required, to permit access to:

- 1. Automatic dampers
- 2. Fire dampers
- 3. In-duct coils
- 4. All plenums
- 5. In-duct humidifiers
- a. Provide sight doors
- 6. Other similar equipment
- 7. Fan Bearings enclosed in ducts.
- 8. Duct smoke Detectors

- a. Provide sight doors

- 9. For cleaning and inspection purposes
- 10. Where indicated on the drawings

- B. Door Size

- 1. Ductwork

- a. Minimum 16" x 12"
- b. In ducts smaller than 12" they shall be 20" x 6" less than duct width except:

- 1) Terminal Box heating coil door may be 10" x 6"

- c. Vacuum cleaning access door shall be 12" round. Doors will be provided by Mechanical Subcontractor for every fifty (50) foot for installation by Drywall Subcontractor.

- 2. Plenums

Pre-Bid RFI WP-09B-059.

- a. Shall be 20" x 56"

- 1) 18" x 45" door may be used only when 20" x 56" will not fit.

- b. Larger door shall be provided if required for equipment removal. Coordinate with equipment.

- C. Door Construction

- 1. Doors shall match material type and gauge of the duct system in which they are installed. This includes hardware such as bolts.
- 2. Minimum gauge shall be 20.

3. Pressure tested to  $\pm 15$ " wc
  - a. Leakage shall be zero at  $\pm 10$ " wg
4. Provide a neoprene gasketed around their entire perimeter.
5. Where sight doors are required, a wire reinforced safety glass shall be utilized.
  - a. All humidifiers
6. Insulated or lined ductwork shall have insulated door
7. Insulated plenums shall have insulated door
8. Insulated doors shall be double wall.
9. Insulation between the metal panels shall be of the same thickness as the duct or panel adjacent to the access doors.
10. Plenum access doors shall be hung on heavy hinges and shall be secured in the closed position by means of latches.
11. Ductwork access doors shall be clamp type with a retaining chain or cable.
12. Ductwork access doors shall be similar to a sandwich-type access door.
13. All plenum hinge doors shall be submitted with test (provide E leakage) data before approval.

D. Positive Pressure Relief Access Doors:

1. Shall be of the pressure relief (positive pressure) spring loaded type. Design shall incorporate self-closing spring latch or be complete with secure retainer chain and "D" handle.
2. These doors shall be mounted downstream of air handling units, and set to relieve at 1 in. w.g. above normal operating pressure.
3. These doors shall be of the automatic reset type.

E. Kitchen Exhaust Access / Cleanout Doors

1. Access/cleanout doors in kitchen exhaust ductwork shall be bolted, gasketed, smoke and grease tight.
2. Fabrication shall conform to NFPA 96; International Mechanical Code; and local code in all respects.
3. The door shall be hinged or chained to the ductwork.

## 2.7 FLEXIBLE CONNECTIONS (AHUS, FANS)

A. Provide flexible connections of 4" minimum fabric width

1. Between ductwork and the inlets and outlets of all fans except:
  - a. Hazardous exhausts
  - b. Lab exhaust fans located indoors.
2. Equipment equipped with fans
3. All ductwork that crosses building expansion joints

B. The connections shall be placed as close to the equipment as practical except at fan suction connections and the clear gap at rest shall be not less than 3". At fan suction connections, locate flexible duct connection at least 3 duct diameters away from fan inlet connection.



- C. There shall be no tension of the fabric under static or dynamic loads
- D. All fabric for flexible duct connections to equipment shall be a minimum of 22 oz. glass fabric, double coated with neoprene, fire retardant, waterproof, airtight, and approved by UL.
- E. Exterior flexible connection shall be insulated type.
- F. Flexible connections shall be fabricated from approved flameproofed fabric conforming to NFPA 90A. Asbestos shall not be acceptable.
- G. Flexible connections shall be installed further upstream from fan powered equipment (in the main duct size) to prevent obstruction of the fan inlet due to suction of the fabric into the airstream.
- H. Ductwork shall be increased in size where the flexible connections are located to prevent fully drawn in connections from blocking any duct area. Submit detail for review.

## 2.8 BLANK OFF PANELS FOR UNUSED LOUVER AREAS

- A. Insulated louver blank-off panels shall be as specified in Section 08 90 00, LOUVERS AND VENTS.

## 2.9 FLEXIBLE DUCTWORK

### A. General

- 1. Flexible duct runs must not exceed 5'-0" in length. Flexible duct shall not exceed a maximum of 1/2" sag per linear foot when installed horizontally.
- 2. Flexible ductwork shall be supported at a maximum spacing of 2'-6", and as detailed on the drawings. Ductwork must not be compressed. Duct elbows must not exceed 45°.

### B. Flexible Duct (Rigid)

- 1. Flexible duct (insulated) shall be UL 181, Class 0 listed air duct and constructed in accordance with NFPA 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
- 2. Triple Lock Buck Duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock that is mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.
- 3. Insulated flex shall have a gray fire retardant polyethylene outer jacket with an 8 oz. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped.
- 4. The flexible duct shall be supported as required.
- 5. Flexible ductwork shall be rated at 12" positive pressure. Duct from 3" to 16" shall have a negative pressure 12" and duct from 18" to 20" shall have a negative pressure of 8".
- 6. All flexible duct shall be individually cartoned and labeled for delivery to the job site for maximum protection.
- 7. Provide:
  - a. Where indicated in construction greater than +2" or less than -2".
  - b. Upstream of supply boxes.
  - c. Downstream or upstream of exhaust boxes when allowed.

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C. Flexible Duct (Fabric)

1. Flexible duct shall be (insulated) shall be UL 181, Class 1 listed air duct and constructed in accordance with NFPA 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
2. Duct fabric shall be of a heavy duty coated fiberglass cloth fabric. The fabric material shall be mechanically locked to the outside helix. (Use of adhesives to lock fabric in place is unacceptable.) The helix is constructed of a corrosive-resistant galvanized steel, formed and mechanically locked to the duct fabric on the outside to prevent tearing of the flexible duct.
3. Insulated flex shall have a gray fire retardant polyethylene outer jacket with an 8 oz. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped.
4. The flexible duct shall be supported as required to prevent sagging. Flexible duct with excessive sagging will not be approved.
5. Flexible ductwork shall be rated at 12" positive pressure and 10" negative pressure. Negative pressure for 14"R and 16"R shall be 5" and negative pressure for 18"R shall be 1".
6. All flexible ducts shall be individually cartoned and labeled for delivery to the job site for maximum protection.
7. Provide:
  - a. Where indicated in  $\pm 2$ " duct construction, except exhaust.
  - b. Downstream of supply boxes.

2.10 2-HOUR FIRE RESISTANT DUCTWORK

- A. Prefabricated double wall, flanged duct system providing a two-hour fire resistance with a galvanized steel liner and galvanized steel impact resistant barrier.
  1. System shall be two-hour rated, "0" clearance, fire resistive duct and enclosure assemblies tested to ISO Standard 6944, Fire Resistance Tests – Ventilation Ducts. Each duct section shall bear the manufacturer's logo and UL label.
- B. 2-hour Duct system shall be constructed with a structural angle iron frame with an overall thickness of 3/8" (9.5 mm) using a mechanically bonded non-combustible rigid composite board material, consisting of a cementitious fiber-reinforced core, mechanically bonded to both inside liner and outside barrier.
- C. The fire resistant duct assembly shall not exceed a flame spread rating of 0.
- D. The fire resistant duct assembly shall not exceed a smoke development rating of 0.
- E. To gain the specified fire resistance rating, external insulation ductwork materials are not acceptable for use.
- F. Through-penetration firestopping materials:
  1. When the ventilation duct passes through a fire-rated floor or wall assembly, the through openings shall be firestopped in accordance with the manufacturer's requirements and UL Listing.
- G. The duct assembly shall be pressure tested to minimum 8" w.c. positive pressure of 6" w.c. negative pressure.

- H. Access doors in 2-hour fire rated ductwork shall be as furnished by the duct system manufacturer to maintain the 2-hour rating.

## 2.11 DAMPERS

### A. General

1. The minimum damper requirements shall be as indicated in the following table:

Damper Construction Table						
Type	Approach Velocity (FPM)	Pressure Rating	Instantaneous Pressure Rating	UL555S Leakage Class	Blade Type	Listing
Fire dampers in ducts greater than +2" w.g. or less than -2" w.g. (FD)	2,000	4"w.g.	10"w.g.	N/A	OBD 3V	UL555 Dynamic
Other fire dampers (FD)	2,000	4"w.g.	8"w.g.	N/A	Curtain or OBD	UL555 Dynamic
Fire smoke dampers in ducts greater than +2" w.g. or less than -2" w.g. and at all shafts (FSD)	3,000	4"w.g.	14"w.g.	I	Air Foil	UL555, UL555S Dynamic
Other fire smoke dampers (FSD)	2,000	4"w.g.	8"w.g.	I	OBD 3V	UL555, UL555S Dynamic
Smoke dampers (SD)	3,000	4"w.g.	14"w.g.	I	Air Foil	UL555S Dynamic
Isolation dampers (at units)	4,500	8"w.g.	20"w.g.	I	Air Foil	N/A
Automatic dampers (AD)	4,500	6"w.g.	14"w.g.	I	Air Foil	N/A
Balancing dampers in ducts wider than 48" and/or deeper than 12" (VD or as specified)	2,500	4"w.g.	N/A	N/A	OBD	N/A
Balancing damper in ducts less than 48" by 12" (VD or as specified)	2,500	2"	N/A	N/A	OBD	N/A

2. Dampers in stainless steel ducts shall be stainless steel.

### B. Automatic Dampers and AHU Isolation Dampers

1. Refer to Division 25, INTEGRATED AUTOMATION.
2. Refer to Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS, and Section 23 73 13, PACKAGED INDOOR CENTRAL-STATION AIR-HANDLING UNITS for dampers furnished with air handling units.
3. Actuators for all automatic dampers shall be as specified in Division 25.

### C. Fire Dampers, Ceiling Radiation Dampers, Smoke Dampers, and Combination Smoke/Fire Dampers

1. Fire dampers, smoke dampers and combination smoke/fire dampers shall be provided as shown on the drawings and wherever Architectural drawings indicate fire and/or smoke rated partitions.

- Devices shall be of the appropriate service for the partition class into which they are installed. Exact requirements and type of partition shall be coordinated with the Architect.
2. All dampers shall meet the requirements of NFPA 90A and further shall be tested, rated and labeled in accordance with UL 555 (6<sup>th</sup> Edition), UL555S (4<sup>th</sup> Edition) and UL555C (1<sup>st</sup> Edition).
  3. All dampers shall be tested, rated and labeled as "Dynamic Rated" for closure against airflow in the following configuration:
    - a. Vertical mount (horizontal airflow):  
Ducted and unducted.
    - b. Horizontal mount (airflow up):  
Ducted and unducted.
    - c. Horizontal mount (airflow down):  
Ducted and unducted.

**Note:** Static rated dampers shall not be allowed.

4. Each damper shall be rated to close against maximum design airflow at its installed location, with 400 fpm and .5 in wg. safety factors and against 4" w.g. maximum pressure across the closed damper.
5. All dampers of all ratings and types shall be of the nominal 100% face area type, with blade package and all frame components out of the airstream. These dampers shall include the required oversize enclosures which shall be sealed by the damper manufacturer for the appropriate duct pressure class into which they are installed. All such dampers shall have appropriate rectangular, flat oval or round duct collars to facilitate connection of mating ductwork. The Contractor shall be responsible for any additional sealing of duct collars and connections required to maintain the duct seal class requirements but shall not jeopardize the UL breakaway connection when utilized.
6. The Contractor shall indicate the location and rating of all dampers on his shop drawings and shall provide access doors at each location of sufficient size and type to permit access to the damper components. A list of fire dampers shall be provided for review. The Contractor shall be solely responsible to coordinate all locations of duct access doors and dampers of all types.
7. Contractor shall include damper manufacturer's installation instructions as part of the damper submittal. These instructions shall describe the applicable requirements for damper sleeve thickness; retaining angles; sealing; duct-to-sleeve connections; preparation of wall, floor or ceiling openings; and all other requirements to provide an installation equivalent to that tested by the damper manufacturer during the UL 555, UL555S and UL555C qualification procedures. Contractor shall detail any proposed installations that deviate from these manufacturer's instructions and explain the needed deviations. All fire, smoke and ceiling radiation damper installations shall comply with the manufacturer's installation instructions. Any submitted deviations must be acceptable to the appropriate authority having jurisdiction.
8. Fire Dampers
  - a. Fire dampers shall be provided as shown on the drawings and wherever Architectural drawings indicate fire-rated partitions to the following schedule:

Partition Assembly Fire Rating	Penetration Type	Damper Rating
1 Hour	Ducted and Sprinklered	No damper; duct sleeved and packed only
1 Hour	Ducted and Non- Sprinklered	1.5 Hour

Partition Assembly Fire Rating	Penetration Type	Damper Rating
1 Hour	Open (Transfer)	1.5 Hour
1.5 to 2 Hours	Ducted or Open	1.5 Hour
3 Hour	Ducted *	3.0 Hour
4 Hour	Ducted *	3.0 Hour
*No open transfer will be permitted through these partitions.		

- b. Fire damper sleeves shall be manufactured with a metal sleeve of appropriate length and thickness for the required damper installation as shown in the table below:

<u>Maximum Duct I.D.</u>	<u>Sleeve Gauge (U.S.)</u>
Up to 84"	20 gauge
85" & Up	18 gauge

- c. Fusible link temperature rating for all fire dampers shall be 212°F or 50°F above the highest system temperature, whichever is greater.
- d. Dampers in stainless steel ducts shall be stainless steel.
- e. Dampers located in welded systems shall be rigidly connected with welded connections (not breakaway).
- f. Large fire dampers may require motor operator to comply with code if this is required. Mechanical Contractor shall provide power and connections from electrical panel.

9. Smoke Dampers and Combination Fire/Smoke Dampers

- a. Smoke dampers and combination fire/smoke dampers shall be provided as shown on the drawings and wherever architectural drawings indicate smoke/fire rated partitions. Combination fire/smoke dampers shall be dynamically rated for 1.5 or 3 hours as determined by the Architect.
- b. Smoke dampers and combination fire/smoke dampers and actuators shall meet the requirements of NFPA 92A and NFPA 92B and further shall be tested, rated and labeled as a "Leakage Rated Damper for Use in Smoke Control Systems" in accordance with the 4th edition of UL 555S. All smoke dampers shall be of low leakage design qualified to UL 555S Leakage Class I (maximum leakage of 4 cfm/sq.ft. at 1" w.g. and 8 cfm/sq.ft. at 4" w.g.) and shall have a UL 555S elevated temperature rating of 350°F.
- 1) Each smoke damper/actuator combination shall be UL 555S rated to operate at maximum design airflow at its installed location with 400 fpm and .5 in wg. safety factors.
- c. Each smoke damper and combination fire/smoke damper shall be supplied with an appropriate damper actuator installed by the damper manufacturer at the time of damper fabrication. Combination fire/smoke dampers shall be manufactured with a metal sleeve of appropriate length and thickness for the required damper installation, and the damper actuator shall be installed on the sleeve exterior. Smoke dampers may be installed in ductwork up to 24" from wall with no openings between the wall and the smoke damper.
- 1) Damper actuators shall be electric type for 120 volt operation.

- 2) Power wiring, including interlocking to smoke detectors and fire alarm system, and panels to affect the sequence of operation shall be by the Electrical Contractor.
- 3) Dampers shall be fail closed as follows:
  - a) Power to Damper: Open
  - b) No Power to Damper: Closed
- d. Damper frame shall be galvanized steel formed into a structural hat channel shape with reinforced corners. The smoke and combination fire/smoke damper blades shall be airfoil type with Class 1 leakage rating. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Blade edge seals shall be silicone rubber designed to withstand 450°F (232°C) and jamb seals shall be stainless steel flexible metal compression type.
- e. Each damper shall be equipped with a remote open or closed position indication switch. The switch shall be over the shaft type using two independent rotary cams and adjustable switch points indicating open and closed positions. Switch can be factory or field applied to manufacturer's damper.
  - 1) These switches shall be furnished by the damper manufacturer and wired by the Electrical Contractor, in a location approved by the Architect.
  - 2) Spare contacts shall be provided for additional remote (fire panel) operation.
- f. Each combination fire/smoke damper shall also be equipped with a temperature limited re-openable feature providing the following operational sequence:
  - 1) Temperature at damper fusible device reaches 165°F or 50°F above highest system temperature, whichever is greatest, and primary heat sensing device closes damper. Remote or local override command panel can then re-open damper.
  - 2) If temperature at damper fusible device reaches 250°F, secondary heat sensing device will close the damper. Override and re-opening above this secondary temperature is not permitted. Both primary and secondary heat responsive devices shall incorporate a manual reset feature allowing restoration of normal operation after fire emergency has been cleared.
- g. If utilizing system operation for smoke control purposes during the early phase of a fire emergency, each combination fire/smoke damper shall be equipped with a 286°F primary fusible device and 350°F minimum rated damper actuator.
- h. Dampers in stainless steel ducts shall be stainless steel.
- i. Dampers located in welded systems shall be rigidly connected with welded connections (not breakaway).

Device	Furnished By	Installed By	Actuator By	Actuator Type	End Switches	Control Wires	Power	UL Assembly
Automatic Damper (AD)	Div. 25	Div. 23	Div. 25	Electric	Div. 25	Div. 25	Div. 25	No
Fire Smoke Damper (FSD)	Div. 23	Div. 23	Damper Manufacturer	Electric	Damper Manufacturer	Div. 28	Div. 28	Yes
Smoke Damper (SD)	Div. 23	Div. 23	Damper Manufacturer	Electric	Damper Manufacturer	Div. 28	Div. 28	Yes
Fire Damper (FD)	Div. 23	Div. 23	If Req'd Damper Manufacturer	If Req'd Electric	If Req'd Damper Manufacturer	N/A	If Req'd Div 23	Yes

## D. Elevator Hoistway Vent Dampers

1. Provide elevator hoistway vent dampers as shown on the drawings. Vent dampers shall comply with UL 555S and the aforementioned requirements for smoke dampers, except actuation shall be as follows:
  - a. Power to Damper: Closed
  - b. No Power to Damper: Open

## 2.12 SOUND ATTENUATING UNITS

## A. General

1. Silencers in aluminum systems shall be aluminum with all casing gauges adjusted accordingly.
2. Silencers in stainless steel systems shall be stainless steel.
3. Silencer in galvanized systems shall be galvanized steel.
4. Silencer in welded systems shall be continuously welded. See sheet metal section.
5. All gauges are based on steel. If aluminum is required equivalent strength aluminum gauges shall be used.

## B. Circular Silencers

1. All circular silencers shall be constructed with a casing of a minimum gauge noted below and minimum 22 gauge galvanized perforated internal liner. All casing seams and joints shall be lockformed and sealed or stitch welded and sealed except welded system shall be continuously welded.

<u>Casing Diameter</u>	<u>Casing Gauge</u>
a. Less than 30"	20
b. 30" to 54"	18
c. Over 54"	16

2. All packless circular silencers shall be constructed with a casing of a minimum gauge noted below and minimum 26 gauge perforated internal liner. All casing seams and joints shall be lockformed and sealed except welded systems shall be continuously welded.

<u>Connection Diameter</u>	<u>Casing Gauge</u>
a. Less than 18"	22
b. 18" to 30"	20
c. 30" to 54"	18
d. Over 54"	16

3. All welded silencers shall be a minimum of 16 gauge.

## C. Rectangular Silencers

1. All rectangular silencers shall be constructed with a casing of a minimum gauge noted below and minimum 22 gauge perforated internal liner.



All casing seams and joints shall be lock-formed and sealed except welded systems shall be continuously welded.

<u>Connection Dimension</u>	<u>Casing Gauge</u>
a. Less than 48"	22
b. Over 54"	Provide Calculations

2. All welded silencers shall be a minimum of 16 gauge.

D. Elbow Silencers

1. All elbow silencers shall be constructed with a minimum 18 gauge outer casing and minimum 22 gauge perforated internal liner. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48" shall have at least two half splitters and one full splitter.
2. All welded silencers shall be a minimum of 16 gauge.

E. Transitional Silencers

1. All transitional rectangular silencers shall be constructed with a minimum of 22 gauge outer casing and minimum 22 gauge perforated internal liner. Transitioning shall occur internal to the silencer such that the height of the gap or air passage is uniformly changing with the length of the splitters.
2. All welded silencers shall be a minimum of 16 gauge.

F. Acoustic Media

1. Dissipative and Film Lined silencers:
  - a. Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be bacteria and fungus resistant, resilient such that it will not crumble or break, and conforming to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.
2. Packless (No-Media silencers):
  - a. All No-Media silencers shall not contain absorptive media of any kind. Attenuation shall be achieved with controlled impedance membranes and broadly tuned resonators.

G. Media Protection

1. Dissipative silencers:
  - a. Where indicated on the silencer schedule, media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber. Axial Cone silencers shall have a glass fiber cloth liner.



## 2. Film Lined silencers:

- a. The acoustic media shall be completely wrapped with Tedlar film to help prevent shedding, erosion and impregnation of the glass fiber.
- b. The wrapped acoustic media shall be separated from the perforated metal by a factory installed ½" thick acoustically transparent spacer.
  - 1) The spacer shall be flame retardant and erosion resistant.
  - 2) A mesh, screen or corrugated perforated liner will not be acceptable as a substitute for the specified spacer.

## H. Combustion Ratings

## 1. Dissipative silencers:

- a. Silencer materials, including glass fiber shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.
  - 1) Flamespread Classification: 15
  - 2) Smoke Development Rating: 5

## I. Film Lined Silencers

1. Silencer materials, including glass fiber, Tedlar film and acoustical spacer shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.
  - a. Flamespread Classification: 20
  - b. Smoke Development Rating: 45

## J. HTL Casings (High Transmission Loss)

1. Where indicated on the silencer schedule, silencers shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality controlled transmission loss. The HTL walls shall consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls. If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to insure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

## 2.13 PREFABRICATED ROOF CURBS

- A. ~~Galvanized steel or extruded aluminum 300 mm (12 inches) above finish roof service, continuous welded corner seams, treated wood nailer, 40 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pound/cubic foot) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.~~ Refer to 23 05 11 – COMMON WORK RESULTS FOR HVAC

## 2.14 FIRESTOPPING MATERIAL

- A. Refer to Section 07 84 00, FIRESTOPPING.

## 2.15 THERMOMETER (AIR SENSORS)

- A. Refer to Division 25, INTEGRATED AUTOMATION.

## 2.16 INSTRUMENT TEST FITTINGS

- A. Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.
- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

~~2.17 LEAD COVERED DUCT (WHERE DUCTS PENETRATE LEAD LINED RADIOLOGY ROOMS)~~

- ~~A. Sheet Lead: 3.1 mm (1/8 inch) thick, securely installed, free of waves, lumps or wrinkles and with as few joints as possible.~~
- ~~B. Joints shall be made to obtain X-ray absorption equivalent to adjacent sheet lead, and finished smooth and neat.~~

## 2.18 ELECTROSTATIC SHIELDING

- A. At the point of penetration of shielded rooms ducts shall be made electrically discontinuous by means of a flexible, nonconductive connection outside shielded room.
- B. Metallic duct portion inside shielded room shall be electrically bonded to shielding.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.
- B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
  - 1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades.

- Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
  3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
  4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.
- C. Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.
- D. Install fire dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test.
- E. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.
- F. Sleeve and seal openings around duct penetrations of sound sensitive partitions as indicated on the drawings and as specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- G. Provide noise barrier duct wrap as indicated on the drawings and as specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC AND PIPING EQUIPMENT.
- H. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.
- I. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- J. Control Damper Installation:
1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
  2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
  3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
  4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

- K. Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.
- L. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Ductwork shall be fabricated and installed to meet the SMACNA Advanced Level of cleanliness. Ductwork shall be cleaned after fabrication, covered with plastic during shipment to the jobsite and while stored at the jobsite prior to installation. During construction, ductwork shall be stored off of the floor and at the end of each day all open ends of installed ductwork shall be covered with plastic.

### 3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Leak testing company shall be independent of the sheet metal company employed by General Contractor.
- B. Ductwork leak test shall be performed for the entire air distribution supply, return, exhaust system section by section including fans, coils and filter section designated as static pressure class 750 Pa (3 inch W.G.) and above. All supply ductwork less than 750 Pa (3 inch W.G) shall also be tested where there is no air terminal units employed in the system.
- C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.
- D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
- E. All tests shall be performed in the presence of the Resident Engineer and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the Resident Engineer and identify leakage source with excessive leakage.
- F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Resident Engineer.
- G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
- H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

### 3.3 DUCTWORK EXPOSED TO WIND VELOCITY

- A. Provide additional support and bracing to all ductwork exposed to outside wind velocity. Exposed ductwork shall withstand wind velocity of 130 mph. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Air handlers sheet metal plenums from louvers to shut-off dampers shall be provided with additional support and bracing to withstand wind velocity of 130 MPH.

## 3.4 TESTING, ADJUSTING AND BALANCING (TAB)

- A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

## 3.5 OPERATING AND PERFORMANCE TESTS

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

--- END ---

SECTION 23 34 00  
HVAC FANS

## PART 1 - GENERAL

## 1.1 DESCRIPTION

- A. Fans for heating, ventilating and air conditioning.
- B. Product Definitions: AMCA Publication 99, Standard I-66.

## 1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- E. Section 23 05 14, VARIABLE FREQUENCY DRIVES.
- F. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- G. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- H. Section 01 91 13, COMMISSIONING.
- I. Section 23 31 00, HVAC DUCTS, CASING AND SILENCERS.
- J. Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- K. Section 23 73 13, PACKAGED INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- L. Section 23 82 16, AIR COILS.
- M. Division 25, INTEGRATED AUTOMATION.
- N. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

## 1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fans and power ventilators shall be listed in the current edition of AMCA 26I, and shall bear the AMCA performance seal.

- C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).
- D. Fans and power ventilators shall comply with the following standards:
  - 1. Testing and Rating: AMCA 210.
  - 2. Sound Rating: AMCA 300.
- E. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- F. Performance Criteria:
  - 1. The fan schedule shall show the design air volume and static pressure. Select the fan motor HP by increasing the fan BHP by 10 percent to account for the drive losses and field conditions.
  - 2. Select the fan operating point as follows:
    - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point
    - b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency
- G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.
- H. Corrosion Protection:
  - 1. Except for fans in fume hood exhaust service, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.
  - 2. Fans for general purpose fume hoods, or chemical hoods, and radioisotope hoods shall be constructed of materials compatible with the chemicals being transported in the air through the fan.
  - 3. Building 6 Therapy Pool air handling unit fans shall have all surfaces in contact with the airstream provided with a minimum of two (2) coats for a minimum of (5) dry mil thick Phenolic coating.
- I. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

#### 1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturers Literature and Data:
  - 1. Fan sections, motors and drives.

2. Centrifugal fans, motors, drives, accessories and coatings.
  - a. In-line centrifugal fans.
  - b. Tubular Centrifugal Fans.
  - c. Up-blast kitchen hood exhaust fans.
  - d. Industrial fans.
  - e. Utility fans and vent sets.
  - f. Un-housed centrifugal (plenum) fans.
3. Prefabricated roof curbs.
4. Power roof and wall ventilators.
5. Propeller fans.
6. Mixed-flow fans.
7. Air curtain units.
- C. Certified Sound power levels for each fan.
- D. Motor ratings types, electrical characteristics and accessories.
- E. Roof curbs.
- F. Belt guards.
- G. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- H. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

#### 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Movement and Control Association International, Inc. (AMCA):
 

99-86.....	Standards Handbook
210-06.....	Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
261-09.....	Directory of Products Licensed to bear the AMCA Certified Ratings Seal - Published Annually
300-08 .....	Reverberant Room Method for Sound Testing of Fans
- C. American Society for Testing and Materials (ASTM):
 

B117-07a.....	Standard Practice for Operating Salt Spray (Fog) Apparatus
D1735-08.....	Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
D3359-08.....	Standard Test Methods for Measuring Adhesion by Tape Test
G152-06.....	Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials
G153-04.....	Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials



- D. National Fire Protection Association (NFPA):  
NFPA 96-08.....Standard for Ventilation Control and Fire Protection of  
Commercial Cooking Operations
- E. National Sanitation Foundation (NSF):  
37-07.....Air Curtains for Entrance Ways in Food and Food Service  
Establishments
- F. Underwriters Laboratories, Inc. (UL):  
181-2005 .....Factory Made Air Ducts and Air Connectors

## 1.6 EXTRA MATERIALS

- A. Provide one additional set of belts for all belt-driven fans.

## PART 2 - PRODUCTS

### 2.1 CENTRIFUGAL FANS

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE. Record factory vibration test results on the fan or furnish to the Contractor.
- B. Fan arrangement, unless noted or approved otherwise:
  - 1. DWDI fans: Arrangement 3.
  - 2. SWSI fans: Arrangement 1, 3, 9 or 10.
  - 3. Plenum fans: Arrangement 3 or 4.
- C. Construction: Wheel diameters and outlet areas shall be in accordance with AMCA standards.
  - 1. Housing: Low carbon steel, arc welded throughout, braced and supported by structural channel or angle iron to prevent vibration or pulsation, flanged outlet, inlet fully streamlined. Provide lifting clips, and casing drain. Provide manufacturer's standard access door. Provide 12.5 mm (1/2 inches) wire mesh screens for fan inlets without duct connections.
  - 2. Wheel: Steel plate with die formed blades welded or riveted in place, factory balanced statically and dynamically.
  - 3. Shaft: Designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fans class.
  - 4. Bearings: Heavy duty ball or roller type sized to produce a B10 life of not less than 50,000 hours, and an average fatigue life of 200,000 hours. Extend filled lubrication tubes for interior bearings or ducted units to outside of housing.
  - 5. Belts: Oil resistant, non-sparking and non-static.
  - 6. Belt Drives: Factory installed with final alignment belt adjustment made after installation.
  - 7. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15HP, fixed pitch for use with motors larger than 15HP. Select pulleys so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
  - 8. Motor, adjustable motor base, drive and guard: Furnish from factory with fan. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for specifications. Provide protective sheet metal enclosure for fans located outdoors.

9. Furnish variable speed fan motor controllers where shown on the drawings. Refer to Section, MOTOR STARTERS. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for controller/motor combination requirements.
- D. In-line Centrifugal Fans: In addition to the requirements of paragraphs A and 2.2.C3 thru 2.2.C9, provide minimum 18 Gauge galvanized steel housing with inlet and outlet flanges, backward inclined aluminum centrifugal fan wheel, bolted access door and supports as required. Motors shall be factory pre-wired to an external junction box.
- E. Tubular Centrifugal Fans: In addition to the requirements of paragraphs A and 2.2.C2 thru 2.2.C9 provide;
  1. Housings: Hot rolled steel, one-piece design, incorporating integral guide vanes, motor mounts, bolted access hatch and end flanges. Provide spun inlet bell and screen for unducted inlet and screen for unducted outlet. Provide welded steel, flanged inlet and outlet cones for ducted connection. Provide mounting legs or suspension brackets as required for support. Guide vanes shall straighten the discharge air pattern to provide linear flow.
- F. Industrial Fans: Use where scheduled or in lieu of centrifugal fans for low volume high static service. Construction specifications paragraphs A and C for centrifugal fans shall apply. Provide material handling flat blade type fan wheel.
- G. Utility Fans, Vent Sets and Small Capacity Fans: Class I design, arc welded housing, spun intake cone. Applicable construction specification, paragraphs A and C, for centrifugal fans shall apply for wheel diameters 300 mm (12 inches) and larger. Requirement for AMCA seal is waived for wheel diameters less than 300 mm (12 inches) and housings may be cast iron.
- H. Spark Resistant/Explosion Proof Fans: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), provide AMCA construction option: A, B or C as indicated. Drive set shall be comprised of non-static belts for use in an explosive atmosphere. Motor shall be explosion proof type if located in air stream.

## 2.2 PLENUM FAN ASSEMBLIES

### A. General

1. All fans shall meet the airflow performance specified and shall not exceed the break horsepower or sound power levels specified on the mechanical equipment schedule.
2. Fan performance shall be based on testing and be in accordance with AMCA Standards 210 and 300. All fans shall have a steep pressure/volume curve.
3. Fans shall be AMCA certified for air and sound performance.
4. Fan(s) shall be plenum type, designed for customized air handling unit airflow
5. Fans shall be AMCA arrangement as shown on drawings with airfoil blades, AISI C-1045 hot rolled steel turned/ground and polished shaft. Wheel and frame shall be of welded construction
6. Completed isolated assemblies shall be dynamically balanced in all 3 planes to category BV-3 for fans greater than 5 hp as required by ANSI/AMCA Standard 204 in the horizontal, vertical and axial planes meeting "Factory Filter In" and "Startup Filter Out" requirements.

7. Fans shall be single width airfoil centrifugal plenum type, designed for rugged industrial duty and suitable for continuous operation. All fans larger than 18" diameter shall have a minimum of 12 blades. Fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed.
  8. Fan shafts shall be solid AISI 1040 or 1045 steel. Shafts shall be turned, ground and polished to a minimum 16-micro-inch finish. Shafts shall be sized to run at a minimum of 20% greater than the maximum AMCA class speed.
  9. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades.
  10. All fan section access doors shall have one (1) latch, which requires a tool to open.
  11. Fans shall be isolated from bulkhead walls by means a neoprene coated flexible fabric connector.
- B. Motor
1. Motor shall be TEFC see Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
  2. Motors shall have a 1.15 service factor. [Motors shall be suitable for use with variable frequency drives].
- C. Drive
1. Provide direct drive as indicated.
- D. Bearings
1. Fan bearings shall be heavy-duty, pillow block, self-aligning ball or roller type, and grease lubricated. Using AFBMA ratings, bearings shall be selected for a minimum L-10 life of 100,000 hours. Both bearings shall have the same bore, type and manufacturer. At least one bearing shall be fixed. Both bearings being the floating type are not acceptable. Extended flexible lube lines shall be provided and extended to the drive side of the fan.
- E. Base
1. Fans shall be supplied with following features: with nominal deflection isolators, as indicated in Section 23 05 41 NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Fan manufacturer's standard paint finish.
  2. Fan assemblies shall be designed for heavy-duty industrial applications with no structural resonance occurring within the fan operating speed range when isolated. Fan framing assemblies shall be fabricated from structural steel. Formed members are not acceptable. This structural steel shall be welded together to form a rigid integral base. Fan assemblies shall be independently isolated with spring-type vibration isolators.
- F. Fan unloading devices
1. Each variable air volume supply and return fan shall have provisions for installation of separate variable frequency drives.

**G. Air Flow Measuring Stations**

1. Where indicated on the plans, fans shall be supplied with a complete flow measuring system capable of supplying a 4 – 20 mA. Output signal to the BAS system that is proportional to airflow. The flow measuring station and a flow transmitter shall be factory mounted.
2. The flow measuring station shall consist of piezometer ring type pressure tap pick-ups located in the inlet cone of each fan. There shall be no obstruction created on the inlet of the fan by installation of flow measuring device. Flow measuring stations installed in the inlet of fan will obstruct the fan inlet and will decrease fan efficiency and increase sound power levels.
3. Provide a gauge with CFM scale on external side of the fan sections, which indicates the fan volume.
4. The electronic flow transmitter shall be mounted on the exterior of the fan section. It shall be capable of receiving signals of total and static pressure from a flow element, of amplifying, extracting the square root, and scaling to produce a 4 – 20 mA or 0 – 5 VDC output signal linear and scaled to air volume or velocity.
5. The flow transmitter shall be capable of the following performance and application criteria.
  - a. Calibrated spans from 0 – 896 FPM, in eight flow range increments. Output signal 4 – 20 mA or 0 – 5 VDC standard. Integral zeroing means 3-way zeroing valve with manual switch. Temperature effect  $\pm 2.0\%$  of full span from 40° to 120°F.
  - b. The transmitter shall not be damaged by over-pressurization up to 200 times greater than span, and shall be furnished with a factory calibrated span and integral zeroing means. The transmitter shall be housed in a NEMA 12 enclosure with external signal tubing, power and output signal connections.

**2.3 POWER ROOF VENTILATOR**

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.
- B. Type: Centrifugal fan, backward inclined blades. Provide down-blast or up-blast type as indicated.
- C. Construction: Steel or aluminum, completely weatherproof, for curb mounting, exhaust cowl or entire drive assembly readily removable for servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self acting back draft damper. Provide electric motor operated damper where indicated.
- D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Bearings shall be pillow block ball type with a minimum L-50 life of 200,000 hours. Motor shall be located out of air stream.
- E. Prefabricated Roof Curb: As specified in paragraph 2.3 of this section.
- F. Up-blast Type: Top discharge exhaust, motor out of air stream. For kitchen hood exhaust applications, provide grease trough on base and threaded drain. The mounting height of the kitchen up-blast exhaust fan shall be in compliance with NFPA 96. (Provide vented curb extension if required to maintain required clearances.)

## 2.4 POWER WALL VENTILATOR

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.
- B. Type: Centrifugal fan, backward inclined blades.
- C. Construction: Steel or aluminum, completely weatherproof, for wall mounting, exhaust cowl or entire drive assembly readily removable for servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self acting back draft damper.
- D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Bearings shall be pillow block ball type with a minimum L-50 life of 200,000 hours. Motor shall be located out of air stream.

## 2.5 PROPELLER FANS

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.
- B. Belt-driven or direct-driven fans as indicated on drawings.
- C. Square steel panel, deep drawn venturi, arc welded to support arms and fan/motor support brackets, baked enamel finish. Provide wall collar for thru-wall installations.
- D. Motor, Motor Base and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Motor shall be totally enclosed type.
- E. Wall Shutter: Fan manufacturer's standard, steel frame, aluminum blades, heavy duty stall type electric damper motor, spring closed.
- F. Wire Safety Guards: Provide on exposed inlet and outlet.

## 2.6 MIXED FLOW FANS

- A. General
  - 1. Base fan performance at standard conditions (density 0.075 Lb/ft<sup>3</sup>).
  - 2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
  - 3. Each fan shall be belt drive in AMCA arrangement as shown on drawings.
  - 4. Fans are to be equipped with lifting lugs.
  - 5. After fabrication all carbon steel components shall be cleaned and chemically treated by a phosphatizing process to insure proper removal of grease, oil, scale, etc. Fan shall then be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be industrial gray. Coating must exceed 1,000-hour salt spray under ASTM B117 test method.
- B. Fan Housing and Outlet
  - 1. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.

2. Tubular fan housing shall be completely welded and coated with a minimum of 2-4 mils of Permator (Polyester Urethane), electrostatically applied and baked. Finish color shall be gray. No uncoated metal fan parts will be allowed.
3. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
4. All mixed flow housings shall include welded steel vanes to straighten airflow prior to exiting the fan discharge.
5. Units shall incorporate a universal mounting system that allows the fan to be mounted in either vertical or horizontal configurations and field rotation of the motor position in 90 degree increments. Bearing life shall not be reduced below specified level in different configurations.
6. An access door shall be supplied for impeller inspection and service.
7. OSHA compliant belt guard or motor cover to be included to completely cover the motor pulley and belt(s).

C. Fan Impeller

1. 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.
2. Fan impeller shall be manufactured with continuously welded steel airfoils and coated with a minimum of 2-4 mils of Permator (Polyester Urethane), electrostatically applied and baked. Finish color shall be industrial gray
3. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

D. Fan Motors and Drive

1. Motors shall meet or exceed EPACT (Energy Policy ACT) efficiencies. Motors to be NEMA T-frame, 1800, Totally Enclosed Fan Cooled (TEFC) with a 1.15 service factor.
2. 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.
3. Fan shaft to 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.
4. Fan shaft bearings shall be Air Handling Quality, bearings shall be heavy-duty grease lubricated, self-aligning or roller pillow block type.
5. Air Handling Quality bearings to 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 insure the inner race diameter is within tolerance to prevent vibration.
6. Bearings shall be selected for a basic rating fatigue life (L-10) of 80,000 hours at maximum operating speed for each pressure class II
7. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.
8. Bearings shall have extended lube lines with fittings to allow for lubrication.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install fan, motor and drive in accordance with manufacturer's instructions.
- B. Align fan and motor sheaves to allow belts to run true and straight.

- C. Bolt equipment to curbs with galvanized lag bolts.
- D. Install vibration control devices as shown on drawings and specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

### 3.2 PRE-OPERATION MAINTENANCE

- A. Lubricate bearings, pulleys, belts and other moving parts with manufacturer recommended lubricants.
- B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.
- C. Clean fan interiors to remove foreign material and construction dirt and dust.

### 3.3 START-UP AND INSTRUCTIONS

- A. Verify operation of motor, drive system and fan wheel according to the drawings and specifications.
- B. Check vibration and correct as necessary for air balance work.
- C. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

### 3.4 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

### 3.5 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

--- END ---

## SECTION 23 36 00

## AIR TERMINAL UNITS AND AIRFLOW CONTROL VALVES

## PART 1 - GENERAL

## 1.1 DESCRIPTION

- A. This section shall include specifications for supply, return and exhaust air terminal units (boxes), air flow control valve (AFCV) system, large volume and air flow control stations.

## 1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise requirements.
- C. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: Ducts and flexible connectors, Sound Attenuators.
- D. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Flow rates adjusting and balancing.
- E. Section 01 91 13, COMMISSIONING: Requirements for commissioning, readiness checklists, and training.
- F. Section 23 82 16, AIR COILS: Heating Coils.
- G. Division 25, INTEGRATED AUTOMATION: Terminal box operators.

## 1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.



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1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
  - 1. Air Terminal Units: Submit product data sheets indicating configuration, general assembly and materials used in fabrication. Submit performance test data for air flow, pressure drop and acoustical for all sizes being utilized.
  - 2. Air Flow Control Valves: Submit product data sheets indicating configuration, general assembly and materials used in fabrication. Submit performance test data for air flow, pressure drop and acoustical for all sizes being utilized.
  - 3. Large Volume Air Flow Control Stations: Submit product data sheets indicating configuration, general assembly and materials used in fabrication. Submit performance test data for air flow, pressure drop and acoustical for all sizes being utilized.
- C. Samples: Provide one typical Air Terminal Unit and one typical Air Flow Control Valve for approval by the Resident Engineer. This unit will be returned to the Contractor after all similar units have been shipped and deemed acceptable at the job site.
- D. Certificates:
  - 1. Compliance with paragraph, QUALITY ASSURANCE.
  - 2. Compliance with specified standards.
- E. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 78 23, GENERAL REQUIREMENTS.
- F. Submit installation requirements and instructions.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (AHRI)/(ARI):  
880-08 .....Air Terminals Addendum to ARI 888-98 incorporated into  
standard posted 15<sup>th</sup> December 2002
- C. National Fire Protection Association (NFPA):  
90A-09 .....Standard for the Installation of Air Conditioning and Ventilating  
Systems
- D. Underwriters Laboratories, Inc. (UL):  
181-08 .....Standard for Factory-Made Air Ducts and Air Connectors  
1995 .....Heating and Cooling Equipment
- E. American Society for Testing and Materials (ASTM):  
C 665-06 .....Standard Specification for Mineral-Fiber Blanket Thermal  
Insulation for Light Frame Construction and Manufactured  
Housing

- F. Sheet Metal and Air Conditioning Contractors national Association (SMACNA) – HVAC Duct Construction Standards – Metal and Flexible

## 1.6 GUARANTEE

- A. In accordance with the GENERAL CONDITIONS

## PART 2 - PRODUCTS

### 2.1 GENERAL

- A. Coils:

1. For air terminal units serving surgical suites, provide copper fins for reheat coils. ~~For all other air terminal units in high humidity areas, provide factory coated coils for protection from corrosion by using multiple stage electro-deposition coating process.~~ Refer to Drawings and Section 23 82 16, AIR COILS for additional coil requirements.
2. Water Heating Coils:
  - a. ARI certified, continuous aluminum or copper plate or spiral fin type, leak tested at 2070 kPa (300 PSI).
  - b. Capacity: As indicated, based on scheduled entering water temperature.
  - c. Headers: Copper.
  - d. Fins: Aluminum or Copper, maximum 315 fins per meter (8 fins per inch).
  - e. Tubes: Copper, arrange for counter-flow of heating water.
  - f. Water Flow Rate: Minimum 0.032 Liters/second (0.5 GPM).
  - g. Provide vent and drain connection at high and low point, respectively of each coil.
  - h. Coils shall be guaranteed to drain.
  - i. Coil shall be provided with a sheet metal casing, minimum 22 gauge, G90 sheet metal, insulated to a minimum of R-6. Coil shall be removable with access door upstream.

- B. Labeling: Control box shall be clearly marked with an identification label that lists such information as nominal CFM, maximum and minimum factory-set airflow limits, coil type and coil connection orientation, where applicable.
- C. Factory calibrate air terminal units to air flow rate indicated. All settings including maximum and minimum air flow shall be field adjustable.
- D. Air Terminal Box Sound Attenuators: Refer to Section 23 31 00, HVAC DUCTS, CASING AND SILENCERS.

### 2.2 AIR TERMINAL UNITS (BOXES)

- A. General: Factory built, pressure independent units, factory set-field adjustable air flow rate, suitable for single duct applications. Use of dual-duct air terminal units is not permitted. Clearly show on each unit the unit identification number matching the documents and factory set maximum and minimum air volumes corresponding to the contract drawings. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC work assumes factory set air volumes. Coordinate flow controller sequence and damper operation details with the drawings and

Division 25, INTEGRATED AUTOMATION. All air terminal units shall be brand new products of the same manufacturer.

- B. Capacity and Performance: The Maximum Capacity of a single terminal unit shall not exceed 960 Liters/second (2300 CFM) with the exception of operating rooms and large lobby/concourse areas, which shall be served by a single air terminal unit at a maximum of 1340 Liters/second (3,200 CFM).
- C. Sound Power Levels:
  - 1. Acoustic performance of the air terminal units shall be based on the design noise levels for the spaces stipulated in Section 23 05 41 (Noise and Vibration Control for HVAC Piping and Equipment). Equipment schedule shall show the sound power levels in all octave bands. Terminal sound attenuators shall be provided, as required, to meet the intent of the design.
- D. Casing: Unit casing shall be constructed of galvanized steel no lighter than 0.85 mm (22 Gauge). Air terminal units serving the operating rooms and Cystoscopy rooms shall be fabricated without lining. Provide hanger brackets for attachment of supports.
  - 1. Lining material: Suitable to provide required acoustic performance, thermal insulation and prevent sweating. Meet the requirements of NFPA 90A and comply with UL 181 for erosion as well as ASTM C 665 antimicrobial requirements. Insulation shall consist of 13 mm (1/2 IN) thick non-porous foil faced rigid fiberglass insulation of 4-lb/cu.ft, secured by full length galvanized steel z-strips which enclose and seal all edges. The minimum R-value shall be 4.6.  
Tape and adhesives shall not be used. Materials shall be non-friable with all surfaces, including all edges, fully encapsulated and faced with perforated metal or coated so that the air stream will not detach material. No lining material is permitted in the boxes serving operating rooms and Cystoscopy rooms. Insulation shall be secured to the terminal casing utilizing mechanical fasteners as well as adhesive.
  - 2. Access panels (or doors): Provide panels large enough for inspection, adjustment and maintenance without disconnecting ducts, and for cleaning heating coils attached to unit, even if there are no moving parts. Panels shall be insulated to same standards as the rest of the casing and shall be secured and gasketed airtight. It shall require no tool other than a screwdriver to remove.
  - 3. Total leakage from casing: Not to exceed 2 percent of the nominal capacity of the unit when subjected to a static pressure of 750 Pa (3 inch WG), with all outlets sealed shut and inlets fully open.
- E. Construct dampers and other internal devices of corrosion resisting materials which do not require lubrication or other periodic maintenance. Minimum thickness of damper blade shall be 20 gauge.
  - 1. Damper Leakage: Not greater than 2 percent of maximum rated capacity, when closed against inlet static pressure of 1 kPa (4 inch WG).
- F. Provide multi-point velocity pressure sensors with external pressure taps.
  - 1. Provide direct reading air flow rate table pasted to box.
  - 2. Provide a minimum of 12 sensing points along two axis, equally spaced.
  - 3. Provide two (2) separate multi-point sensors for terminal boxes larger than nominal 16 inch diameter inlet. Sensors shall be twinned together outside of inlet for a single velocity pressure signal.

- G. Provide static pressure tubes.
- H. Externally powered DDC variable air volume controller and damper actuator to be furnished under Division 25, INTEGRATED AUTOMATION for factory mounting on air terminal units. The DDC controller shall be electrically actuated.
1. Factory calibrate air terminals to air flow rate indicated on the documents. All settings, including maximum and minimum air flow shall be field adjustable. Provide air flow calibration chart on each terminal.
  2. The ATC Contractor shall be responsible for all costs associated with shipping the controls to the terminal box manufacturing facility. Box damper actuators, transformers and controller shall be installed by the box manufacturer. The box manufacturer shall factory mount and wire the controller and actuator in accordance with the ATC Contractor's instructions. Controller installation costs shall be borne by the airflow terminal box manufacturer. Box manufacturer shall provide velocity inlet probe and NEMA control cover. Controller and actuator specified in Division 25.
- I. Unit Performance
1. A assembly shall consist of valve, coil attenuator and transitions as called for on the documents
  2. The performance of the assembly shall be tested and certified.
    - a. Each box size shall be tested with:
      - 1) Coils
      - 2) Sound attenuators
      - 3) Box
      - 4) Each Flow configuration.
    - b. With an inlet static of 1 ½" w.g. at the system side of the supply box.
    - c. With an inlet static of -1 ½" w.g. at the system side of the exhaust box.
  3. These tests shall include the pressure lose of each component and the sound power levels in each octave band leaving the assembly.

## 2.3 AIR FLOW CONTROL VALVES (AFCV ) AND CONTROL SYSTEM

### A. General

1. A laboratory airflow control system shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust volume of a laboratory fume hood shall be precisely controlled by an Adaptive Face Velocity controller to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on actual hood usage. The laboratory control unit shall vary the amount of air into the room to maintain temperature control, minimum ventilation, airflow balance, and laboratory pressurization in relation to adjacent spaces (positive or negative). All laboratory airflow control systems devices shall be by a single manufacturer.
2. Manufacturer: The company manufacturing the products specified in this section shall have a minimum of ten years experience producing products of this type.

3. The contractor shall be responsible for any and all costs associated with any and all changes resulting from the use of a supplier other than the listed acceptable manufacturers.
4. Due to the life safety issues of this equipment, the manufacturer shall provide to the Owner during and after the warranty period, at no additional cost, five (5) years of preventative maintenance for products that incorporate airflow sensors (e.g., pitot tube, flow cross, air bar, hot wire, vortex shedder, etc.) and flow transducers. The laboratory controls manufacturer shall remove the airflow sensors quarterly during the five year period to inspect and clean them as to prevent inaccuracies due to long term build-up from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. The transducer shall be checked and recalibrated to insure long term accuracy.

B. System Performance Requirements

1. The laboratory airflow control system shall be fully stand-alone for each individual laboratory. The system shall not use or rely on information from controllers in other laboratory areas to control the functions within its laboratory.
2. The laboratory airflow control system shall employ individual Face Velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow in a variable volume mode to maintain a constant face velocity over a minimum range of 20 to 100% at full sash opening. Safety and energy savings shall be insured through a corresponding minimum change in hood exhaust flow of 5 to 1. Response time shall be less than one second with no more than a 5% volume deviation within one second of the sash reaching 90% of its final value with a full height sash movement of one second.
3. The laboratory airflow control system shall also maintain intersystem stability within one second of a change in pressure and/or flow to eliminate hunting, system oscillations, and crosstalk between airflow controllers.
4. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization and fume hood make-up air tracking. The system shall respond and maintain room pressurization (negative or positive) within one second of a change in room/system conditions.
5. The laboratory airflow control system shall maintain specific airflow ( $\pm 5\%$  of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change airflow change or quantity of airflow control devices on the manifold (within 0.6" to 3.0" wc).
6. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.
7. The laboratory airflow control system shall maintain specific airflow ( $\pm 5\%$  of signal) with a minimum 10 to 1 turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

C. Fume Hood Sash Components

1. A vertical sash sensor shall be provided to measure the height of each vertically moving fume sash consisting of a potentiometer wheel and cable. Cable shall be stainless steel with 3 mils of epoxy coating. Sensor potentiometer shall have proof of testing and life span of a million cycles or more. A horizontal sash sensor shall be provided for each pair of horizontal or overlapping sashes that are located on horizontal, combination, California, walk-in, or distillation type fume hoods. Sensors shall be magnetic bar type with bridge diodes and contacts.

All wiring shall be provided with a retractable cable and hidden from view. Control systems employing side-wall mounted velocity sensors are completely unacceptable.

2. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow setpoints to maintain a constant face velocity throughout this range. A minimum volume shall be set to ensure flow through the fume hood even with the sash totally closed.

D. Fume Hood Monitor with LED or Numerical Display

1. A fume hood monitor shall be provided to receive the sash opening signals from the vertical and or horizontal sash sensors. The monitor shall compute the total open sash area and then output an exhaust airflow control signal to the appropriate volume control device.
2. The face velocity and minimum exhaust flow level of the fume hood shall be set at the fume hood monitor via trimpot adjustments. Accurate adjustment of the face velocity shall be provided at two (2) different sash positions.
3. An emergency exhaust capability shall be provided to override the sash sensor and command maximum exhaust airflow. A push to start, push to stop, push-button switch shall initiate this mode.
4. A night energy waste alert circuit employing a light level sensor shall be included in the monitor to sense the combination of a darkened laboratory room and a fume hood that has its sash left up.
5. Fume hood monitor shall include an LED display or numerical velocity display to indicate a relative measure of hood face velocity, visual indication for normal operation, visual and audible alarm for an unsafe alert and visual and audible alarm to indicate emergency exhaust operation.
6. A push-button switch shall be provided to mute the audible alarm. The mute mode is automatically reset when the alarm condition ceases.

E. Airflow Control Valve - General

1. The airflow control valve shall be a venturi valve type air flow control valve.
2. The airflow control valve shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.
3. The airflow control valve shall maintain accuracy within  $\pm 5\%$  of signal over an airflow turndown range of no less than 10 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
4. A static pressure reset sensor shall be provided for 15% of total valve quantity. Sensor shall measure static pressure across airflow control valves located at representative locations in the system. Monitoring of sample valve static pressure shall allow supply/exhaust fan static pressure reset as outlined in Division 25.
5. The airflow control valve shall be constructed of one of the following two types:

- a. Class A-The airflow control valve for non-corrosive airstreams such as room/lab supply and general exhaust shall be constructed of 16 gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be spring-grade stainless steel.

RFI:08631 - Locate at the end of each branch main on the furthest air valve (3 or 4 per floor). See attached sketch.



All shaft bearing surfaces shall be made of a Teflon, or polyester, or PPS (polyphenylene sulfide) composite.

- 1) Sound attenuating devices used in conjunction with general exhaust or supply airflow control valves shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. Refer to project schedule for compliance of external sound attenuator devices.
- b. Class B-The airflow control valves for corrosive airstreams such as fume hoods and bio-safety cabinets shall have baked-on corrosion resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite. Provide all Class B air valves with differential pressure switch.
  - 1) Sound attenuating devices used in conjunction with Class B air flow control valves shall be constructed of stainless steel. Refer to project schedule for compliance of external sound attenuating devices.
6. Constant Volume Air Flow Control Valves for constant volume fume hoods and/or snorkel exhaust shall maintain a constant volume pressure independent, manually adjustable, volume setpoint, all valves shall be provided with a pressure switch for alarm status. It shall be factory calibrated and set for desired airflow rate. It shall also be capable of field adjustment for future changes of desired airflow rate. Valve shall not be equipped with any pneumatic or electronic control actuator requirements. Valve construction shall be as described herein.
7. Certification
  - a. Each airflow control valve shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least +1% of signal over the entire range of measurement. Electronic valves shall be further calibrated and their accuracy verified to +5% of signal at eight different airflows per valve.
  - b. All airflow valves shall be individually marked with valve specific, factory calibration data. As a minimum, it should include: valve tag number, serial number, model number, eight point valve characterization information (electronic valves), and quality control inspection numbers. All information shall be stored on computer diskette in ASCII format for future retrieval or for hard copy printout to be included with as-built documentation.

C. Airflow Control Sound Specifications

1. Unless otherwise specified, the airflow control device shall not exceed the sound power levels in Table 1, Table 2 and Table 3.
2. If the airflow control device cannot meet the sound power level specification, a properly sized silencer or sound attenuator must be used. All silencers must be of a packless or no media design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20 inches of water.

3. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.

Table 1. Exhaust Airflow Control Device Sound Power Level

		Exhaust Sound Power Level in dB (re: 10(-12) watts)					
Octave Band Number		2	3	4	5	6	7
Center Frequency in Hz		125 Hz	50 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-100 cfm Device	800 cfm @ 0.6" wc	63	55	52	54	50	49
	200 cfm @ 0.6" wc	46	42	38	37	32	25
	800 cfm @ 3.0" wc	73	70	64	66	65	60
	200 cfm @ 3.0" wc	51	52	51	50	52	51
1500-150 cfm Device	1200 cfm @ 0.6" wc	65	58	53	56	52	52
	400 cfm @ 0.6" wc	50	45	38	39	37	31
	1200 cfm @ 3.0" wc	72	70	62	65	64	60
	400 cfm @ 3.0" wc	55	57	55	53	56	55
3000-300 cfm Device	2400 cfm @ 0.6" wc	63	56	55	58	54	55
	800 cfm @ 0.6" wc	51	45	41	42	39	34
	2400 cfm @ 3.0" wc	75	71	65	68	67	63
	800 cfm @ 3.0" wc	58	58	56	56	59	58

Table 2. Supply Airflow Control Device Sound Power Level (Discharge)

		Discharge Sound Power Level in dB (re: 10(-12) watts)					
Octave Band Number		2	3	4	5	6	7
Center Frequency in Hz		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-100 cfm Device	800 cfm @ 0.6" wc	62	57	54	58	54	51
	200 cfm @ 0.6" wc	45	46	42	44	40	34
	800 cfm @ 3.0" wc	72	71	67	75	72	68
	200 cfm @ 3.0" wc	53	56	54	58	56	54
1500-150 cfm Device	1200 cfm @ 0.6" wc	63	59	55	60	54	53
	400 cfm @ 0.6" wc	53	49	44	49	45	39
	1200 cfm @ 3.0" wc	72	73	69	77	72	68
	400 cfm @ 3.0" wc	58	63	61	63	60	57
3000-300 cfm Device	2400 cfm @ 0.6" wc	64	60	58	63	56	56
	800 cfm @ 0.6" wc	52	48	47	52	46	41
	2400 cfm @ 3.0" wc	75	75	72	78	73	70
	800 cfm @ 3.0" wc	59	62	62	66	62	60



Table 3. Supply Airflow Control Device Sound Power Level (Radiated)

		Radiated Sound Power Level dB (re: 10-12 watts)					
Octave Band Number		2	3	4	5	6	7
Center Frequency in Hz		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-100 cfm Device	800 cfm @ 0.6" wc	44	41	45	41	36	34
	200 cfm @ 0.6" wc	33	28	31	29	26	20
	800 cfm @ 3.0" wc	53	53	56	57	55	53
	200 cfm @ 3.0" wc	41	38	41	39	39	37
1500-150 cfm Device	1200 cfm @ 0.6" wc	47	53	40	42	38	36
	400 cfm @ 0.6" wc	35	39	31	34	33	26
	1200 cfm @ 3.0" wc	52	60	54	60	59	53
	400 cfm @ 3.0" wc	42	44	43	46	46	42
3000-300 cfm Device	2400 cfm @ 0.6" wc	58	56	45	47	43	42
	800 cfm @ 0.6" wc	45	43	36	39	37	29
	2400 cfm @ 3.0" wc	69	68	60	65	63	57
	800 cfm @ 3.0" wc	54	53	48	51	50	48

## 2.4 LARGE VOLUME AIR FLOW CONTROL STATIONS

- A. Provide where indicated, remote controlled air volume units consisting of a multi-point, symmetrical averaging Pitot tube traverse air flow measuring stations as specified herein with built-in air processing section and electric operated opposed-blade volume control damper.
- B. Each remote controlled air volume unit shall be fabricated of a heavy gage galvanized steel casing, minimum 20 gauge, in a 24" depth and rectangular configuration and equivalent size approximating that of the duct in which it is to be mounted. Each unit shall be complete with air equalizer and straightener, total and static pressure sensors with symmetrical averaging manifold, electric operated opposed-blade volume damper and fittings for airflow meter attachment.
- C. The maximum allowable pressure loss through the units shall not exceed 0.25" w.c. at 2000 fpm. The sound level within the duct shall not be increased more than 5 Db at an airflow rate of 2500 fpm.
- D. Contractor to coordinate actuator/controller installation with Section 23 09 23.

## PART 3 - EXECUTION

### 3.1 INSTALLATION – AIR TERMINAL BOXES AND LARGE VOLUME AIR FLOW CONTROL STATIONS

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur. Support shall not block or interfere with maintenance access to unit.
- D. Locate air terminal units to provide a straight section of inlet duct for proper functioning of volume controls. See VA Standard Detail.
- E. The inlet duct size shall be as noted on the plans and/or the schedule. Air terminal boxes shall be connected to the sheet metal per requirements found herein under "Sheet Metal Work" Section.
- F. Terminal boxes shall be installed with adequate service space to access the controller side of the unit and the reheat coil control valve.

### 3.2 INSTALLATION – AIR FLOW CONTROL VALVE (AFCV) SYSTEM

- A. The Division 23 Contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.
- B. The Division 23 Contractor shall provide and install insulation as required.

### 3.3 OPERATIONAL TEST

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

### 3.4 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

### 3.5 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

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SECTION 23 37 00  
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Gravity Intake and Exhaust Ventilators with Associated Roof Curbs
- B. Air Outlets and Inlets: Diffusers, Registers, and Grilles.

1.2 RELATED WORK

- A. Outdoor and Exhaust Louvers: Section 08 90 00, LOUVERS AND VENTS.
- B. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- D. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fire Safety Code: Comply with NFPA 90A.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
  - 1. Pressure drop and free area performance. Review outlets and inlets as to size, finish and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application and noise level. Manufacturer shall review requirements of outlets as to size, finish and type of mounting before submitting shop drawings and schedule of outlets. Manufacturer shall check location of outlets and make necessary adjustments in position to conform with architectural features, symmetry and lighting arrangement before submitting shop drawings.

- C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Diffusion Council Test Code:  
1062 GRD-84 ..... Certification, Rating, and Test Manual 4<sup>th</sup> Edition
- C. American Society of Civil Engineers (ASCE):  
ASCE7-05 ..... Minimum Design Loads for Buildings and Other Structures
- D. American Society for Testing and Materials (ASTM):  
A167-99 (2004) ..... Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip  
B209-07 ..... Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- E. National Fire Protection Association (NFPA):  
90A-09 ..... Standard for the Installation of Air Conditioning and Ventilating Systems
- F. Underwriters Laboratories, Inc. (UL):  
181-08 ..... UL Standard for Safety Factory-Made Air Ducts and Connectors
- G. ADC 1062: GRD – Test Code for Grilles, Registers and Diffusers; 1984.
- H. ASHRAE 70 – Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
- I. SMACNA (DCS) – HVAC Duct Construction Standard – metal and Flexible; 1995.

## PART 2 - PRODUCTS

### 2.1 GRAVITY INTAKE/EXHAUST VENTILATORS (ROOF MOUNTED)

- A. Aluminum, ASTM B209, louvered, spun, or fabricated using panel sections with roll-formed edges, 13 mm (1/2 inch) mesh aluminum welded wire bird screen, with gravity or motorized dampers where shown, accessible interior, designed for wind velocity specified in Paragraph 3.3.
1. Spun Intake/Exhaust Ventilators: Spun aluminum structural components shall be constructed of minimum 1.3 mm (16 Gauge) marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The spun aluminum baffle shall have a rolled bead for added strength.

2. Louvered Intake/Exhaust Hoods: Louvered hood constructed from 0.081 Gauge extruded aluminum tiers welded to a minimum 3.3 mm (8 Gauge) aluminum support structure. The aluminum hood shall be constructed of a minimum 0.064 marine alloy aluminum and provided with a layer of anti-condensate coating. The aluminum base shall have continuously welded curb cap corners for maximum leak protection.
  3. Low Silhouette Intake/Exhaust Ventilator: The unit shall be of bolted and welded construction utilizing corrosion resistant fasteners. The aluminum hood shall be constructed of minimum 1.60 mm (14 Gauge) marine alloy aluminum, bolted to a minimum 3.25 mm (8 Gauge) aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. Birdscreen constructed of 13 mm (1/2 inch) mesh shall be mounted across the relief opening.
- B. See ventilator schedule on the drawings. Sizes shown on the drawings designate throat size. Area of ventilator perimeter opening shall be not less than the throat area.
- C. Dampers for Gravity Ventilators without Duct Connection: Construct damper of the same material as the ventilator and of the design to completely close opening or remain wide open. Hold damper in closed position by a brass chain and catch. Extend chains 300 mm (12 inches) below and engage catch when damper is closed.
- D. See paragraph 3.2 for Intake/Exhaust requirements for exposure to high wind velocities.
- E. Provide Roof Curb by unit manufacturer. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for additional requirements.

## 2.2 EQUIPMENT SUPPORTS

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

## 2.3 AIR OUTLETS AND INLETS

- A. Materials:
1. Steel or aluminum, as noted on the Schedule, all supply air outlets installed in operating rooms and Cystoscopy rooms (see Article 2.3C.3) shall be stainless steel. Use aluminum air outlets and inlets for facilities located in high-humidity areas. Exhaust air registers located in combination toilets and shower stalls shall be constructed from aluminum. Provide manufacturer's standard gasket.
  2. Exposed Fastenings: The same material as the respective inlet or outlet. Fasteners for aluminum may be stainless steel.
  3. Contractor shall review all ceiling drawings and details and provide all ceiling mounted devices with appropriate dimensions and trim for the specific locations.
  4. Distribution devices, except where such devices are specified or scheduled to be stainless steel or extruded anodized aluminum, shall be factory primed and finish painted by the manufacturer in a color as approved by the Architect during shop drawing review, unless otherwise noted.
  5. All diffusers, grilles and registers must be compatible with the designed ceiling/wall type. Refer to architectural drawings for exact details of ceiling/wall construction.
- B. Performance Test Data: In accordance with Air Diffusion Council Code 1062GRD. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT for NC criteria.

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C. Supply Air Outlets:

1. Ceiling Supply Plaque Diffusers: Suitable for exposed T-bar ceilings, round neck connection as shown on the drawings. Face dimension shall accommodate nominal 24" x 24" ceiling grid.
  - a. Diffusers shall consist of a precision-formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.
  - b. An inner plaque assembly shall be incorporated that drops no more than ¼" below the ceiling plane to assure proper air distribution performance.
  - c. The inner plaque assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck.
  - d. Provide blank-off baffles for one, two, and three-way blow pattern as indicated on the drawings.
  - e. Schedule Type: Series SD-10.
2. Ceiling Vane Diffusers: Suitable for surface mounting, exposed T-bar or special tile ceilings, square or round neck connection as shown on the drawings. Provide plaster frame for units in plaster ceilings.
  - a. Ceiling or sidewall supply air diffusers shall be of the restricted multi-orifice jet induction and air mixing type, consisting of louvered sections with built-in diffusing vanes.
  - b. The vanes shall be arranged to discharge air from adjacent channels at a 45° angle in opposite directions to the plane of discharge to ensure rapid mixing of primary and room air. Each individual diffusing vane shall be welded in (2) places to the adjacent louver sections to make a rigid integral unit. The vanes shall extend to the discharge edges of the louvers.
  - c. Where louver sections abut core frame, the louver ends shall be welded to core frame. The louver ends shall be rounded and hemmed before welding to core frames.
  - d. Diffusers shall be square or rectangular, as shown on the drawings. Diffusers shall be assembled in patterns which provide 1-way, 2-way, 3-way or 4-way air discharge with each side delivering a quantity of air proportional to the area served. The manufacturer shall review the proposed location of each diffuser to ensure the blow pattern will not adversely affect the room occupants and make all necessary corrections and/or suggest alternate locations to the installing contractor. The diffusers shall be provided with a removable core permitting easy access to the neck connection.
  - e. The diffusers shall be constructed with an integral collar extending at least 1" above the core to accommodate an internal duct connection. Collar corners shall have welded angles on the outside to prevent leakage and ensure that internal duct connection can be made secure.
  - f. All square diffusers installed within a grid ceiling shall include an extension pan to fill and be placed within a 2' x 2' ceiling grid, suitable for and match the grid type.
  - g. Schedule Type: Series SD-20.
3. Slot diffuser/plenum:
  - a. Diffuser: Frame and support bars shall be constructed of heavy gauge extruded aluminum. Provide adjustable pattern controllers, to provide stable, horizontal air flow pattern from 0 to 100 degrees, slot width shall be 1". Continuous lengths shall be joined with alignment tabs for precise installation over a wide range of operating conditions, constant static pressure, constant outlet area.

- b. Galvanized steel boot plenum, minimum 24 gauge with inlet connection.
  - c. Provide inlet connection diameter equal to duct diameter shown on drawings or provide transition coupling if necessary. Inlet duct and plenum size shall be as recommended by the manufacturer.
  - d. Maximum pressure drop at design flow rate: 25 Pa (0.10 inch W.G.).
  - e. Schedule Type: Series SD-40.
4. Supply Grilles in Security Areas: Suitable for ceiling or sidewall installation, square neck connection as shown on the drawings.
- a. The diffuser shall consist of a removable inner louver assembly with a 1, 2, 3 or 4-way directional pattern.
  - b. The face of the diffuser shall be covered by a steel plate constructed of 12 gauge steel with 13/16" square holes and 3/16" fret.
  - c. The face shall come standard with screw holes for surface mounting.
  - d. Schedule Type: Series SD-50.
5. Sidewall Supply Grilles: Double deflection type with horizontal face bars, mitered corners and countersunk fasteners.
- a. Margin: Flat, 30 mm (1-1/4 inches) wide.
  - b. Bar spacing: 20 mm (3/4 inch) maximum.
  - c. Finish: Off white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded with manufacturer's standard finish.
  - d. Schedule Type: Series SD-60.
6. Radial Pattern Supply, High Induction:
- a. Radial pattern diffuser shall provide a flush line with ceiling system, non-flush face diffusers are not acceptable. The unit shall consist of a diffuser face assembly and a diffuser back assembly. The diffuser face assembly must be assembled into the diffuser back assembly and be delivered ready to install. The diffuser face assembly shall feature a combination of adjustable engineered longitudinal louvers and perforated sheet metal, oriented and proportioned in a manner to provide either a 90 degree or 180 degree radial, non-aspirating air flow pattern. The perforated sheet metal shall consist of 5/32" diameter holes on 1/4" centers on 2" lengths or 3/16" diameter holes on 1/4" centers on 4" lengths. The diffuser face assembly shall be removable with common tools. It must be hinged on one side and secured in place with quarter-turn fasteners on the opposing side finish. Unit shall be entirely constructed of 304 stainless steel.
  - b. The diffuser back assembly shall be fabricated as a fully assembled single unit, consisting of the back frame, an integral diffusion baffle specifically designed for each size and air pattern and a 2" high collar complete with locking bead for positive duct connection.
  - c. Engineering data shall be based upon tests conducted in accordance with ASHRAE Standard 70-1991. Method of Testing for Rating the Performance of Air Outlets and Inlets at non-isothermal conditions. Publish Noise Criteria (NC) data shall be determined based upon a 10dB room attenuation across all octave bands. Lab test reports shall be available upon request.
  - d. Schedule Type: Series SD-71 and SD-72.

## 7. Operating Room Supply Diffuser:

- a. Each operating room air system shall consist of modular slot diffusers which shall provide a protective air curtain around the operating area and laminar flow diffusers which shall provide a supply of sterile air over the operating table area.
- b. The slot diffuser and laminar flow diffuser shall be of stainless steel construction.
- c. The slot diffusers shall consist of a .037 inch 304 stainless steel plenum with continuous welded joints and chamfered corners to facilitate cleaning. The diffuser face shall be stainless steel construction with two slots and fixed pattern deflectors. Plenums shall have stainless steel inlet collars complete with removable dampers from plenum face. The removable dampers shall be opposed blade type, constructed of stainless steel. Damper shall be adjusted without removing face of the diffuser. The diffuser face shall be attached by stainless steel 90° quick-release fasteners and safety cable to open easily. The diffuser face, mounting frame, face and interior surface of plenum shall have an ASTM A480 #4 finish.
- d. The laminar flow diffusers shall have components of 304 stainless steel. The perforated face plate, damper deflector, interior baffles and diffuser back pan plenum assembly shall be of .037 inch thickness. The plenum shall be constructed with continuously welded joints. The perforated face plate shall be easily removable with 90° quick-release fasteners and safety cable for easy cleaning and damper adjustment. Diffusers shall have an ASTM A480 #4 finish.
- e. Schedule Types:
  - 1) Laminar Flow: SD- 73
  - 2) Perimeter Slot: SD-74

## 8. Therapy Pool Supply Grilles: Double deflection type with horizontal face bars, mitered corners and countersunk fasteners.

- a. Margin: Flat, 30 mm (1-1/4") wide
- b. Bar spacing, 20 mm (3/4") maximum
- c. Construction: Aluminum
- d. Finish: Aluminum
- e. Schedule Type: Series SD-81

## 9. Multi-purpose / Gym Supply Grille: Double deflection type with horizontal face bars, mitered corners and countersunk fasteners.

- a. Margin: Flat, 30 mm (1-1/4") wide
- b. Bar Spacing: 20 mm (3/4") maximum
- c. Construction: Minimum 16 gauge steel frame, 14 gauge steel front bars, 24 gauge steel rear bars.
- d. Finish: Baked enamel or powder coat, color as selected by Architect.
- e. Schedule Type: Series SD-82.

## D. Return and Exhaust Air Inlets:

1. Ceiling Return/Exhaust Plaque Diffuser: to match ceiling supply plaque diffuser (SD-10 Series).
  - a. Schedule Type: Series RG-10; EG-10.



2. Ceiling or Wall Return/Exhaust Grilles: Fixed horizontal face bars set at 35 degrees, ½ inch spacing, approximately 30 mm (1-1/4 inch) margin, aluminum or steel construction, countersunk face fasteners, frame to match ceiling construction.
  - a. Schedule Type: RG-20 Series; EG-20 Series.
3. Linear Slot Type: To match supply units (SG-4D Series)
  - a. Schedule Type: RG-40 Series; EG-40 Series.
4. Return/Exhaust Grilles in Security Areas: Suitable for ceiling or sidewall installation, square neck connection as shown on the drawings.
  - a. The face shall be constructed of 12 gauge steel with 13/16" x 13/16" square holes on 1" centers.
  - b. The face shall be provided with screw holes for surface mounting.
  - c. Schedule Type: RG-50 Series, EG-50 Series.
5. Linear Bar Grilles: Extruded aluminum and positive holding concealed fasteners.
  - a. Margin Frame: Flat, 20 mm (3/4 inch) wide.
  - b. Bars: Minimum 5 mm (3/16 inch) wide by 20 mm (3/4 inch) deep, zero deflection unless otherwise shown. Bar spacing shall be a minimum of 3 mm (1/8 inch) on center. Reinforce bars on 450 mm (18 inch) center for sidewall units and on 150 mm (6 inch) center for units installed in floor or sills.
  - c. Schedule Type Series: EG-60.
6. Ceiling Return/Exhaust Perforated Grille: Suitable for exposed T-bar ceilings, square or round neck connection as shown on the drawings. Face dimension shall accommodate nominal 24" x 24" ceiling grid.
  - a. Diffusers shall have a steel or aluminum perforated face with 3/16" diameter holes on 1/4" staggered centers and no less than 51% free area.
  - b. The backpan shall be heavy gauge steel construction with margin styles and sizes shown per plans.
  - c. The perforated face must be hinged to the back panel to provide access and be removable for cleaning.
  - d. Schedule Type: RG-80 Series; EG-80 Series.
7. Therapy pool return/exhaust grille: Fixed horizontal face bars set at 35 degrees, ¾" spacing, approximately 30mm (1-¼ inch margin), aluminum construction.
  - a. Schedule Type: RG-91; EG-91.
8. Multipurpose/gym and O.R. low return/exhaust grille: Fixed horizontal face bars set at 45 degrees, 3/4" spacing, approximately 30mm (1-1/4" margin), 14 gauge steel construction.
  - a. Schedule Type: RG-92; RG-93; EG-92.

## 2.4 WIRE MESH GRILLE

- A. Fabricate grille with 2 x 2 mesh 13 mm (1/2 inch) galvanized steel or aluminum hardware cloth in a spot welded galvanized steel frame with approximately 40 mm (1-1/2 inch) margin.
- B. Use grilles where shown in unfinished areas such as mechanical rooms.

## 2.5 FILTER RETURN/EXHAUST GRILLE

- A. Provide grille with in stream 1-inch deep MERV 4 filter and removable face.
  - 1. Finish: Off-white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded aluminum with manufacturer's standard aluminum finish. Stainless Steel shall be No. 4 finish.
  - 2. Standard Type: Fixed horizontal face bars set at 30 to 45 degrees, approximately 30 mm (1-1/4 inch) margin.
  - 3. Steel, Aluminum, or Stainless steel as scheduled.
  - 4. Standard face connected to a mounting frame with space for a throwaway filter. Hold face closed by a locking screw. Provide retaining clips to hold filter in place. Provide fiberglass throwaway filter.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.
- B. Protection and Cleaning: Protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by Resident Engineer. Protect equipment during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

### 3.2 INTAKE/ EXHAUST HOODS EXPOSED TO WIND VELOCITY

- A. Provide additional support and bracing to all exposed ductwork installed on the roof or outside the building to withstand wind velocity of 130 mph.

### 3.3 TESTING, ADJUSTING AND BALANCING (TAB)

- A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

### 3.4 OPERATING AND PERFORMANCE TESTS

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

--- END ---

SECTION 23 40 00  
HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Air filters for heating, ventilating and air conditioning.
- B. Definitions: Refer to ASHRAE Standard 52.1 for definitions of face velocity, net effective filtering area, media velocity, resistance pressure drop), atmospheric dust spot efficiency and dust-holding capacity. ASHRAE Standard 52.1 measures arrestance, dust spot efficiency and dust holding capacity of filters.
- C. Refer to ASHRAE Standard 52.2 for definitions of MERV (Minimum Efficiency Reporting Value), PSE (Particle Size Efficiency) and particle size ranges for each MERV number. ASHRAE Standard 52.2 measures particle size efficiency (PSE).

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Filter housing and racks: Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS; Section 23 73 13, PACKAGED INDOOR CENTRAL-STATION AIR-HANDLING UNITS.

1.3 QUALITY ASSURANCE

- A. Air Filter Performance Report for Extended Surface Filters:
  - 1. Submit a test report for each Grade of filter being offered. The report shall not be more than three (3) years old and prepared by using test equipment, method and duct section as specified by ASHRAE Standards 52.1 and 52.2 for type filter under test and acceptable to Resident Engineer, indicating that filters comply with the requirements of this specification. Test for 150 m/min (500 fpm) will be accepted for lower velocity rated filters provided the test report of an independent testing laboratory complies with all the requirements of this specification.
  - 2. Government Option: The Government at its option may take one of the filters for each different type submitted and run an independent test to determine if the filter meets the requirements of this specification. When the filter meets the requirements, the Government will pay for the test. When the filter does not meet the specification requirements, the manufacturer will be required to pay for the test and replace the filters with filters that will perform as required by the specifications.
  - 3. Guarantee Performance: The manufacturer shall supply ASHRAE 52.2 test reports on each filter type submitted. Any filter supplied will be required to maintain the minimum efficiency shown on the ASHRAE Standard 52.2 report throughout the time the filter is in service.

Within the first 6-12 weeks of service a filter may be pulled out of service and sent to an independent laboratory for ASHRAE Standard 52.2 testing for initial efficiency only. If this filter fails to meet the minimum level of efficiency shown in the previously submitted reports, the filter manufacturer/distributor shall take back all filters and refund the owner all monies paid for the filters, cost of installation, cost of freight and cost of testing.

- B. Filter Warranty for Extended Surface Filters: Guarantee the filters against leakage, blow-outs, and other deficiencies during their normal useful life, up to the time that the filter reaches the final pressure drop. Defective filters shall be replaced at no cost to the Government.
- C. Comply with UL Standard 900 for flame test.
- D. Nameplates: Each filter shall bear a label or name plate indicating manufacturer's name, filter size, rated efficiency, UL classification and file number.

#### 1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
  - 1. Extended surface filters.
  - 2. Holding frames. Identify locations.
  - 3. Side access housings. Identify locations, verify insulated doors.
  - 4. HEPA filters.
  - 5. Magnehelic gages.
- C. Air Filter performance reports.
- D. Suppliers warranty.
- E. Field test results for HEPA filters as per paragraph 2.3.E.3.

#### 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
  - 52.1-92R Gravimetric and Dust-Spot procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
  - 52.2-2007.....Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
- C. American Society of Mechanical Engineers (ASME):
  - NQA-1-2008 Quality Assurance Requirements for Nuclear Facilities Applications
- D. Underwriters Laboratories, Inc. (UL):
  - 900; Revision 15 July 2009 Test Performance of Air Filter Units

## PART 2 - PRODUCTS

## 2.1 REPLACEMENT FILTER ELEMENTS TO BE FURNISHED

- A. To allow temporary use of HVAC systems for testing and in accordance with Paragraph, TEMPORARY USE OF MECHANICAL AND ELECTRICAL SYSTEMS in Section 01 00 00, GENERAL REQUIREMENTS, provide one complete set of spare filters to the Resident Engineer.
- B. The Resident Engineer will direct whether these additional filters will either be installed as replacements for dirty units or turned over to VA for future use as replacements.

## 2.2 EXTENDED SURFACE AIR FILTERS

- A. Use factory assembled air filters of the extended surface type with supported or non-supported cartridges for removal of particulate matter in air conditioning, heating and ventilating systems. Filter units shall be of the extended surface type fabricated for disposal when the dust-load limit is reached as indicated by maximum (final) pressure drop.
- B. Filter Classification: UL approved Class 1 or Class 2 conforming to UL Standard 900.
- C. Filter Types:

HVAC Filter Types Table 2.2C					
Type	MERV Value ASHRAE 52.2	MERV-A Value ASHRAE 62.2 Appendix J	Application	Particle Size	Thickness /Type
A	8	8-A	Pre-Filter	3 to 10 Microns	50 mm (2-inch) Throwaway
B	11	11-A	After-Filter	1 to 3 Microns	150 mm (6-inch) or 300 mm (12-inch) Rigid Cartridge
C	13	13-A	After-Filter	0.3 to 1 Microns	150 mm (6-inch) or 300 mm (12-inch) Rigid Cartridge
D	14	14-A	After-Filter	0.3 to 1 Microns	150 mm (6-inch) or 300 mm (12-inch) Rigid Cartridge

## D. HEPA Filters

HEPA Filters Table 2.2D					
Type	Efficiency at 0.3 Micron	Application	Initial Resistance (inches w.g.)	Rated CFM	Construction
E	99.97	Final Filter	1.35	1100	Galvanized Frame X-Body

## 2.3 MEDIUM EFFICIENCY PLEATED PANEL PRE-FILTERS (2"; MERV 8; UL 900 CLASS 2):

- A. Construction: Air filters shall be medium efficiency ASHRAE pleated panels consisting of cotton and synthetic or 100% virgin synthetic media, self supporting media with required media stabilizers, and beverage board enclosing frame. Filter media shall be lofted to a uniform depth and formed into a uniform radial pleat. The media stabilizers shall be bonded to the downstream side of the media to maintain radial pleats and prevent media oscillation. An enclosing frame of no less than 28-point high wet-strength beverage board shall provide a rigid and durable enclosure. The frame shall be bonded to the media on all sides to prevent air bypass. Integral diagonal support members on the air entering and air exiting side shall be bonded to the apex of each pleat to maintain uniform pleat spacing in varying airflows.
- B. Performance: The filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2. It shall also have a MERV-A of 8 when tested per Appendix J of the same standard. The media shall maintain or increase in efficiency over the life of the filter. Pertinent tolerances specified in Section 7.4 of the Air-Conditioning and Refrigeration Institute (ARI) Standard 850-93 shall apply to the performance ratings. All testing is to be conducted on filters with a nominal 24" x 24" face dimension.

Filter Type	A
Minimum Efficiency Reporting (MERV)	8
Dust Holding Capacity (Grams)	105
Nominal Size (Width x Height x Depth)	24x24x2
Rated Air Flow Capacity (Cubic Feet per Minute)	2,000
Rated Air Flow Rate (Feet per Minute)	500
Final Resistance (Inches w.g.)	1.0
Maximum Recommended Change-Out Resistance (Inches w.g.)	0.66
Rated Initial Resistance (Inches w.g.)	0.33

- C. The filters shall be approved and listed by Underwriters' Laboratories, Inc. as Class 2 when tested according to U. L. Standard 900 and CAN 4-5111.

## 2.4 HIGH EFFICIENCY EXTENDED SURFACE (INTERMEDIATE/AFTER (FINAL)) CARTRIDGE FILTERS (12"; MERV 14/13/11; UL 900 CLASS 2):

- A. Construction: Air filters shall consist of 8 pleated media packs assembled into 4 V-banks within a totally plastic frame. The filters shall be capable of operating at temperatures up to 80 degrees C (176 degrees F). The filters must either fit without modification or be adaptable to the existing holding frames. The molded end panels are to be made of high impact polystyrene plastic. The center support members shall be made of ABS plastic. No metal components are to be used.
- B. Media: The media shall be made of micro glass fibers with a water repellent binder. The media shall be a dual density construction, with coarser fibers on the air entering side and finer fibers on the air leaving side. The media shall be pleated using separators made of continuous beads of low profile thermoplastic material. The media packs shall be bonded to the structural support members at all points of contact, this improves the rigidity as well as eliminates potential air bypass in the filter

- C. Performance: Filters of the size, air flow capacity and nominal efficiency (MERV) shall meet the following rated performance specifications based on the ASHRAE 52.2-1999 test method. Where applicable, performance tolerance specified in Section 7.4 of the Air-Conditioning and Refrigeration Institute (ARI) Standard 850-93 shall apply to the performance ratings. All testing is to be conducted on filters with a nominal 24"x24" header dimension.

Filter Type	D	C	B
Minimum Efficiency Reporting Value (MERV)	14	13	11
Gross Media Area (Sq. Ft.)	197	197	197
Dust Holding Capacity (Grams)	486	430	465
Nominal Size (Width x Height x Depth)	24x24x12	24x24x12	24x24x12
Rated Air Flow Capacity (cubic feet per minute)	2,000	2,000	2,000
Rated Air Flow Rate (feet per minute)	500	500	500
Final Resistance (inches w.g.)	2.0	2.0	2.0
Maximum Recommended Change-Out Resistance (Inches w.g.)	0.74	0.68	0.54
Rated Initial Resistance (inches w.g.)	0.37	0.34	0.27

## 2.5 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS STANDARD CAPACITY (FINAL FILTER APPLICATION)

- A. Air filters shall be HEPA grade standard capacity air filters with waterproof micro glass fiber media, corrugated aluminum separators, urethane sealant, 16-gauge steel enclosing frame and fluid sealing gasket. Sizes shall be as noted on drawings or other supporting materials.
- B. Construction: Filter media shall be one continuous pleating of microfine glass fiber media. Pleats shall be uniformly separated by corrugated aluminum separators incorporating a hemmed edge to prevent damage to the media. The media pack shall be potted into the enclosing frame with a fire-retardant urethane sealant. The enclosing frame shall be of 16-gauge steel, with a zinc aluminum alloy finish, and shall be bonded to the media pack to form a rugged and durable enclosure. The filter shall be assembled without the use of fasteners to ensure no frame penetrations. Overall dimensional tolerance shall be correct within  $-1/8"$ ,  $+0"$ , and square within  $1/8"$ . A poured-in-place seamless sealing gasket shall be included on the downstream side of the enclosing frame to form a positive seal upon installation.
- C. Performance: The filter shall have a tested efficiency of 99.97% when evaluated according to IEST Recommended Practice. Initial resistance to airflow shall not exceed 1.0" w.g. at rated capacity. Filter shall be listed by Underwriters Laboratories as UL 900. The filter shall be capable of withstanding 10" w.g. without failure of the media pack. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

HEPA Performance (Standard Capacity) Table 2.5A		
Nominal Size (inches)	Airflow Capacity (cfm)	Media Area (Square Feet)
24H by 24W by 12D	1080 at 1.0" w.g.	153
24H by 12W by 12D	500 at 1.0" w.g.	33
Follow manufacturers' recommendation for change out resistance, typically double the initial.		

- D. Supporting Data: The filter shall be labeled as to tested efficiency, rated/tested cfm, pressure drop and shall be serialized for identification. The manufacturer shall supply a Certificate of Conformance for each HEPA filter supplied to the facility.

## 2.6 FILTER HOUSINGS/SUPPORT FRAMES

### A. Side Servicing Housings (HVAC Grade)

1. Filter housing shall be two-stage filter system consisting of 16-gauge galvanized steel enclosure, aluminum filter mounting track, universal filter holding frame, insulated dual-access doors, static pressure tap, filter gaskets and seals. In-line housing depth shall not exceed 21". Sizes shall be as noted on enclosed drawings or other supporting materials.
2. Construction: The housing shall be constructed of 16-gauge galvanized steel with pre-drilled standing flanges to facilitate attachment to other system components. Corner posts of Z-channel construction shall ensure dimensional adherence. //Where installed outdoors, the housing shall be weatherproof and suitable for rooftop/outdoor installation.// The housing shall incorporate the capability of two stages of filtration without modification to the housing. A filter track, of aluminum construction shall be an integral component of housing construction. The track shall accommodate a 2" deep prefilter, a 6" or 12" deep rigid final filter, or a pocket filter with header. Insulated dual access doors, swing-open type, shall include high-memory sponge neoprene gasket to facilitate a door-to-filter seal. Each door shall be equipped with adjustable and replaceable positive sealing UV-resistant star-style knobs and replaceable door hinges. A universal holding frame constructed of 18-gauge galvanized steel, equipped with centering dimples, multiple fastener lances, and polyurethane filter sealing gasket, shall be included to facilitate installation of high-efficiency filters. The housing shall include a pneumatic fitting to allow the installation of a static pressure gauge to evaluate pressure drop across a single filter or any combination of installed filters.
3. Performance: Leakage at rated airflow, upstream to downstream of filter, holding frame, and slide mechanism shall be less than 1% at 3.0" w.g. Leakage in to or out of the housing shall be less than one half of 1% at 3.0" w.g. Accuracy of pneumatic pressure fitting, when to evaluate a single-stage, or multiple filter stages, shall be accurate within  $\pm$  3% at 0.6" w.g.
4. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

### B. Holding Frame System (HVAC Grade):

1. Air filter-holding frames shall be 16-gauge galvanized steel with filter sealing flange, centering dimples, sealing gasket and lances for appropriate air filter fasteners. Sizes shall be noted on drawings or other supporting materials.
2. Construction: Filter holding frame shall be constructed of 16-gauge galvanized steel. The frame shall be assembled from two corner sections and welded to assure a rigid and durable frame assembly. The frame shall include a variety of pre-punched lances for filter fastener attachment. Fastener shall be capable of being installed without the use of tools, nuts or bolts. Lance penetrations shall be upstream of filter flange to assure leak-free integrity. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange. A 3/4" filter-sealing flange shall be an integral component of the holding frame. All corners shall be flush mitered and a permanently mounted polyurethane foam gasket shall be mounted on the sealing flange to assure filter to frame sealing integrity.
3. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.



**C. Side-Access Housing (HEPA Grade)**

1. Filter housing shall be two-stage filter system consisting of 14-gauge galvanized steel enclosure, spring-loaded crank-type sealing assembly for gasket seal type final filters, insulated dual-access doors with gasketing and positive sealing doorknobs. In-line housing depth shall not exceed 25". Sizes shall be as noted on enclosed drawings or other supporting materials.
2. Construction: The housing shall be constructed of 14-gauge galvanized steel with mating flanges to facilitate attachment to other system components. All pressure boundaries shall be of all welded construction. The housing shall be weatherproof and suitable for rooftop/outdoor installation. A prefilter track to accommodate nominal 2" deep prefilters, shall be an integral component of the housing. The housing shall incorporate a spring-loaded crank-type final filter sealing mechanism. The mechanism shall be geared to exert 700 pounds of pressure against each filter. The clamping frame shall have a continuous flat surface seal to compress all four downstream gasketed surfaces of the downstream seal filter. The final filter locking mechanism shall include a 3/4" socket adapter to facilitate opening or closing the mechanism. Insulated dual access doors shall include high-memory sponge neoprene gasket to facilitate a door-to-filter seal. Each door shall be equipped with adjustable and replaceable UV-resistant positive sealing knobs. The access doors shall be both hinged for swing open operation or designed to be completely removable. The housing shall include static pressure ports (1/8" NPT male) to facilitate pressure drop measurements across prefilter, final filter, or combination thereof.
3. Performance: Manufacturer shall provide evidence of facility certification to ISO 9001:2008.

**D. Built-up Bank HEPA Holding Frames**

1. Holding frames shall be constructed of 14-gauge galvanized steel. Frames shall be welded and include centering dimples, pre-drilled mounting holes, filter sealing flange and swing bolt assemblies. An appropriate number of swing bolts to match air filters shall also be included. Sizes shall be as noted on drawings or other supporting materials.
2. Construction: Filter frame shall be all-welded construction of 14-gauge galvanized steel. The frame shall include pre-drilled mounting holes to align frame-to-frame and ensure built-up bank support. Annular based centering dimples shall be an integral component to assist in proper seating of filter gasket to filter sealing flange. Assembly holes shall be within dimples to recess assembly bolts. Filter securing swing bolt assemblies, of the same construction as the frame, shall be offset to facilitate multiple filter installations. The assembly shall include appropriate swing bolts to match filter depth and equi-bearing clamps to allow uniform filter gasket sealing.
3. Performance: The sealing assembly shall be capable of sealing each element with 30 inch/lbs. of torque to 50% filter gasket compression. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

**E. Bag-in/Bag-out HEPA Air Filter Housing**

1. Housing shall be side-access bag-in/bag-out, fluid seal housing. The housing shall be adequately reinforced to withstand a negative or positive pressure of 15" water gage. Housing design and filter arrangement shall allow air to enter and exit housing without changing direction. The housing shall accommodate standard size filters that do not require any special attachments or devices to function properly in the housing. The housing shall accommodate fluid seal filters which require a penetrating knife edge installed on all filter sealing surfaces. The knife edge shall insert into the fluid filled perimeter channel located on the face of the filter.

By engaging the filter seal/release mechanism the filter shall move (push) the fluid filled channel to the sealed position. For removal of the air filters the filter seal/release mechanism shall remove (pull) the filter free of the blade type knife edge. This entire process is performed from inside the filter change out bag.

2. Construction:
  - a. Housing shall be constructed of 14 gauge and 11 gauge T-304 stainless steel metal. All pressure retaining joints and seams shall be continuously welded with no porosities. Joints and seams requiring intermittent welds, such as reinforcement members, shall be intermittently welded. Housing shall be free of burrs and sharp edges. All weld joints and seams that are a portion of any gasket setting surface, and duct connection flanges, shall be ground smooth and flush with adjacent base metals. All welded joints and seams shall be wire brushed to remove heat discoloration. The housing shall be reinforced to withstand a positive or negative pressure of 15" w.g. The upstream and downstream ductwork connections shall have 1 1/2" outward-turned flanges.
  - b. The housing shall have a bagging ring around each filter access port that is sealed by a gasketed filter access door. The filter access door gasket shall be silicone and shall be replaceable, if necessary. The bagging ring shall have two (2) continuous formed raised ridges to secure the PVC change-out bag. The bagging ring shall be hemmed on the outer edge to prevent the change-out bag from tearing.
  - c. Ancillary hardware including filter seal/release mechanism, door handles, door studs and labels shall be 300 series stainless steel. Filter access door knobs shall be cast aluminum and designed to prevent galling of threads.
  - d. One (1) PVC change-out bag shall be furnished with each filter access port. Change-out bags shall be 8-mil. thick with a yellow translucent, non-sticking, matte finish. It shall include a 1/4" diameter elastic shock cord hemmed into the opening of the bag so when stretched around the housing bagging ring flange, a secure fit is created. The bag shall include three (3) integral glove ports to assist in filter change-out. One (1) nylon security strap shall be included per filter access port to prevent the bag from sliding off the bagging flange during the change-out process. Design of components shall be such that all change-out operations shall be within the bag so there is a barrier between the worker and the filter at all times.
3. Performance: All welding procedures, welders, and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. All production welds shall be visually inspected by qualified personnel, incorporating the workmanship acceptance criteria described in Section 5 & 6 of AWS D9.1-1990, Specification for Welding of Sheet Metal.
4. The filter housing shall be factory tested for filter fit, alignment of filter sealing knife edge and operation of filter clamping mechanism. The filter sealing surface and the complete assembly pressure boundary shall be leak tested by the pressure decay method as defined in ASME N510-1995 Reaffirmed., Testing of Nuclear Air Cleaning Systems, paragraphs 6 and 7. The filter sealing surface shall be tested at +10" water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume. The overall system pressure boundary shall be leak tested at +15" water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume.
5. Filter bags shall be capable of continuous operating to temperature extremes of -18°C to 66°C(0°F to 150°F).
6. Multi-wide housing shall be equipped with a filter removal rod to pull the filters to the change-out position. The removal rod shall operate from the inside of the filter change out bag.
7. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

- F. Equipment Identification: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

## 2.7 ACTIVATED CARBON PLEATED PANEL FILTERS

### A. Performance Characteristics

1. Filters of the model designation, size and air flow capacity shall meet the following rated performance specifications based on the ASHRAE 52 test method, performance tolerance specified in Section 7.4 of the Air-Conditioning and Refrigeration Institute (ARI) Standard 850-93 shall apply to the performance ratings. All testing is to be conducted on filters with a nominal 24" x 24" face dimension, at a filter face velocity of 500 FPM.

Model Designation		Model of Choice	
Nominal Size (Width x Height x Depth)		24x24x2	
Rated Air Flow Capacity (CFM)		2,000	
Final Resistance (In W. G.)		1.2"	
Rated Initial Resistance (In W. G.)		0.75"	
Rated Efficiency		MERV 7	

2. The filters shall be approved and listed by Underwriters' Laboratories, Inc. Class 2 when tested according to U. L. Standard 900.

### B. Physical Characteristics

1. Each filter shall consist of 3-stages of media to collect both particulate and odor contaminants. The 3-stages of media shall be contained in a die cut frame, constructed of high wet strength, moisture resistant beverage board.
2. Filter Media to be constructed of a 3-stage media system;
  - a. Stage 1: Prefilter Layer – constructed of a high loft polyester media, minimum  $\frac{3}{4}$ " thick, acting as a prefilter for particulate to extend the life of the carbon media.
  - b. Stage 2: Activated Carbon Layer – consists of a polyester substrate, impregnated with a high density of granular, 60% minimum activity-rated carbon. The amount of carbon per square foot of filter area shall be as follows:

Model Designation	Carbon Density (grams/sq. ft. filter face area)
Model of Choice	300

- c. Stage 3: Final Filter Layer – consists of an open cell, reticulated polyurethane foam media. The foam pad must wrap around the edges of the carbon material, fully encasing the pad, to ensure no carbon granules are shed downstream.
- d. Carbon Activity – the carbon shall be granular with a 60% minimum activity rating on carbon tetrachloride adsorbate, tested at 25° C.
- e. Filter Frame to consist of two die-cut pieces of clay coated beverage board, one for the air entering side and one for the air leaving side. Each piece of the two mating halves of the frame overlaps one another providing double ply frame sides. The inside of the filter frame shall be bonded to the media on both sides of the filter.
- f. An expanded metal grid shall be installed on the downstream side filters to provide additional strength and support to the filter.

## 2.8 INSTRUMENTATION

- A. Magnehelic Differential Pressure Filter Gages: Nominal 100 mm (four inch) diameter, zero to 500 Pa (zero to two inch water gage), three inch for HEPA) range, except for MERV 17 HEPA Final Filters, where the range shall be zero to 750 Pa (zero to three inch water gage) Gauges shall be flush-mounted in aluminum panel board, complete with static tips, copper or aluminum tubing, and accessory items to provide zero adjustment.
- B. DDC static (differential) air pressure measuring station. Refer to Division 25, INTEGRATED AUTOMATION.
- C. Provide one DDC sensor across each extended surface filter. Provide Petcocks for each gauge or sensor.
- D. Provide one common filter gauge for two-stage filter banks with isolation valves to allow differential pressure measurement.

## 2.9 HVAC EQUIPMENT FACTORY FILTERS

- A. Manufacturer standard filters within fabricated packaged equipment should be specified with the equipment and should adhere to industry standard.
- B. Cleanable filters are not permitted.
- C. Automatic Roll Type filters are not permitted.

## 2.10 FILTER RETURN GRILLES

- A. Refer to Section 23 37 00 AIR OUTLETS AND INLETS.

# PART 3 – EXECUTION

## 3.1 INSTALLATION

- A. Install supports, filters and gages in accordance with manufacturer's instructions.
- B. Label clearly with words "Contaminated Air" on exhaust ducts leading to the HEPA filter housing.

## 3.2 START-UP AND TEMPORARY USE

- A. Clean and vacuum air handling units and plenums prior to starting air handling systems.
- B. Install or deliver replacement filter units as directed by the Resident Engineer.

--- END ---

SECTION 23 72 00  
AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

1. This Section specifies rotary air-to-air heat exchangers and run-around heat recovery systems.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS: Requirements for pre-test of equipment.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 21 23, HYDRONIC PUMPS: Requirements for pumping equipment.
- D. Section 23 07 11, HVAC INSULATION: Requirements for piping insulation.
- E. Section 01 91 13, COMMISSIONING: Requirements at commissioning, readiness checklists and training.
- F. Section 23 21 13, HYDRONIC PIPING: Requirements for piping for expansion tanks.
- G. Section 23 82 16, AIR COILS: Requirements for run-around system coils.
- H. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: Requirements for sheet metal ducts and fittings.
- I. Section 23 40 00, HVAC AIR CLEANING DEVICES: Requirements for filters used before heat recovery coils.
- J. Section 23 05 93, TESTING, ADJUSTING and BALANCING FOR HVAC: Requirements for testing, adjusting and balancing of HVAC system.
- K. Division 25, INTEGRATED AUTOMATION: Requirements for controls, instrumentation and monitoring.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, GUARANTEE in specification Section 00 72 00, GENERAL CONDITIONS.
- B. Refer to paragraph QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

- C. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.
- D. Performance Criteria: Heat recovery equipment shall be provided by a manufacturer who has been manufacturing such equipment and the equipment has a good track record for at least 3 years.
- E. Performance Test: In accordance with PART 3.
- F. Warranty for rotary air-to-air heat exchangers shall be 10 years on parts and labor.

#### 1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
  - 1. Rotary Heat Exchanger
  - 2. Plate Heat Exchanger
  - 3. Run-Around Energy Recovery System
- C. Certificate: Submit, simultaneously with shop drawings, an evidence of satisfactory service of the equipment on three similar installations.
- D. Submit type, size, arrangement and performance details. Present application ratings in the form of tables, charts or curves.
- E. Provide installation, operating and maintenance instructions, in accordance with Article, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.
- F. Completed System Readiness Checklists provided by the Commissioning Agent and completed

#### 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating, and Refrigeration Institute (AHRI)  
AHRI 1060-2005.....Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment
- C. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):  
52.1-92 .....Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter  
52.2-07 .....Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size  
84-08.....Method of Testing Air-to-Air Heat/Energy Exchangers

- D. American Society for Testing and materials (ASTM)
  - D635-10.....Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
  - E84-10.....Standard Test Method for Surface Burning Characteristics of Building Materials
- E. Underwriters Laboratories, Inc (UL)
  - 1812-2009 .....Standard for Ducted Heat Recovery Ventilators
  - 1815-2009 .....Standard for Non-Ducted Heat Recovery Ventilators

## PART 2 - PRODUCTS

### 2.1 ROTARY AIR-TO-AIR HEAT EXCHANGER:

- A. Exchanger Rotor or Wheel: Aluminum transfer media with a flame spread rating of 25 and less and smoke developed rating of 50 and less, and independently tested in accordance with ASTM standard E-84-09. Rotor media shall be independently tested in accordance with ASHRAE Standard 84-09. It shall allow laminar flow (but not radial) when operating within published operating airflow ranges and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 800 micron particles without fouling or clogging. Treat media with non-degrading molecular sieve desiccant coating that is hygroscopic, bacteriostatic, non-corroding and non-toxic. No asbestos material will be allowed. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with AHRI Standard 1060. All edges shall have an anti-corrosion epoxy coating.
- B. Rotor: Polymer segmented wheel strengthened with radial spokes impregnated with non-migrating, water-selected, 3 Angstrom molecular-sieve desiccant coating.
  - 1. Maximum Solid Size for media to pass: 800 microns.
- C. Casings shall be sealed on periphery of rotor as well as on duct divider and purge section. Seals shall be adjustable, of extended life materials and effective in limiting air leakage. The seals shall be of a maintenance free "non-contact" type to eliminate wear, excessive drag and resulting added horsepower required for the motor drive system, while still being capable of resisting high pressure differences. The seals shall be made in two sections – an extruded rubber seal of a 4-pass labyrinth "turbine" type design minimum  $\frac{3}{4}$ " thick and an extruded aluminum strip with adjustment slots for fastening bolts to the casing frame. The seal system must be able to withstand a pressure difference up to 12 in., w.c. without deflecting or causing excessive air leakage. The seals shall be adjustable and set to within 0.05 inch of the rotor surface.
- D. The structural frame and casing shall be designed and manufactured so as to allow a maximum rotor deflection of 1/32 inch, as measured at the outer radius, during maximum rated airflow condition.
- E. Wheel shall be supported by tapered roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction. External tapered roller bearings with double set screw locking collars shall be provided and sized for a minimum L-10 life of 1,000,000 hours of operation and shall be changeable without a complete disassembly of the rotor. Shaft journals shall be machined to proper tolerance as specified by the bearing manufacturer.

Shaft shall be machined as to provide a shoulder against the bearings for a positive locked position to eliminate any lateral movement of the rotor due to axial bearing loads. Grease fittings shall be easily accessible. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

1. Variable-speed exchanger wheels shall have exchanger wheel speed and leaving-air temperature controlled by means of a variable-speed motor controller. The speed shall be controlled as noted in paragraph G below. Operation shall be from 115/1/60 and by a proportioning temperature controller which shall vary output voltage of a silicon controlled rectifier (SCR) to a rectified power motor which will change speed in proportion to changes of voltage to its armature. Automatic changeover for summer-winter operations shall be controlled by an adjustable thermostatic switch. Set point of adjustable proportioning temperature controller and thermostatic switch shall be indicated on visible scale. System shall be capable of speed reduction down to 5 percent of capacity while maintaining adequate torque at any point of operation to rotate wheel.
  - F. An automatic, factory-fabricated, field-adjustable purge unit shall limit exhaust air carry-over to less than 1.0 percent of rated volume. Purge shall be effective when static pressure difference between supply and exhaust is 125 Pa (one-half, inch wg) or greater, and it shall have provision for restriction or adjustment to limit purge air volume to not over five percent of rated air flow when a static pressure difference up to 2.5 kPa (10 inch wg) exists.
  - G. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to ensure easy access to internal parts and have integral flanges for flanged duct connection and lifting holes or lugs.
  - H. Controls starting relay shall be factory mounted and wired, and include a manual motor starter for field wiring. Variable frequency controller shall be factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. When exhaust-air temperature is less than outdoor-air temperature, the rotor shall be at maximum speed.
    1. Pilot-Light Indicator: Display rotor rotation and speed.
    2. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
  - I. Filters: Refer to Section 23 72 00, CUSTOM INDOOR CENTRAL STATION AIR HANDLING UNITS and Section 23 40 00 HVAC AIR CLEANING DEVICES.
- 2.2 AIR-TO-AIR PLATE HEAT EXCHANGER
- A. Comply with UL Standards 1812.
  - B. Plates: Corrugated 0.53 mm (0.021 inch) diamond embossed aluminum with spacing as recommended by the manufacturer.
  - C. Bedding: Thermosetting reinforced resin. Provide plate seal-off and passage separation at top, bottom and center divider. The resins shall be self-extinguishing type in accordance with ASTM D635.



- D. Casing and End Strips: Casing of 1.6 mm (16 gage) galvanized steel, except casings for corrosive air streams shall be stainless steel. End strips of the same material as exchanger plates. Ends of unit exchanger plates shall be sealed with high temperature silicon sealant prior to installation of end strip for corrosive air streams provide welded end strips to avoid cross contaminations.
- E. Casings shall have integral flanges for flanged duct connections and shall have lifting holes or lugs.
- F. Drain Pan: Same material as unit casing. Drain-pan surface shall be covered with molded ABS, and shall have drain connections on exhaust and supply side. Comply with requirements in ASHRAE 62.1-2004.
- G. Corrosion Protection: The Building 6 Therapy Pool air handling unit air-to-air plate heat exchanger shall have epoxy coating on all surfaces in contact with the supply and exhaust air streams. Minimum coating thickness shall be 5 microns.
- H. Accessories: Furnish where indicated on the drawings.
  - 1. Face and Bypass Dampers: Manufacturer's standard, complete with operators, with factory-installed controls to operate face-and-bypass dampers during summer and winter.
- I. Filters: Refer to Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR HANDLING UNITS and to Section 23 40 00 HVAC AIR CLEANING DEVICES.

## 2.3 RUN-AROUND ENERGY RECOVERY SYSTEM

- A. System shall be field fabricated, as shown, containing coils, piping and 25 percent glycol, pumps, insulation, and accessories.
- B. Automatic Temperature Controls and Sequence of Operations: As shown on drawings and as specified in Division 25, INTEGRATED AUTOMATION.
- C. Components shall comply with requirements in the following specification sections:
  - 1. Pumps: Section 23 21 23, HYDRONIC PUMPS
  - 2. Insulation: Section 23 07 11, HVAC INSULATION
  - 3. Pipes, Fittings, and Specialties: Section 23 21 13, HYDRONIC PIPING
  - 4. Coils: Section 23 82 16, AIR COILS
  - 5. Controls: Division 25, INTEGRATED AUTOMATION

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Follow the equipment manufacturer's instructions for handling and installation, and setting up of ductwork for makeup and exhaust air streams for maximum efficiency.
- B. Rotary Air-to-Air Exchanger: Adjust seals and purge as recommended by the manufacturer. Verify correct installation of controls.
- C. Seal ductwork tightly to avoid air leakage.

- D. Install units with adequate spacing and access for cleaning and maintenance of heat recovery coils as well as filters.

### 3.2 FIELD QUALITY CONTROL

- A. Operational Test: Perform tests as per manufacturer's written instructions for proper and safe operation of the heat recovery system.
  - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Adjust seals and purge.
  - 3. Test and adjust controls and safeties.
- B. Replace damaged and malfunctioning controls and equipment.
- C. Set initial temperature and humidity set points. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Prepare test and inspection reports to the Senior Resident Engineer in accordance with specification Section 01 00 00, GENERAL REQUIREMENTS.

### 3.3 INSTRUCTIONS

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of heat recovery equipment.

### 3.4 START UP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Resident Engineer and Commissioning Agent. Provide a minimum of 7 days prior notice.
- B. Rotary air-to-air heat exchangers shall have field deflection test performed following installation. Rotor deflection shall not exceed maximum specified under design airflow conditions.

### 3.5 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

## 3.6 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

**--- E N D ---**

SECTION 23 73 00  
CUSTOM INDOOR CENTRAL-STATION AIR HANDLING UNITS

## PART 1 - GENERAL

## 1.1 DESCRIPTION

- A. Air handling units including integral components specified herein.
- B. Definitions: Custom Indoor Air-Handling Unit (AHU): A custom factory fabricated and tested assembly of modular sections consisting of fan, coils, filters, plenums, dampers, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

## 1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Sound and vibration requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- C. Piping and duct insulation: Section 23 07 11, HVAC INSULATION.
- D. Commissioning: Section 01 91 13, COMMISSIONING.
- E. Piping and valves: Section 23 21 13, HYDRONIC PIPING.
- F. Heating and cooling coils and pressure requirements: Section 23 82 16, AIR COILS.
- G. Supply, return, and exhaust fans: Section 23 34 00, HVAC FANS.
- H. Requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining, and air leakage: Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS.
- I. Air filters and filters' efficiency: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- J. HVAC controls: Division 25, INTEGRATED AUTOMATION.
- K. Testing, adjusting and balancing of air and water flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- L. Types of motors: Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- M. Types of motor starters: Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- N. Variable Frequency Drives: Section 23 05 14, VARIABLE FREQUENCY DRIVES.

- O. Heat recovery heat wheels: Section 23 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

### 1.3 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Air Handling Units Certification: Certify air-handling units in accordance with ARI 430.
- C. Heating, Cooling, and Air Handling Capacity and Performance Standards: ARI 430, ARI 410, ASHRAE 51, and AMCA 210.
- D. Performance Criteria:
  - 1. The fan schedule indicates design CFM – Design Cubic Feet per Minute. The Fan motor BHP (KW) at the operating point on the fan curves shall be increased by 10% (safety factor) to cover the drive losses and field conditions. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
  - 2. Select the fan operating point as follows:
    - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point.
    - b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency.
  - 3. Operating Limits: AMCA 99.
- E. Units shall be constructed by a manufacturer who has been manufacturing air handling units for at least five (5) years.
- F. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

### 1.4 SUBMITTALS

- A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish a complete submission for all air handling units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.
- B. Manufacturer's Literature and Data:
  - 1. Submittals for AHUs shall include fans, drives, motors, coils, humidifiers, sound attenuators, mixing box with outside/return air dampers, heat wheels, dampers, filter housings, blender sections, and all other related accessories.

- The Contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, diffusion plates, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points and requirements, unit support system, vibration isolators, drain pan, piping connections, pressure drops through each component (filter, coil etc).
2. Submittal drawings of section or component only will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements. This data shall be submitted in hard copies and in electronic version compatible to REVIT as approved by the VA prior to submittal preparation.
  3. Submit sound power levels in each octave band for fan and at entrance and discharge of AHUs at scheduled conditions.
  4. Provide fan curves showing cubic feet per minute, static pressure, efficiency, and horsepower for design point of operation and at maximum design cubic feet per minute.
  5. Submit total fan static pressure, external static pressure, for AHU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.
  6. Manufacturer's Instructions: Indicate assembly, support details, connection requirements and start up instructions.
- C. Maintenance and operating manuals in accordance with Section 01 78 23, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.
- D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.
- E. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.
1. Units shall be shipped in one (1) piece or in as few sections as possible and in shrink wrapping to protect the unit from dirt, moisture and road salt.
  2. If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.
  3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g. bolts, gaskets etc.) will be included to assemble unit on site (see section 2.1.A4).
  4. Lifting lugs will be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.
  5. Provide additional shipping and rigging supports for sections with instructions for the Contractor for what to remove and when.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)/(ARI):
  - 410-01 ..... Standard for Forced-Circulation Air-Heating and Air-Cooling Coils
  - 430-09 ..... Central Station Air Handling Units
- C. Air Movement and Control Association International, Inc. (AMCA):
  - 210-07 ..... Laboratory Methods of Testing Fans for Rating
- D. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
  - 170-2008 ..... Ventilation of Health Care Facilities
- E. SMACNA HVAC Duct Construction Standards – Metal and Flexible
- F. Military Specifications (Mil. Spec.):
  - MIL-P-21035B-2003 ..... Paint, High Zinc Dust Content, Galvanizing Repair (Metric)
- G. National Fire Protection Association (NFPA):
  - NFPA 90A..... Standard for Installation of Air Conditioning and Ventilating Systems, 2009
  - NFPA 70 ..... National Electric Code
- H. Energy Policy Act of 2005 (P.L.109-58)

## PART 2 - PRODUCTS

### 2.1 AIR HANDLING UNITS

- A. General:
  - 1. AHUs shall be entirely of double wall galvanized steel construction without any perforations except as specified in section 2.1.C.2. Casing is specified in paragraph 2.1.C. Foil face lining is not an acceptable substitute for double wall construction. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.90 oz. of zinc per square foot (G90). Aluminum constructed units may be provided subject to VA approval and documentation that structural rigidity is equal or greater than the galvanized steel specified.
  - 2. The contractor and the AHU manufacturer shall be responsible for insuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components.
  - 3. AHUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The unit shall be assembled into the largest sections possible subject to shipping and rigging restrictions. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. All units shall be fully assembled, tested and then split to accommodate shipment and job site rigging. On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the job site. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.

4. The AHU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a local representative at the job site to supervise the assembly and to assure the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation that this representative has provided this service on similar jobs to the Contracting Officer. If a local representative cannot be provided, the manufacturer shall provide a factory representative.
5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.
6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed 1/200 of the span based on a differential static pressure of  $\pm 8$  inch WG. Span may be reduced by adding additional supports. Deflection shall be measured at the worst case location, center of the panel at the center of the span.

B. Base:

1. Provide a heavy duty steel base for supporting all major AHU components. Bases shall be constructed of wide-flange steel I-beams, channels, or minimum 6 inch high 10 Gauge steel base rails. Welded or bolted cross members shall be provided as required for lateral stability. Contractor shall provide supplemental steel supports as required to obtain proper unit weight distribution and operation heights for cooling coil condensate drain trap as shown on drawings.
2. AHUs shall be completely self supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended as shown on drawings.
3. The AHU bases not constructed of galvanized steel shall be cleaned, primed with a rust inhibiting primer, and finished with rust inhibiting exterior enamel.

C. Casing (including wall, floor and roof):

1. General: AHU casing shall be constructed as solid double wall, galvanized steel insulated panels without any perforations, integral of or attached to a structural frame. The thickness of insulation, mode of application and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU located in the non-conditioned spaces at 85°F db and 78°F wb.
2. Casing Construction: Units with direct outside air equal or greater than 50% of design supply air volume (Foam Panel or Fiberglass Panel)

Table 2.1.C.2

Outer Panel	22 Gage Minimum
Inner Panel	20 Gage Minimum
Insulation Thickness	Foam or Fiberglass 3 inch Minimum
Density	3.0 lb/ft <sup>3</sup> Minimum
Septum Wall	20 Gage Minimum
Floor Interior	16 Gage Minimum
Under Floor Liner	22 Gage
Roof	16 Gage Minimum
Safeing at Cooling Coil	16 Gage Stainless Steel
Other	16 Gage
Total R Value	18 ft <sup>2</sup> .°F.hr/Btu Minimum



3. Casing Construction: Units with direct outside air less than 50% of design supply air volume (Foam Panel or Fiberglass Panel)

Table 2.1.C.2

Outer Panel	22 Gage Minimum
Inner Panel	20 Gage Minimum
Insulation Thickness	Foam or Fiberglass 2 inch Minimum
Density	3.0 lb/ft <sup>3</sup> Minimum
Septum Wall	20 Gage Minimum
Floor Interior	16 Gage Minimum
Under Floor Liner	22 Gage
Roof	16 Gage Minimum
Safeing at Cooling Coil	16 Gage Stainless Steel
Other	16 Gage
Total R Value	12 ft <sup>2</sup> .°F.hr/Btu Minimum

4. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.
5. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.
6. Access Doors: Provide in each access section and where shown on drawings. Doors shall be same thickness and double wall construction as the unit casing. Doors shall be a minimum of 24 inches wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 6 feet. Doors shall be gasketed, hinged, and latched to provide an airtight seal. Access doors for fan section, mixing box, humidifier coil section shall include a minimum 10 inch x 10 inch or 10 inch round, of double thickness, with air space between the glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.
- Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 100 lb weight hung on latch side of door. Door hinges shall be stainless steel.
  - Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 45 degrees further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 8 inch WG.
  - Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.
  - Provide removable access panels in unit sections where interior components are larger than the door. Panels shall be of same construction as the walls of the unit.
7. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.

## D. Floor:

1. Unit floor shall be level without offset space or gap and designed to support a minimum of 100 lbs per square foot distributed load without permanent deformation or crushing of internal insulation. Maximum deflection shall be  $L/240$  at design loading. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation. Unit floors in casing sections, which may contain water or condensate, shall be welded watertight with drain pan, minimum 3" high. The watertight floor shall NOT be used as part of the coil drain pan collection system.
2. Where indicated, furnish and install floor drains, flush with the floor, with nonferrous grate cover and stub through floor for external connection.

## E. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 1.7 inches and shall handle all condensate without overflowing. Drain pan shall be double-wall, double sloping type, and fabricated from stainless steel 304 with at least 2 inch thick insulation sandwiched between the inner and outer surfaces. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.

1. An intermediate, stainless-steel 304 condensate drip pan with copper downspouts shall be provided on stacked cooling coils. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
3. Installation, including frame, shall be designed and sealed to prevent blow-by.
4. Base pan shall extend beyond the leaving edge of the coils by a dimension equal to 0.50 times the combined height of the cooling coil bank.

## F. Roof

1. Unit roof shall be level without offset space or gap and designed to support a minimum of 75 lbs. per square foot distributed load without permanent deformation or crushing of internal insulation. Maximum deflection shall be  $L/360$  at design load.
2. Provide additional internal roof support for point loads for equipment removal and replacement. All equipment ceiling mounted lifting lugs shall be sized for a minimum of 1.5 times the weight of the component being replaced, i.e., fan, coil, motor, etc.

## G. Centrifugal Fan Sections

## 1. General

- a. Refer to Section 23 34 00, HVAC FANS.
- b. Unless otherwise noted, fans shall be unhooded (plenum style) centrifugal fans of direct drive, arrangement 4.
- c. Fan selection and ratings shall be based on tests made in accordance with ASHRAE 51 and AMCA 210 and shall be licensed to bear the AMCA seal.
- d. Fan Construction Class shall be as noted on the drawings.
- e. Fans shall be labeled in accordance with UL 705 – Standard for Power Ventilators.
- f. Fan wheels shall be airfoil type with a minimum of (10) blades.

- g. Fans shall have sharply rising pressure characteristics at the operating point specified and shall be quiet and stable in operation. Horsepower characteristics shall be self-limiting and at peak value at the specified operating point.
  - h. The specified fan RPM, outlet velocity, and tip speed are the maximum acceptable. The motor horsepower, CFM, and static pressure are the minimum acceptable.
  - i. Fan arrangements shall be minimum AMCA pressure class, single-width, single-inlet or double-width, double-inlet, clockwise or counter-clockwise rotation, shall be as scheduled on the drawings and as coordinated by the Contractors in the field.
  - j. Each fan shall be fully assembled with motor and drive on a structural steel base and run tested at the factory prior to shipment of the unit.
  - k. Where indicated on the drawings, fan shall be furnished with factory-mounted inlet air flow measuring station.
  - l. After field installation, compliance with fan vibration requirements shall be demonstrated with field test in accordance with this Section, Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, and Section 23 05 93, TESTING, ADJUSTING AND BALANCING FOR HVAC.
- 2. Fan Base
  - a. Fan with motor and drive shall be mounted on a structural steel base having a minimum 6" depth.
  - b. The base shall be electrically welded, and after welding, the base shall be cleaned, primed and painted to match fan coating.
  - c. Base steel sizing and construction shall be sufficient to allow the entire assembly to withstand the rigors of shipping and rigging.
  - d. Base shall be provided with lifting lugs and motor slide rails.
  - e. Fans with inertia bases as indicated in equipment schedules on mechanical drawings shall have structural bases constructed to accommodate concrete after installation.
  - f. Where indicated on the drawings, supply air fans shall be mounted on concrete inertia bases with concrete poured by unit manufacturer.
  - g. All bases shall be constructed with gusseted brackets to accommodate field installed spring isolators as specified under Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- H. Unit manufacturer shall provide all dampers at units as indicated on the documents, outside air, return air, isolation, etc. Damper blades shall be stainless steel or aluminum type. Dampers shall have metal compressible jamb seals and extruded vinyl or metal blade edge seals. Dampers shall rotate on stainless steel bearings. Leakage rate shall not exceed 2.5 cubic meters/minute/square meter (8 CFM per sq. foot) at 250 Pa (1 inch WG) for a 48" x 48" damper size. Dampers and operators shall be furnished and factory installed by AHU manufacturer. Dampers shall be industrial grade suitable for maximum system pressure of  $\pm 12$ " w.g. Damper operators shall be of the same manufacturer as controls furnished under Division 25, INTEGRATED AUTOMATION.
- I. Mixing Boxes: Mixing box shall consist of casing and outdoor air and return air dampers in opposed blade arrangement with damper linkage for automatic operation. Coordinate damper operator with Division 25, INTEGRATED AUTOMATION. Dampers shall be of ultra-low leak design with metal compressible bronze jamb seals and extruded vinyl edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings. Leakage rate shall not exceed 1.6 cubic 5 CFM per square foot at 1 inch WG and 9 CFM per square foot at 4 inch WG Electronic operators shall be furnished and mounted in an accessible and easily serviceable location by the air handling unit manufacturer at the factory. Damper operators shall be of same manufacturer as controls furnished under Division 25, INTEGRATED AUTOMATION.

- J. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.
1. Filters including one complete set for temporary use at site shall be provided independent of the AHU. The AHU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The AHU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown on drawings) required for AHU testing.
  2. Factory-fabricated filter section shall be of the same construction and finish as the AHU casing including filter racks and hinged double wall access doors. Filter housings shall be constructed in accordance with side service or holding frame housing requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.
  3. Air-Handling Units serving surgical suites shall have after filters located on the downstream side of the supply air fans and cooling coils. Provide a diffuser section between the fan and the after-filters to ensure uniform air distribution. The final filters shall be HEPA filters located prior to the air outlets.
- K. Diffuser Section: Furnish a diffuser segment with perforated diffuser plate immediately downstream of supply fan to assure uniform distribution of leaving air across the face of the downstream cooling coil and filters to create uniform velocity profiles across the entire opening. Bolt or weld diffuser plate to a sturdy steel support frame so that it remains rigid. Manufacturer shall include any diffuser section pressure loss in excess of diffuser plate and this value shall be included in unspecified internal losses when selecting fan.
- L. Coils: Coils shall be mounted on stainless steel supports to assure proper anchoring of coil and future maintenance. Coils shall be face removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide factory installed extended supply, return, drain, and vent piping connections. For air handling units with greater than 50% outside air at design load, provide copper fins for all coils. Refer to Drawings and Section 23 82 16, AIR COILS for additional coil requirements.
- M. Humidifier: When included in design, coordinate the humidification requirements with section 23 84 13 Humidifiers. Provide humidification section with welded aluminum or stainless steel drain pan of adequate length to allow complete absorption of water vapor. Provide humidifiers with stainless steel dispersion panel or distributors as indicated, with stainless steel supports and hardware.
- N. Sound Attenuators: Refer to Drawings, Specification Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, and Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS, for additional unit mounted sound attenuator requirements. AHU sound attenuators shall be factory installed as an integral part of AHU.
- O. Discharge Section: Provide aerodynamically designed framed discharge openings or spun bellmouth fittings to minimize pressure loss.
- P. Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL.
1. Provide a complete factory wired electrical system for each unit, so as to allow single-source responsibility and to ensure proper selection and installation of all electrical components.

2. The unit manufacturer shall provide prewired and switched non-corroding vapor-tight marine lights in each compartment that has an access door and in the service corridors as follows:
  - a. Lights shall be suitable for use in wet and damp locations.
  - b. Lighting, internal wiring, switching mounted in bell boxes, and all other electrical wiring associated with the lighting shall be provided by the unit manufacturer, at the factory.
  - c. Lights shall have 120 volt cold weather (-20°F) ballasts and shall comply with UL 1570 and shall carry the UL label.
3. Provide duplex 20-amp electrical outlets with ground fault intervention suitable to be utilized for power tools.
  - a. Unit manufacturer shall provide (2) 120 volt, single-phase 20-amp electric connections for the lights and receptacles (separate circuit for lights, receptacles), via junction boxes with circuit breakers for connection in the field by the Electrical Contractor (20 amperes power supply).
4. The air handling unit manufacturer shall provide a non-fused safety disconnect switch (with interlocking VFD Contactors) for each fan, factory wired to the fan by the air handling unit manufacturer. Power wiring from the power source to each VFD and from VFD to each fan disconnect switch (including wiring of interlock contacts between VFD and disconnect) shall be provided by the Electrical Contractor under Division 26.
5. Coordinate location and switching arrangement to ensure that layout shown on the drawings is followed strictly. Lighting system for each unit shall be wired through switches and extended to a terminal block at the side, one at each end of the unit, of each unit ready to accept 120V power. Provide (2) 3-way light switches for each AHU to activate all of the lights inside the unit sections that have access doors on that "side" of the unit from either switch. Provide similar switching arrangement for any piping spaces provided.
6. Provide weatherproof 120 VAC electrical outlets prewired to a terminal block on the side of the unit.
  - a. Wiring and Conduit (By Unit Manufacturer)
    - 1) The unit wiring shall be No. 12 GA minimum stranded copper wire sheathed in a THHN covering, which will be distributed through the unit in Rigid steel conduit, IMC or EMT.
      - a) The use of aluminum wire or flexible BX cable is prohibited.
    - 2) To allow for adjustment of fan motors provide:
      - a) 3'-0" section of MC Cable shall be provided at each motor.
      - b) MC Cable shall:
        - (1) Shall comply with NEC 300.22.
        - (2) Shall be suitable for indoor and outdoor locations.
        - (3) Shall be suitable for wet locations
    - c) A separate ground wire for each motor shall be connected to a terminal strip in the disconnect switch.

- 3) Enclosures
  - a) Outdoor electrical enclosures shall have a NEMA 3R rating.
  - b) Indoor enclosures shall be rated NEMA 12.
- 4) In addition to requirements outlined herein, all wiring shall comply with:
  - a) NEC requirements.
  - b) Division 26 of this specification.

#### 7. Space Limitations

- a. The air handling units shall be designed within the dimensions and space limitations, as indicated on the drawings and as specified.
- b. The unit manufacturer shall take these dimensions and space limitations into consideration for the design required and shall submit dimensional data on the drawings.
- c. Advise the Engineer early in the bid process should any problems be detected with existing space limitations.

### PART 3 – EXECUTION

#### 3.1 INSTALLATION

- A. Install air handling unit in conformance with ARI 435.
- B. Assemble air handling unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035. Vacuum the interior of air handling units clean prior to operation.
- C. Leakage and test requirements for air handling units shall be as specified herein.
- D. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- E. Seal and/or fill all openings between the casing and AHU components and utility connections to prevent air leakage or bypass.

#### 3.2 STARTUP SERVICES

- A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.
- B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.

- C. An authorized factory representative and the Contractor shall start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc. The factory representative shall submit a written start-up report to the Architect.

### 3.3 FACTORY TESTING

- A. A minimum of three (3) units shall be tested by the unit manufacturer prior to shipping. The tested units shall include a minimum of one unit of each type (DOAS, supply/return, etc.). Required factory tests shall be as follows:

1. Factory Full Load Flow Test:

- a. Air volume and static pressure test shall verify that the air volume is within the range of 100% to 110% of scheduled nominal CFM requirements when operating at design static pressure.
- b. The test for airflow and static capability shall include airflow measuring devices installed in all ducts returning to or leaving the unit.
- c. These devices shall be installed in accordance with the measuring device manufacturer's recommendations.
- d. Pressures external to the unit shall be simulated using a combination of ducts and dampers.
- e. The tests shall prove design airflow and static capability of the complete assembled unit.

2. Factory 50% Load Flow Test:

- a. In addition test all VAV units at a 50% turn down.
- b. Procedure similar to factory full load flow test.

3. Factory: Casing Leakage Test:

- a. Tests shall be run to prove that unit casing leakage is leakage Class 3 at  $\pm 8.0$ " w.c. Test shall be in accordance with SMACNA.
- b. The unit shall be tested on the positive side of the fan septum wall to +8" w.c. and on the negative side to -8" w.c. in two tests (not at the same time).
- c. The leakage of both tests is to be summed (added) to derive the total unit leakage.
- d. Factory test shall meet the specified values.
- e. The use of any temporary caulking at any permanent panel joints is unacceptable.
- f. Temporary test caulking shall be utilized at the unit shipping splits to simulate "as installed" conditions.

4. Factory Casing Deflection Test:

- a. Test unit casing deflection at 8" positive pressure and 8" negative pressure and measuring deflection with dial micrometer gauges.
- b. All measurements to be made at center of span, center of panel. Note if there are additional supports center span may not be center of panel.

5. Deficiencies

- a. Any deficiencies in unit performance must be corrected by the unit manufacturer in the manufacturing plant prior to shipping.

## 6. Test Procedures

- a. A complete test procedure shall be submitted for approval and shall include:
  - 1) Detailed the methods.
  - 2) All equipment to be employed for each specific test
  - 3) All techniques to be employed for each specific test.
  - 4) A copy of all instrument certifications shall be submitted and shall include as a minimum:
    - a) All air flow measuring devices.
    - b) Vibration meters.
    - c) Pressure measuring devices.
    - d) Electrical meters.
    - e) Dial measurement gauges.
  - 5) Equipment will not be considered approved until written approval of testing procedures is reviewed.
  - 6) Test reports shall be certified by a Registered Engineer in the state of the manufacturing facility, stamped and signed.

## 3.4 FIELD TESTING

- A. Each unit shall be tested, following installation and assembly in the field, as follows:

## 1. Field Pressure Test:

- a. Pressurized leak testing shall be performed in the field after assembly of the unit sections by the Contractor at  $\pm 8"$ .
- b. The unit manufacturer shall correct and/or pay for the repair of all deficiencies found during testing.
- c. The Contractor shall provide all field labor necessary to join the unit sections, including all electric and drain splits after they are delivered to the site and set in place.
- d. All field work shall be provided under the direct supervision of a qualified Engineer employed by the unit manufacturer.
- e. This test shall be performed within 2 weeks of the unit assembly and placement.

## 2. Drain Pan Test:

## a. Test

- 1) Check drain trap for seal
- 2) Plug pan
- 3) Flood drain pans with water to near top of drain pan
- 4) Pull plug with fan operating

## b. Acceptable results:

- 1) Shall drain completely in 3 minutes or less
- 2) Trap seal still functional
- 3) After three minutes NO puddles shall remain in the pan larger then 2 inches in diameter and no more then 3mm deep.



## 3. Field Vibration Test:

- a. All fans
- b. All VFD driven fans throughout the range of control.
- c. Each individual fan shall be tested for vibration in X-Y-Z directions at the manufacturer's facility before shipment to the unit manufacturer to assure that specified fan balancing criteria is adhered to.
- d. Unit manufacturer shall test each fan in operation as installed in the unit.

## 1) Vibration Test

## a) Centrifugal fan

- (1) Each fan shall be fully assembled with motor and drive on a structural steel base and run tested at the factory prior to shipment of the unit.
- (2) Testing shall be conducted at the operating speed or maximum fan class speed.
- (3) The amplitude of vibration (displacement in mils) at operating speed measured at each unit fan bearing shall not exceed the values given in the following table:
- (4) Maximum allowable:

Fan RPM	Displacement Mils
500	4.2
800	3.0
1100	2.3
1400	1.9
1700 or Greater	1.6

- e. Record VFD frequencies that exhibit excessive vibration due to natural harmonics. These "skip" frequencies shall be programmed out of VFD operation and included with VFD labeling and AHU documentation.

- B. Any deficiencies in the unit performance uncovered during field testing shall be corrected by the unit manufacturer in coordination with the HVAC Contractor.

## 3.5 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

## 3.6 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

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SECTION 23 73 13  
PACKAGED INDOOR CENTRAL STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Air handling units including integral components specified herein.
- B. Definitions: Packaged Indoor Air Handling Unit (AHU): A factory fabricated and tested assembly of modular sections consisting of housed-centrifugal fan with V-belt drive or plenum fan with direct-drive, coils, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Sound and vibration requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- C. Piping and duct insulation: Section 23 07 11, HVAC INSULATION.
- D. Commissioning: Section 01 91 13, COMMISSIONING.
- E. Piping and valves: Section 23 21 13, HYDRONIC PIPING.
- F. Heating and cooling coils and pressure requirements: Section 23 82 16, AIR COILS.
- G. Return and exhaust fans: Section 23 34 00, HVAC FANS.
- H. Requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining, and air leakage: Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS.
- I. Air filters and filters' efficiency: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- J. Energy Recovery Devices: Section 23 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT.
- K. Testing, adjusting and balancing of air and water flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- L. Types of motors: Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- M. Types of motor starters: Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
- N. Division 25, INTEGRATED AUTOMATION.

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1.3 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Air Handling Units Certification
  - 1. Air Handling Units with Housed Centrifugal Fans: The air handling units shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.
  - 2. Air Handling Units with a single Plenum Fan shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.
- C. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
- D. Performance Criteria:
  - 1. The fan BHP shall include all system effects for all fans and v-belt drive losses for housed centrifugal fans.
  - 2. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
  - 3. Select the fan operating point as follows:
    - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point.
    - b. Air Foil, Backward Inclined, or Tubular Fans Including Plenum Fans: At or near the peak static efficiency but at an appropriate distance from the stall line.
  - 4. Operating Limits: AMCA 99 and Manufacturer's Recommendations.
- E. Units shall be factory-fabricated, assembled, and tested by a manufacturer, in business of manufacturing similar air-handling units for at least five (5) years.
- F. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

## 1.4 SUBMITTALS:

- A. The Contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish a complete submission for all air handling units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.
- B. Manufacturer's Literature and Data:
  - 1. Submittals for AHUs shall include fans, drives, motors, coils, humidifiers, sound attenuators, mixing box with outside/return air dampers, filter housings and all other related accessories.

- The Contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, diffusion plates, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc).
2. Submittal drawings of section or component only will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements. This data shall be submitted in hard copies and in electronic version compatible to REVIT as approved by the VA at the time of submission.
  3. Submit sound power levels in each octave band for the inlet and discharge of the fan and at entrance and discharge of AHUs at scheduled conditions. In absence of sound power ratings refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
  4. Provide fan curves showing Liters/Second (cubic feet per minute), static pressure, efficiency, and horsepower for design point of operation and at maximum design Liters/Second (cubic feet per minute).
  5. Submit total fan static pressure, external static pressure, for AHU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.
- C. Maintenance and operating manuals in accordance with Section 01 78 23, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.
- D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.
- E. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.
1. Units shall be shipped in one (1) piece where possible and in shrink wrapping to protect the unit from dirt, moisture and/or road salt.
  2. If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.
  3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g. bolts, gaskets etc.) will be included to assemble unit on site (see section 2.1.A4).
  4. Lifting lugs will be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.

**1.5 APPLICABLE PUBLICATIONS**

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)/(ARI):
  - 410-01 ..... Standard for Forced-Circulation Air-Heating and Air-Cooling Coils
  - 430-09 ..... Central Station Air Handling Units
- C. Air Movement and Control Association International, Inc. (AMCA):
  - 210-07 ..... Laboratory Methods of Testing Fans for Rating
- D. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
  - 170-2008 ..... Ventilation of Health Care Facilities
- E. American Society for Testing and Materials (ASTM):
  - ASTM B117-07a ..... Standard Practice for Operating Salt Spray (Fog) Apparatus
  - ASTM D1654-08 ..... Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
  - ASTM D1735-08 ..... Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
  - ASTM D3359-08 ..... Standard Test Methods for Measuring Adhesion by Tape Test
- F. Military Specifications (Mil. Spec.):
  - MIL-P-21035B-2003 ..... Paint, High Zinc Dust Content, Galvanizing Repair (Metric)
- G. National Fire Protection Association (NFPA):
  - NFPA 90A ..... Standard for Installation of Air Conditioning and Ventilating Systems, 2009
- H. Energy Policy Act of 2005 (P.L.109-58)

**PART 2 - PRODUCTS****2.1 AIR HANDLING UNITS**

- A. General:
  - 1. AHUs shall be fabricated from insulated, solid double-wall galvanized steel without any perforations in draw-through configuration. Casing shall be fabricated as specified in section 2.1.C.2. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90). Aluminum constructed units, subject to VA approval, may be used in place of galvanized steel. The unit manufacturer shall provide published documentation confirming that the structural rigidity of aluminum air-handling units is equal or greater than the specified galvanized steel.
  - 2. The contractor and the AHU manufacturer shall be responsible for ensuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components.

All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost to the government.

3. AHUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The unit shall be assembled into the largest sections possible subject to shipping and rigging restrictions. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. All units shall be fully assembled, tested, and then split to accommodate shipment and job site rigging. On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the job site. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.
4. The AHU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a factory-trained and qualified local representative at the job site to supervise the assembly and to assure that the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation to the Contracting Officer that the local representative has provided services of similar magnitude and complexity on jobs of comparable size. If a local representative cannot be provided, the manufacturer shall provide a factory representative.
5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.
6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed 1/200 of the span based on a differential static pressure of 1991 PA (8 inch WG) or higher.
7. Corrosion Protection: Building 6 Therapy Pool Air Handling Unit shall have all casing components in contact with the airstream provided with a minimum of (2) coats for a minimum of 5 (dry) mil thick Phenolic coating. In addition, corrosion protection for coils, plate heat exchanger and fans shall be provided as specified in the respective sections.

B. Base:

1. Provide a heavy duty steel base for supporting all major AHU components. Bases shall be constructed of wide-flange steel I-beams, channels, or minimum 125 mm (5 inch) high 3.5 mm (10 Gauge) steel base rails. Welded or bolted cross members shall be provided as required for lateral stability. Contractor shall provide supplemental steel supports as required to obtain proper operation heights for cooling coil condensate drain trap as shown on drawings.
2. AHUs shall be completely self supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended as shown on drawings.
3. The AHU bases not constructed of galvanized steel shall be cleaned, primed with a rust inhibiting primer, and finished with rust inhibiting exterior enamel.

C. Casing (including wall, floor and roof):

1. General: AHU casing shall be constructed as solid double wall, galvanized steel insulated panels without any perforations, integral of or attached to a structural frame. The thickness of insulation, mode of application and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU located in the non-conditioned spaces.

## 2. Casing Construction:

Table 2.1.C.2

Outer Panel	0.8 mm (22 Gage) Minimum
Inner Panel	0.8 mm (22 Gage) Minimum
Insulation	Foam
Thickness	50 mm (2 inch) Minimum
Density	48 kg/m <sup>3</sup> (3.0 lb/ft <sup>3</sup> ) Minimum
Total R Value	2.3 m <sup>2</sup> .K/W (13.0 ft <sup>2</sup> .°F.hr/Btu) minimum

## 3. Casing Construction (Contractor's Option):

Table 2.1.C.3

Outer Panel	1.3 mm (18 Gage) Minimum
Inner Panel	1.0 mm (20 Gage) Minimum
Insulation	Fiberglass
Thickness	50 mm (2 inch) Minimum
Density	24 kg/m <sup>3</sup> (1.5 lb/ft <sup>3</sup> ) Minimum
Total R Value	1.4 m <sup>2</sup> .K/W (8.0 ft <sup>2</sup> .°F.hr/Btu) minimum

4. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.
5. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.
6. Access Doors: Provide in each access section and where shown on drawings. Show single-sided and double-sided access doors with door swings on the floor plans. Doors shall be a minimum of 50 mm (2 inch) thick with same double wall construction as the unit casing. Doors shall be a minimum of 600 mm (24 inches) wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 1850 mm (6 feet). Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan section, mixing box, coil section shall include a minimum 150 mm x 150 mm (6 inch x 6 inch) double thickness, with air space between the glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.
  - a. Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 45 kg (100 lb) weight hung on latch side of door.
  - b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 0.785 radian (45 degrees) further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 1991 Pa (8 inch WG).
  - c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.
7. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate with electrical and temperature control subcontractors for number and location of penetrations.



Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.

D. Floor:

1. Unit floor shall be level without offset space or gap and designed to support a minimum of 488 kg/square meter (100 lbs per square foot) distributed load without permanent deformation or crushing of internal insulation. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation. Unit floors in casing sections, which may contain water or condensate, shall be watertight with drain pan.
2. Where indicated, furnish and install floor drains, flush with the floor, with nonferrous grate cover and stub through floor for external connection.

E. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 43 mm (1.7 inches) and shall handle all condensate without overflowing. Drain pan shall be double-wall, double sloping type, and fabricated from stainless (304) with at least 50 mm (2 inch) thick insulation sandwiched between the inner and outer surfaces. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.

1. An intermediate, stainless-steel (304) condensate drip pan with copper downspouts shall be provided on stacked cooling coils. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
3. Installation, including frame, shall be designed and sealed to prevent blow-by.

F. Housed Centrifugal Fan Sections:

1. Fans shall be minimum Class II construction, double width, double inlet centrifugal, air foil or backward inclined type as indicated on drawings, factory balanced and rated in accordance with AMCA 210 or ASHRAE 51. Provide self-aligning, pillow block, regreasable ball-type bearings selected for a B (10) life of not less than 50,000 hours and an L (50) average fatigue life of 200,000 hours per AFBMA Standard 9. Extend bearing grease lines to motor and drive side of fan section. Fan shall be located in airstream to assure proper air flow.
2. Provide internally vibration isolated fan, motor and drive, mounted on a common integral bolted or welded structural steel base with adjustable motor slide rail with locking device. Provide vibration isolators and flexible duct connections at fan discharge to completely isolate fan assembly. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, for additional requirements.
3. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed.

After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).

G. Fan Motor, Drive, and Mounting Assembly (Housed Centrifugal Fans):

1. Fan Motor and Drive: Motors shall be premium energy efficient type, as mandated by the Energy Policy Act of 2005, with efficiencies as shown in the Specifications Section 23 05 12 (General Motor Requirements For HVAC Equipment), on drawings and suitable for use in variable frequency drive applications on AHUs where this type of drive is indicated. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC, for additional motor and drive specifications. Refer to Specification Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
2. Fan drive and belts shall be factory mounted with final alignment and belt adjustment to be made by the Contractor after installation. Drive and belts shall be as specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide additional drive(s) if required during balancing, to achieve desired airflow.

H. Plenum Fans:

1. General: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum bladed. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.
2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).

~~3. The plenum fans shall be driven by variable speed drives with at least one back-up drive as shown in the design documents. Use of a drive with bypass is not permitted.~~

**4.3. Fan Accessories**

- a. Fan Airflow Measurement: Provide an airflow measuring device integral to the fan to measure air volume within +/- 5 percent accuracy. The probing device shall not be placed in the airflow path to stay clear of turbulence and avoid loss of performance.

- I. Fan Motor, Drive, and Mounting Assembly (Plenum Fans):
1. Fan Motor and Drive: Motors shall be premium energy efficient type, as mandated by the Energy Policy Act of 2005, with efficiencies as shown in the Specifications Section 23 05 12 (General Motor Requirements For HVAC and Steam Equipment), on drawings and suitable for use in variable frequency drive applications. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC, for additional motor and drive specifications. Refer to Specification Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS
- J. Mixing Boxes: Mixing box shall consist of casing and outdoor air and return air dampers in opposed blade arrangement with damper linkage for automatic operation. Coordinate damper operator with Division 25, INTEGRATED AUTOMATION. Dampers shall be of ultra-low leak design with metal compressible bronze jamb seals and extruded vinyl edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings or bronze bushings. Leakage rate shall not exceed 1.6 cubic meters/min/square meter (5 CFM per square foot) at 250 Pa (1 inch WG) and 2.8 cubic meters/min/square meter (9 CFM per square foot) at 995 Pa (4 inch WG). Electronic operators shall be furnished and mounted in an accessible and easily serviceable location by the air handling unit manufacturer at the factory. Damper operators shall be of same manufacturer as controls furnished under Division 25, INTEGRATED AUTOMATION.
- K. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.
1. Filters including one complete set for temporary use at site shall be provided independent of the AHU. The AHU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The AHU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown on drawings) required for AHU testing.
  2. Factory-fabricated filter section shall be of the same construction and finish as the AHU casing including filter racks and hinged double wall access doors. Filter housings shall be constructed in accordance with side service or holding frame housing requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.
- L. Diffuser Section: Furnish a diffuser segment with perforated diffuser plate immediately downstream of supply fan to assure uniform distribution of leaving air across the face of the downstream after-filters to create uniform velocity profiles across the entire opening. Bolt or weld diffuser plate to a sturdy steel support frame so that it remains rigid. Manufacturer shall include any diffuser section pressure loss in excess of diffuser plate and this value shall be included in unspecified internal losses when selecting fan.
- M. Coils: Coils shall be mounted on hot dipped galvanized steel supports to assure proper anchoring of coil and future maintenance. Coils shall be face or side removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide factory installed extended supply, return, drain, and vent piping connections. Coils installed in air handling units with design requirement for outside air greater than 50% of total supply air shall be equipped with copper fins.

- N. Humidifier: When included in design, coordinate the humidification requirements with section 23 22 13 Steam and Condensate Heating Piping. Provide air-handling unit-mounted humidification section with stainless steel drain pan of adequate length to allow complete absorption of water vapor. Provide stainless steel dispersion panel or distributors as indicated, with stainless steel supports and hardware.
- O. Sound Attenuators: Refer to Drawings, Specification Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, and Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS, for additional unit mounted sound attenuator requirements. AHU sound attenuators shall be factory installed as an integral part of AHU.
- P. Discharge Section:
1. Provide aerodynamically designed framed discharge openings or spun bellmouth fittings to minimize pressure loss.
- Q. Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL.
1. Vapor-proof lights using cast aluminum base style with glass globe and cast aluminum guard shall be installed in access sections for fan, mixing box, and any section over 300 mm (12 inch) wide. A switch shall control the lights in each compartment with pilot light mounted outside the respective compartment access door. Wiring between switches and lights shall be factory installed. All wiring shall run in neatly installed electrical conduits and terminate in a junction box for field connection to the building system. Provide single point 115 volt - one phase connection at junction box.
  2. Install compatible 100 watt bulb in each light fixture.
  3. Provide a convenience duplex weatherproof receptacle next to the light switch.
  4. Disconnect switch and power wiring: Provide factory or field mounted disconnect switch. Coordinate with Division 26, ELECTRICAL.

### PART 3 – EXECUTION

#### 3.1 INSTALLATION

- A. Install air handling unit in conformance with ARI 435.
- B. Assemble air handling unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air handling units clean prior to operation.
- C. Leakage and test requirements for air handling units shall be the same as specified for ductwork in Specification Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS except leakage shall not exceed Leakage Class (C<sub>L</sub>) 12 listed in SMACNA HVAC Air Duct Leakage Test Manual when tested at 1.5 times the design static pressure. Repair casing air leaks that can be heard or felt during normal operation and to meet test requirements.
- D. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

- E. Seal and/or fill all openings between the casing and AHU components and utility connections to prevent air leakage or bypass.

### 3.2 STARTUP SERVICES

- A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.
- B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.
- C. An authorized factory representative should start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc.

### 3.3 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

### 3.4 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

--- END ---

## SECTION 23 81 23

## COMPUTER-ROOM AIR-CONDITIONERS

## PART 1 - GENERAL

## 1.1 DESCRIPTION

- A. This section specifies process cooling split systems air conditioning unit.
- B. Definitions:
  - 1. Unitary (ARI): Consists of one or more factory-made assemblies, which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function.

## 1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS: Requirements for pre-test of equipment.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 01 91 13, COMMISSIONING.
- D. Section 23 21 23, HYDRONIC PUMPS: Requirements for pumping equipment.
- E. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Requirements for vibration isolators and room noise level.
- F. Section 23 07 11, HVAC INSULATION: Requirements and for ducts and piping insulation.
- G. Section 23 21 13, HYDRONIC PIPING: Requirements for condensate piping and fittings.
- H. Section 23 31 00, HVAC DUCTS AND CASINGS: Requirements for sheet metal ducts and fittings.
- I. Section 23 40 00, HVAC AIR CLEANING DEVICES: Requirements for filters including efficiency.
- J. Section 23 05 93: TESTING, ADJUSTING, AND BALANCING FOR HVAC: Requirements for testing, adjusting and balancing of HVAC system.

## 1.3 QUALITY ASSURANCE

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

- B. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

#### 1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES.
- B. Manufacturer's Literature and Data, rated capacities operating characteristics, required specialties and accessories.
1. Indoor Air Conditioning Unit
- C. Submit detailed equipment assemblies with dimensions, operating weights, required clearances.
- D. Submit wiring diagrams for power, alarm and controls.
- E. Certification: Submit, simultaneously with shop drawings, a proof of certification:
1. That computer room air-conditioning units have been certified by ARI.
- F. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required sensible-to-heat-ratio.

#### 1.5 GUARANTEE

- A. The unit shall be guaranteed against all mechanical defects in material, arts or workmanship and shall be repaired or replaced at the Contractor's expense within the period of one year from final acceptance. Contractor shall adhere to a four hour service response time to troubles during the guarantee period.

#### 1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning and Refrigeration Institute (ARI) Standards:  
210/240-06 ..... Performance Rating of Unitary Air-Conditioning Equipment  
410-01 ..... Forced-Circulation Air-Cooling and Air-Heating Coils
- ARI-DCPP    Directory of Certified Product Performance - Applied Directory of Certified Products
- C. Air Movement and Control Association (AMCA):  
210-99 ..... Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI)



- D. American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE):  
15-04..... Safety Standard for Refrigeration Systems (ANSI)  
90.1-04 ..... Energy Standard for Buildings except Low-Rise Residential  
..... Buildings (ANSI Approved; IESNA Co-sponsored)  
2008 Handbook HVAC Systems and Equipment  
52.1-92 ..... Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning  
..... Devices used in General Ventilation for Removing Particulate Matter
- E. American Society of Testing and Materials (ASTM):  
B117-03 ..... Standard Practice for Operating Salt Spray (Fog) Apparatus
- F. National Electrical Manufacturer's Association (NEMA):  
MG 1-06..... Motors and Generators (ANSI)
- G. National Fire Protection Association (NFPA) Publications:  
70-05..... National Electrical Code  
90A-02 ..... Standard for the Installation of Air-Conditioning and Ventilating Systems

## PART 2 - PRODUCTS

## 2.1 CEILING-MOUNTED UNITS

- A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of 610 by 1220 mm (24 by 48 inches).
- B. Cabinet: Galvanized steel with baked-enamel finish, insulated with 13-mm (1/2-inch) thick duct liner.
- ~~C. Integral factory-supplied supply and return grille to fit ceiling grid kit of 610 by 1220 mm (24 by 48 inches), with filter.~~
- D.C.** Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- E.D.** Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
- F.E.** Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.
1. Cooling Medium: Building Chilled Water.
  2. Chilled water coil 2-way modulating control valve shall be motorized slow-acting type to reduce water hammer. Design pressure shall be 150 psig static pressure.
  3. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
- G.F.** Hot Water Reheat Coil: Seamless copper tubes expanded into aluminum fins.
1. The control system shall be factory pre-piped with a 2-way solenoid valve and cleanable Y-strainer.



**H.G.** Filter: 25-mm (1 inch) thick, disposable, glass-fiber media.

1. Recommended Final Resistance: 0.62 inches wg.
2. Initial Resistance: 0.25 inches wg.
3. Arrestance: 90 percent according to ASHRAE 52.1.
4. MERV Rating: 7 according to ASHRAE 52.2.

**I.H.** Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

**J.I.** Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.

**K.J.** Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.

**L.K.** Drain Cycle: Field-adjustable drain duration and drain interval.

**M.L.** Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

**N.M.** Control System: Unit-mounted panel with main fan contactor, control transformer with circuit breaker, solid-state temperature and humidity control heating contactor, and high-temperature thermostat. Wall-mounted control panel shall be solid-state, with start-stop switch adjustable humidity dirty set point, and adjustable temperature set point.

**O.N.** Remote Communication Connection: Open protocol gateway for communication with Building Automation System. Communication protocol shall be BACnet MS/TP.

## 2.2 FAN MOTORS

- A. Default motor characteristics are specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- B. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- C. Motor Sizes: Minimum size as indicated to operate in service factor range above 1.0.
- D. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

## 2.3 SPECIAL TOOLS

- A. If any part of equipment furnished under these specifications requires a special tool for assembly, adjustment, setting, or maintenance and the tool is not readily available from the commercial tool market, furnish the necessary tools with equipment as a standard accessory.

## 2.4 ALARMS

- A. The control system shall monitor unit operation and active an audible and visual alarm in the event of the following factory present alarm conditions.
1. High temperature
  2. Low temperature
  3. High humidity
  4. Low humidity
  5. Loss of power
  6. Filter clog

## 2.5 DISCONNECT SWITCH NON-LOCKING

- A. The non-automatic, non-locking, molded case circuit breaker shall be factory-mounted in the high voltage section of the electrical panel. The switch shall be accessible from the front of the unit.

## 2.6 FIRESTAT

- A. The firestat shall immediately shut down the system when high temperatures are detected. The firestat shall be mounted with the sensing element in the return air.

## 2.7 SMOKE DETECTOR

- A. The smoke detector shall immediately shut down the environmental control system and activate the alarm system when activated. The sensing element shall be located in the return air compartment.

# PART 3 – EXECUTION

## 3.1 INSTALLATION

- A. Handle and install refrigeration units and accessories in accordance with the instructions and recommendations of the manufacturer.
- B. Coordinate installation of Computer room Air Conditioning Units with Computer room access flooring installer.
- C. Field Piping: Chilled Water Piping, Hot water Piping and Condensate Drain Piping, as specified in specification Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
- D. Electrical System Connections and Equipment Ground: As specified in Division 26 Sections.

### 3.2 CONNECTIONS

- A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
- B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Water and Drainage Connections: Comply with applicable requirements to provide adequate connections for condensate drain, and humidifier flushing system.
- E. Chilled Water and Hot-Water Heating Piping: Comply with applicable requirements in Section 23 21 13, HYDRONIC PIPING. Provide shutoff valves in inlet and outlet piping to cooling and heating coils.

### 3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
  - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. After startup service and performance test, change filters and flush humidifier.

### 3.4 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

### 3.5 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

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SECTION 23 82 00  
CONVECTION HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies fan coil units.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise requirements.
- C. Section 01 91 13, COMMISSIONING.
- D. Section 23 21 13, HYDRONIC PIPING: Heating hot water and chilled water piping.
- E. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: Ducts and flexible connectors.
- F. Division 25, Integrated Automation.: Valve operators.
- G. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Flow rates adjusting and balancing.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
1. Fan-Coil units.

## C. Certificates:

1. Compliance with paragraph, QUALITY ASSURANCE.
2. Compliance with specified standards.

## D. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 78 23, GENERAL REQUIREMENTS.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (ARI):  
440-05 ..... Room Fan Coils
- C. National Fire Protection Association (NFPA):  
90A-02 ..... Standard for the Installation of Air Conditioning and Ventilating Systems  
70-05..... National Electrical Code
- D. Underwriters Laboratories, Inc. (UL):  
181-05 ..... Standard for Factory-Made Air Ducts and Air Connectors  
1995-05 ..... Heating and Cooling Equipment

## 1.6 GUARANTEE

- A. In accordance with FAR (Federal Acquisition Regulation) Clause 52.246-21.

## PART 2 - PRODUCTS

## 2.1 ROOM FAN-COIL UNITS

- A. Capacity Certification: ARI 440.
- B. Safety Compliance: NEC compliant and UL listed.
- C. Noise Levels: Operating at full cooling capacity, sound power level shall not exceed by more than 5 dB the numerical value of sound pressure levels associated with noise criteria specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Select units at intermediate speed, for compliance with the noise criteria.
- D. Chassis: Galvanized steel, acoustically and thermally insulated to attenuate noise and prevent condensation.

- E. Cabinet Type: Not lighter than 1.3 mm (18 gage) steel, reinforced and braced. Arrange components and provide adequate space for installation of piping package and control valves. Finish shall be factory-baked enamel color as selected by the Architect
  - 1. Horizontal Unit: Hinged bottom access panel with cam-lock fasteners. Provide stamped integral discharged grilles in front of cabinet.
  - 2. Concealed Units: Enclosed type with inlet and outlet duct collars.
- F. Fans: Centrifugal, direct drive, galvanized steel or polyester resin.
  - 1. Direct Drive Unit Motors: Electrically Commutated Motor (ECM) shall be brushless DC controlled by an integral controller / inverter that operates the wound stator and senses rotor position to electronically commutate the stator. Motor shall be permanent magnet type with near-zero rotor losses designed for synchronous rotation. The motor shall utilize permanently lubricated ball bearings. Motor shall maintain minimum 70% efficiency over the entire operating range. Motor speed control shall be accomplished through a PWM controller specifically designed for compatibility with the ECM. The speed controller shall have terminals for field verification of fan capacity utilizing a digital volt meter. A calibration graph shall be supplied indicating Fan CFM verses DC Volts.
  - 2. Belt Drive Unit Motors: Open Drip Proof (UDP) as specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
- G. Cooling and Heating Coils:
  - 1. Hydronic (two separate coils for cooling and heating): Copper tubes, 10 mm (three-eighths inch) minimum inside diameter, not less than 4.3 mm (0.017 inch) thick with copper or aluminum fins. Coils shall be pressure tested for bursting and strength in accordance with Underwriters Laboratories, Inc., requirements for pressure tested coils, and shall be designed to provide adequate heat transfer capacity. Provide manual air vent at high point of each coil and drain at each low point.
- H. Piping Package: Furnished with unit by the manufacturer to fit control valves provided by the controls supplier. Submit manufacturer's detailed drawings of the piping in the end compartments for approval prior to fabrication of the piping packages. Provide ball stop valves on the supply and return pipes and balancing fittings on the return pipes.
- I. Drain pans: Furnish galvanized steel with solderless drain connections and molded polystyrene foam insulating liner:
  - 1. Auxiliary drain pan: Located under control valve and piping to prevent dripping.
- J. Air Filter: Manufacturer's standard throwaway type, not less than one inch thick, supported to be concealed from sight and be tight fitting to prevent air by-pass. Filters shall have slide out frames and be easily replaced without removing enclosure or any part thereof.
- K. Control valves and unit mounted return air thermostats are to be field installed.

## PART 3 - EXECUTION

## 3.1 INSTALLATION

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.
- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.

## 3.2 OPERATIONAL TEST

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

## 3.3 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

## 3.4 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

--- END ---

SECTION 23 82 16  
AIR COILS

## PART 1 - GENERAL

## 1.1 DESCRIPTION

- A. Heating and cooling coils for air handling unit and duct applications.

## 1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- C. Section 23 73 13, PACKAGED INDOOR CENTRAL STATION AIR-HANDLING UNITS.
- D. Reheat coils for VAV/CV terminals: Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.

## 1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Unless specifically exempted by these specifications, heating and cooling coils shall be tested, rated, and certified in accordance with ARI Standard 410 and shall bear the ARI certification label.

## 1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data for Heating and Cooling Coils: Submit type, size, arrangements and performance details. Present application ratings in the form of tables, charts or curves.
- C. Provide installation, operating and maintenance instructions.
- D. Certification Compliance: Evidence of listing in current ARI Directory of Certified Applied Air Conditioning Products.
- E. Coils may be submitted with Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS; or Section 23 73 13, PACKAGED INDOOR CENTRAL-STATION AIR-HANDLING UNITS.



## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (ARI):  
Directory of Certified Applied Air Conditioning Products  
ARI 410-02..... Forced-Circulation Air-Cooling Air-Heating Coils.
- C. American Society for Testing and Materials (ASTM):  
B75/75M-02..... Seamless Copper Tube (Metric)
- D. National Fire Protection Association (NFPA):  
70-05..... National Electric Code
- E. National Electric Manufacturers Association (NEMA):  
250-03 ..... Enclosures for Electrical Equipment (1,000 Volts Maximum)

## PART 2 - PRODUCTS

## 2.1 HEATING AND COOLING COILS

- A. Conform to ASTM B75 and ARI 410.
- B. Tubes: Minimum 16 mm (0.625 inch) tube diameter; Seamless copper tubing.
- C. Fins: 0.1397 mm (0.0055 inch) aluminum or 0.1143 mm (0.0045 inch) copper mechanically bonded or soldered or helically wound around tubing. Provide copper fins for air handling units with greater than 50% outside air at design load, and reheat coils serving surgical suites.
- D. Headers: Copper, welded steel or cast iron. Provide seamless copper tubing or resistance welded steel tube for volatile refrigerant coils.
- E. "U" Bends, Where Used: Machine die-formed, silver brazed to tube ends.
- F. Coil Casing: 1.6 mm (16 gage) galvanized steel for heating coils, stainless steel for all cooling coils, with tube supports at 1200 mm (48 inch) maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.
- G. Pressures kPa (PSIG):

<u>Pressure</u>	<u>Water Coil</u>
Test	2070 (300)
Working	1380 (200)

- H. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.
- I. Vents and Drain: Coils that are not vented or drainable by the piping system shall have capped vent/drain connections extended through coil casing.

- J. Cooling Coil Condensate Drain Pan: Section 23 73 00, CUSTOM INDOOR CENTRAL-STATION AIR-HANDLING UNITS; Section 23 73 13, PACKAGED INDOOR CENTRAL STATION AIR-HANDLING UNITS.
- K. Corrosion Protection: Building 6 Therapy Pool air handling unit coils shall be epoxy-coated as follows:
  - 1. Coils shall have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation and a uniform dry film thickness from 0.8 – 1.2 mil on all surface areas including fin edges. Superior hardness characteristics of 2H per ASTM D3363-92A and a cross-hatch adhesion of 4B-5B per ASTM B3359.93. Impact resistance shall be up to 160 in/lb per ASTM D2794-93. Humidity and water immersion resistance shall be up to a minimum 1000 and 260 hours respectively (ASTM D2247-92 and ASTM D870-02). Corrosion durability shall be confirmed through testing to no less than 5,000 hours salt spray per ASTM B117-90 using scribed aluminum test coupons.

## 2.2 REHEAT COILS, DUCT MOUNTED

- A. Continuous circuit booster type for hot water as shown on drawings. Material of coils same as noted in Article 2.1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Follow coil manufacturer's instructions for handling, cleaning, installation and piping connections.
- B. Comb fins, if damaged. Eliminate air bypass or leakage at coil sections.

--- END ---

SECTION 23 84 13  
HUMIDIFIERS

## PART 1 – GENERAL

## 1.1 DESCRIPTION

- A. This section specifies steam humidifiers mounted within ductwork and air handling units.

## 1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS: Requirements for pre-test of equipment.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 01 91 13, COMMISSIONING.
- D. Section 23 21 13, HYDRONIC PIPING: Requirements for field hot water piping.
- E. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING: Requirements for field steam and condensate piping.
- F. Section 23 31 00, HVAC DUCTS, CASINGS AND SILENCERS: Requirements for sheet metal ducts and fittings.
- G. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC: Requirements for testing, adjusting and balancing of HVAC system.
- H. Division 25, INTEGRATED AUTOMATION.
- I. Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS: Requirements for motor starters.

## 1.3 QUALITY ASSURANCE

- A. Refer to the GENERAL CONDITIONS.
- B. Commissioning of a system or systems specified in this section shall be part of the construction process. Documentation and testing of these systems; as well as training of the VAMC operation and maintenance personnel, is required in cooperation with the VA Resident Engineer and the Commissioning Authority. Project Close-out is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Section 019113, COMMISSIONING, for detailed commissioning requirements.
- C. Refer to paragraph, QUALITY ASSURANCE, in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Unit(s) shall be provided by a manufacturer who has been manufacturing humidifiers and have been in satisfactory service for at least five (5) years.

#### 1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:
  - 1. Technical data on design operating inlet and outlet conditions, rated capacities and performances, furnished and required specialties, accessories, humidification capacity, absorption distance and unit electrical power data.
  - 2. A general arrangement diagram with overall dimensions showing all major components with overall dimensions, utility and piping connections and capacities, operating weight and required service and equipment removal clearances.
  - 3. Control diagrams for stand alone use for humidifying air, control interface with ATC system and all control set points.
  - 4. Manufacturers instructions for installation and required maintenance.
- C. Certificate: Evidence of satisfactory performance on three similar installations.
- D. Provide installation, operating and maintenance instructions, in accordance with Article, INSTRUCTIONS, in specification Section 01 78 23, GENERAL REQUIREMENTS.

#### 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
  - 52.-2-07 .....METHOD OF TESTING General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size (ANSI)
  - 62.1-07 .....Ventilation for Acceptable Indoor Air Quality (ANSI)
- C. National Fire Protection Association (NFPA)
  - 90A-02 .....Standard for the Installation of Air-Conditioning and Ventilating Systems
  - 70-05.....National Electrical Code
- D. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
  - .....HVAC Duct Construction Standards, Metal and Flexible

### PART 2 – PRODUCTS

#### 2.1 DUCT AND AIR HANDLING UNIT MOUNTED STEAM HUMIDIFIERS

- A. Provide steam humidifiers for electronic modulating control, of the steam separator type, providing full separation ahead of an integral steam jacketed control valve which discharges through an internal steam jacketed drying chamber, a silencing chamber, and a multiple steam jacketed distribution manifold. Humidifiers shall be single or multiple tube(s) as scheduled. Tube length shall match width of ductwork.

- B. Humidifiers shall receive steam at supply pressure (low pressure) and discharge at atmospheric pressure. Humidifiers shall be provided with inlet strainer and external inverted bucket steam traps. Humidifiers shall be constructed as follows:
1. Separating chamber shall be designed to remove all water droplets and all particulate matter larger than (3) microns when humidifier is operating at maximum capacity without objectionable noise. Chamber shall be cast iron or stainless steel.
  2. A stainless steel modulating valve shall be provided. This control valve shall have a minimum turn down ratio:
    - a. 1/2" – 25:1
    - b. 3/4" to 2" – 50:1
  3. The internal drying chamber shall be jacketed by steam at supply pressure. The silencing chamber shall be steam jacketed and utilize a stainless steel silencing medium.
  4. Multiple distribution manifold shall provide uniform distribution over its entire length and be jacketed by steam at supply pressure to ensure that vapor discharged is free of water droplets. A full-length stainless steel internal silencing screen shall be provided. Provide as a minimum of one control for every 5 manifolds. See details for additional information. Provide steam trapping in strict accordance with manufacturer's details and instructions.
- C. In addition provide with each humidifier separator a temperature safety switch, which prevents operation when the condensate temperature returning from the manifold jacket is too low. Provide access doors in ducts downstream of humidifiers for visual verification of humidifier operation.
- D. Controls
1. Contractor shall provide airflow switches to provide means of detecting airflow and/or a failure of airflow in the system, which will de-energize a switch which will shut off supply control valve to prevent steam from entering the steam humidifier.
  2. Contractor shall provide a duct mounted humidistat controller to act as a high limit to override the sensor control whenever the high limit is reached as well as maintain the high limit set point until main sensor resumes control. The high limit humidistat shall be mounted into the ductwork at least 8'-0" downstream of the humidifier.
  3. Provide a remote wall mounted humidistat to modulate and control the humidifier to maintain setpoint.

## 2.2 ELECTRIC POINT OF USE HUMIDIFIER

### A. Humidifier

1. The humidifier shall be an electrically heated immersion heater type.
2. The humidifier shall be tested and approved by ETL/ETL-C Testing Laboratories, Inc. (ETL #472940).
3. The humidifier shall be suitable for use with pure water such as deionized, demineralized or reverse osmosis water with a maximum purity of 18 megaohms per sq. centimeter.
4. The humidifier shall have an evaporating reservoir with a gasket sealed cover which is capable of operating at pressures of at least 19" (W.C.) without steam or water leaks. The reservoir shall be made of type 304 stainless steel with welded joints.
5. The humidifier shall be designed to facilitate easy removal of the heater assembly for inspection. The cover and heater assembly shall be secured to the unit by the use of quick release clamps. The heater assembly shall be removable from the side of the humidifier without disturbing the cover or injection tube system's steam supply piping.

6. A stainless steel float operated low water cut-off switch shall be provided. The float switch shall provide positive low water cutout of the humidifier immersion heaters.
7. The immersion heater(s) shall be incoloy clad and designed for 80 watts per sq. inch.
8. A stainless steel float operated water fill valve mounted on the top of the reservoir near the front shall be provided. The fill valve shall provide automatic refilling of the humidifier reservoir. The water inlet shall be located to allow a minimum water gap of 1-1/2".
9. The humidifier shall have a 3/4" over-flow pipe to prevent overfilling of the humidifier reservoir.
10. A 3/4" stainless steel ball valve shall allow for manual draining of the humidifier reservoir.
11. The humidifier shall have a manual reset over-temperature switch factory installed on the humidifier reservoir. The temperature switch shall provide humidifier over-temperature protection.

B. Controls

1. The humidifier shall be provided with an ETL listed JIC NEMA 12 control cabinet, shipped loose (reference factory mounting option). The control cabinet shall be made of 14 gauge steel with ANSI 61 gray polyester powder coating, continuous hinge and oil-resistant gasket. The panel shall include a factory wired sub-panel with magnetic contactor(s), time delay relay, fused control circuit transformer, numbered terminal block and heater fuse(s).
2. A programmable microprocessor controller shall be factory mounted and wired on the cover of the control panel. The control cabinet shall have a factory wired time delay relay circuit. The delay circuit shall prevent cycling of the low water interlock circuit due to water fluctuations within the humidifier reservoir. All humidifier electrical, ground and control terminal connections shall be enclosed in an ETL listed NEMA 12 enclosure. The controller shall provide the following standard features:
  - a. Self-diagnostics and system verification on start-up.
  - b. Evaporating reservoir water level verification, control and safety interlock. The controller shall be compatible with all water types.
  - c. Automatic reservoir drain and flush system. The controller shall periodically drain and flush the reservoir according to the actual accumulated humidifier "run" time. (except RO/DI water).
  - d. Cold water tempering prevents excessively hot water from draining during an automatic or seasonal drain cycle.
  - e. Seasonal drain system shall automatically drain the humidifier reservoir after a selected "NON-USE" period. The controller shall automatically reset the humidifier on a call for humidity.
  - f. Safety circuit input terminals including over-temperature shut down.
  - g. Terminal connections to accept virtually all control input signals. Input control range is selected as an "ON-SCREEN" prompt.
  - h. User adjustable controlling and High-limit RH PID functions with Auto-Tune control.
  - i. Door mounted display and user interface. Provides two lines of system messaging on a vacuum fluorescent display screen, LED operational indication and keypad parameter entry system.
  - j. Time delayed scrolling display loop – displays all system parameters and alarms in a scrolling loop every ten minutes or upon key press. The Display Loop includes: System status, Actual space RH, Duct RH, High-limit RH, Outdoor air temperature, Power output, Humidifier/System capacity (in lbs/hr or kg/hr), Accumulated run time, Water level, Water temperature and Control type.
  - k. Time-to-Service messaging.
  - l. Numbered screen prompts for set-up and service identification.
  - m. Full "ON-SCREEN" help information at all displays prompts alarms or errors. The "HELP" message includes on screen diagnostic assistance.
  - n. Keypad lock-out with user selected access levels.

- o. Terminal connections for a remote keypad display module.
- p. Full Networking and BAS communication ports. Communication ports shall provide two-way communication between the controller and the Building Automation System (BAS).
- q. High/Low humidity deviation alarm contacts for modulating control.
- r. Fault alarm contacts.
- s. Flash Memory – allows system upgrades through R232 port with a laptop computer and access to e-mail.
- t. Variable air volume (VAV) anticipation control. The software shall accept a modulating high-limit humidity input and space controlling RH input and modulate the heater output to prevent over saturation of the supply air due to changes in the quantity of air flow. A compatible humidity sensor shall be shipped loose for field installation.
- u. Cold weather relative humidity reset. The software shall accept a modulating temperature input and automatically reduce the space RH set-point on a drop in the outside temperature. The reduction of the RH set-point during cold weather periods prevents damage due to interior window condensation.
- v. Reservoir thermocouple water control. The software provides standby water sensing and freeze protection.
- w. A remote wall mount user interface keypad/display module shall be furnished.

### PART 3 – EXECUTION

#### 3.1 IN-DUCT STEAM HUMIDIFIER INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install equipment exposed to finished area after walls and ceiling are finished and painted. Do not damage equipment.
- C. In-duct steam humidifier shall be installed in accordance with manufacturer recommendations, Contract Drawings, and reviewed submittals.
- D. Steam humidifier shall be installed so as to ensure easy accessibility for service or removal and replacement of control valves, shut-off valves, strainers, and humidifiers.
- E. Install access doors so that visual verification of humidifier operation is easily accomplished.
- F. Provide drain from watertight stainless steel (or aluminum) ductwork. Pipe drain to nearest floor drain or slop sink.

#### 3.2 FUNCTIONAL PERFORMANCE AND INTEGRATED SYSTEMS TESTING

- A. Functional Performance and Integrated Systems Testing (FP & IST) is part of the commissioning process. FP & IST shall be performed by the Contractor, and witnessed and documented by the Commissioning Authority. Refer to Section 019113, COMMISSIONING, for FP & IST requirements.

### 3.3 TRAINING

- A. Training of the VAMC operation and maintenance personnel shall be required in cooperation with the VA Resident Engineer. Provide competent, factory-authorized personnel to instruct operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 017900, DEMONSTRATION AND TESTING, and Section 019113, COMMISSIONING, for Contractor training requirements.

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