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6/15/16	Entire document	-	mgl44

PART 1 - INTRODUCTION

- A. This document provides design standards for Building Air Handler Systems.


PART 2 - GENERAL DESIGN REQUIREMENTS

2.1 DESIGN

- A. Calculations, the Engineer will submit the following calculations upon request.
 - 1. Air side pressure drop calculations. Calculation's shall include AHU component pressure drop, and entire supply, return, and exhaust air distribution system.
 - 2. Psychrometric calculations for the entire process air stream including but not limited system, zone, and room level. The calculations shall be submitted on both an excel spreadsheet format, and a psychrometric chart. The information shall include all applicable state points and include process lines.
 - 3. Coil capacity calculations. Calculations shall take into account water temperature reset schedules.

- B. Air Flow Stations:
 - 1. Air flow stations shall meet the following requirements.
 - a. Air flow stations shall be located in a serviceable location.
 - b. Air flow stations shall be located within the AHU equipment.
 - c. Air flow stations shall not be an integral part on the AHU, and shall be removable for repair or replacement.
 - d. Refer to Controls standard for other requirements.

- C. Design air flow:
 - 1. The design CFM and ESP pressure shall account for the following factors.
 - a. Duct leakage consistent with allowable SMACNA and final air balancing allowances per the contract documents.
 - b. Loaded air filters
 - c. Air side coil fouling, and wetted surface of coils.
 - d. Space planning and additional capacity.

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D. Noise, vibration and attenuation.

1. Account for noise, and vibration and design system in compliance with applicable Code, and ASHREA Standards. Designer shall address both air borne, and vibration generated noise.
2. Provide appropriate attenuation to meet noise criteria requirements.
3. Execute recommendations of project retained sound consultant if applicable.

E. Housekeeping pad,


1. AHU shall be set on appropriate reinforced concrete pad, pad shall be a minimum of four inches high, and extend no less than six inches along the perimeter of system.

F. Coil, drain pan, and condensate piping requirements,

1. Steam condensate
 - a. Allow for sufficient clearance for condensate to gravity drain from the coil, through the steam trap, then from the steam trap to point of condensate collection.
2. Condensate drain pan connection.
 - a. Allow for sufficient clearance for condensate drain to gravity to point of discharge. The support rails of the unit shall be of sufficient height to provide adequate space for condensate discharge to local floor drain.
3. Condensate piping
 - a. Provide and coordinate floor drain requirements
 - b. Piping will be installed as not to be a trip hazard, does not run across a means of egress, and prevent the installation and removal of equipment.
 - c. Pocketed floor slabs to allow for clearance of condensate trap are not permitted. Additionally condensate drains are not permitted to be piped through floor slab, to floor below.
 - d. Condensate trap shall be drainable, provide removable plug at bottom of trap.

G. Maintenance and Service

1. Design installation of units to allow access space around air handling units for service and maintenance of AHU, and adjacent equipment.
2. Allow clearance for coil replacement. In no case shall the clearance be less than 1.5 times the width of the unit.
3. Allow for sufficient clearance to remove the fan assembly.
4. Allow for sufficient clearance to replace air filters and similar devices.
5. Allow for sufficient clearance and a path within the mechanical room to remove and replace AHU components such as but not limited to coils, fan assemblies, and motors.

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H. Coil isolation and balancing valves

1. Provide isolation valves for both supply and return circuits
2. Provide balancing valve for each coil.
3. Coils shall have isolation and balancing valves for each supply and return circuit. For example, where individual cooling coils are in a stacked configuration and each is equipped with a supply and return connection each supply and return circuit will have a dedicated isolation valve, and balancing valve on the return side of the coil.

I. Humidification coil and air flow

1. Coil shall be selected to prevent moisture carry over. The designer shall review the requirements for moisture eliminators where required.
2. Dispersion distance of humidifier shall not exceed six inches.
3. Coils shall be rated for Municipal, RO, and DI water.
4. Refer to Humidifier Standard for other requirements.


J. Coils: Water, Glycol, and Steam

1. Cooling coil velocity shall not exceed 450 FPM
2. Heating coil velocity shall not exceed 500 FPM.
3. MUA and Air-handler Units shall have glycol based preheat coils.
 - a. Exception: Where MAT at the mixing box deck is not below freezing temperature, glycol preheat coils may be omitted with approval of Yale Engineering.
4. Provide high point vents, and low point drains.
5. Steam coils to be provided with vacuum breakers.
6. Refer to Air Coils Standard for other requirements.

K. Coil Freeze Protection Requirements

1. Provide freeze stats inter-locked to shut down system and isolate freeze source. Freeze stats shall be manual reset type, and have multiple contacts. For example, BMS alarm circuit, and AHU fans and dampers. Additionally, there shall be multiple freeze stat zones across the coil, each on a separate manual resettable trip circuit.
2. Outdoor and mixed air sections shall be designed for proper mixing of air prior to introduction into coil. Ensure the unit is provided with sufficient devices and controls to monitor and prevent system coils from freezing.
3. Water coils shall be protected against freezing without having to seasonally drain and refill coils.

L. Casing Insulation Requirements

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1. Casing shall not form condensation on the exterior surface, including joints and seams. Consultant shall evaluate ambient conditions and determine minimum R-Value required to prevent condensation at the corresponding internal air temperature within the casing enclosure, including the mixing box section.
2. Comply with requirements as required by ANSI/AHRI Standard 1350 and ARI Standards 260, 350, and governing energy codes.

M. AHU casing openings.


1. Openings such as but not limited to supply, return, and exhaust shall be framed, and damned to prevent moisture and water from entering or exiting the unit.
2. Openings such as but not limited to supply, return, and exhaust shall be framed to except the connection of duct, dampers, pipe or similar appurtenances. Provide a flange type connection.
3. Openings shall not have exposed internal insulation.

N. Exterior Units

1. Outdoor units to be provided with weatherproofing (roofing, guttering, etc.).
2. Outdoor units to be provided with full length and height service vestibule.
3. Isolation and control valves shall be located within service vestibule.
4. Vestibule will be provided with ventilation, heating, floor drains, electrical receptacles, and lighting. When applicable, spill air shall dump within service vestibule as a means to heat and cool said vestibule. The vestibule shall be provided with proper spill air relief mechanism.
5. Hydronic piping for outdoor units shall be designed such that piping and coils shall not require evacuation for winter operation. Other means of freeze protection shall be incorporated. If heat trace must be used, heat trace shall have alarmed points to notify BMS of heat trace failure.
6. Vestibules will have a minimum of one keyed and lockable entrance door.

O. AHU System Quality Assurance

1. Unit performance shall be certified in accordance with ANSI/AHRI Standard 430, "Performance Rating of Central Station Air-Handling Units."
2. Air performance of all moving devices shall be rated in accordance with ANSI/AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating" and shall be licensed to bear the AMCA certified rating.
3. Provide air handling unit internal insulation having maximum flame spread rating of 25 and maximum smoke developed rating of 50, per NFPA requirements.
4. The Consultant shall include in the specifications a requirement for equipment leakage testing by the air handling unit manufacturer once assembled on site with all

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penetrations in place and sealed. This test shall be witnessed by representatives from the University and the Project Manager of Record.

P. Codes and Standards

1. ARI 410 - Standard for chilled water, hot water and steam coils
2. ARI 430 - Central Station Air Handling Units
3. AMCA 99 - Standards Handbook
4. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
5. AMCA 300 - Test Code for Sound Rating Air Moving Devices
6. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
7. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
8. ASTM D4230 - Measuring Humidity with Cooled Surface Condensation
9. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems


PART 3 - MINIMUM PRODUCT REQUIREMENTS

A. Acceptable manufacturers:

1. Air Handling Units with Coils (Custom, Make-up, Process, Commodity)
 - a. Air Enterprise
 - b. Gouvernaire
 - c. Buffalo
 - d. Trane
 - e. York
 - f. McQuay
 - g. Yale approved equal
2. Centrifugal Fans
 - a. Barry
 - b. New York Blower
 - c. Chicago Blower
 - d. Yale approved equal

B. AIR-HANDLER UNIT – CUSTOM UNITS

1. Minimum Product Requirements
 - a. Provide factory-assembled central station units. Supply with fan sections, coil

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sections, low velocity angle bank filter sections, dampers and mixing box.

2. Casing/housing

- a. Panels: Unit shall be heavy gauge, double wall, galvanized or approved non-ferrous welded assembly.
- b. Portions of interior panel that are subject to moisture shall be SS, galvanized or non-ferrous material.
- c. Performance of the casing shall conform to the following requirements.


Class Deflection, CD _X	Rating Differential, inches W.C.	Maximum Normalized Deflection, in/in of span	
CD _D	10	.0033 (L/300)	
Class Leakage, CD _X	Max. Casing Leakage Rate, cfm/100 Ft ²		
CD _L	1		
Class Thermal Transmittance, CD _X	Thermal Transmittance w/o Leakage, Btu/hr/ft ² /F	Thermal Transmittance with Leakage, Btu/hr/ft ² /F	
CD _T	U ≤ 0.05	U ≤ 0.06	

3. Wall and Roof Panels: All such panels shall be double wall acoustical panels per the following:

- a. Acoustical panels for indoor units shall be minimum 2" nominal wall thickness. Outdoor units shall be minimum 4" wall thickness. Exterior panel shall be fabricated with galvanized sheet steel (or non-ferrous material) of sufficient gauge and reinforcement to meet the structural design criteria herein. Provide acoustical grade fill type insulation. All penetrations, access doors, etc., shall be equipped with gaskets or caulked air tight with resilient caulk. Minimum acoustic performance shall produce levels not exceeding PNC 65 outside the housing immediately adjacent to its exterior surfaces.


4. Structural Supports:

- a. All structural steel shall be ASTM A 36 channel, tube steel, angle, or bar stock. All steel shall be galvanized or prime coat painted (2 coats).
- b. Air handler base shall be minimum 6" structural channel or tube steel and shall

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be provided under all sections.

- c. Fan/motor assembly shall be mounted on a Mason Industries style WFSL isolator base with Mason style SLF springs with 4" deflection. Components may be equal of Amber/Booth, Korfund, Peabody, Vibration Mountings and Controls, or Vibration Eliminator Company.
 - d. All main load bearing structural steel shall be minimum 3" channel, tube steel, or angle.
 - e. Intermediate supports shall be per SMACNA or manufacturer's standard.
 - f. Module construction shall be suitable to withstand the rigors of shipping, rigging, and setting in place. Provide all necessary lifting lugs.
5. Flooring:
- a. Flooring material shall be aluminum installed to be airtight, smooth, water-tight, and equally strong as a 12 gauge steel floor. Use minimum 1/8" thick for 3003-H12 (18 KSI yield strength) tempered aluminum, 1/4" thick for 3003-O (6 KSI yield strength) non-tempered aluminum, or other combination with equal strength. Provide 2" high dam at all floor openings so as to retain a 2" deep water spill inside the unit without leaking.
 - b. Floor shall be insulated per same standard as casing.
6. Access Doors:
- a. Access doors shall be provided for every section of the AHU.
 - b. Access doors shall contain thermal pane viewing windows, with thermal breaks, and installed so that the inside surface is flush with the casing.
 - c. Swinging access doors shall open against fan pressure where possible. Material shall be same as for wall panels. Each door shall have a minimum 3 hinges, 1 door handle on each side, and 2 camlocks operable from each side. All hardware shall be zinc plated, or non-corrosive equal. All latches shall be suitable for locking with a padlock.
 - d. Where access doors are not provided, access panels shall be provided for equipment removal, where required. They shall be large enough to easily remove any section of serviceable and replaceable equipment. Preferred method of attachment to housing is by A-307 bolts threaded into structural steel housing frame from the outside.
 - e. All access doors and panels shall be double gasketed to limit air leakage.
7. Coil/Filter Supports:
- a. All equipment supports shall be designed to support equipment during shipment and after being hooked up and placed in operation at the job site. All

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supports shall be arranged to allow disassembly and removal of coils, filters, and fans without disassembling supports. Supports shall not restrict air flow to coils, filters, or fans.

8. Insulation (Under Floor):

- a. A minimum 24 gauge support pan under insulation shall be provided to protect insulation, for outdoor and indoor units.

9. Exterior Finish (Outdoor Units):

- a. Exterior finish shall be phosphatized galvanized (or approved equal) and shall be factory painted.


- b. The unit panel assembly shall be painted with a 2 part polyamide epoxy paint on the exterior surfaces. Before painting, surfaces shall be cleaned, and surfaces shall be treated with a phosphate rinse to assure paint adhesion. The painting system shall have been tested by an independent firm to applicable ASTM standards and the minimum properties shall be:

- 1) Salt Spray: Five percent salt solution fog at 95°F for 500 hours, no deterioration.
- 2) Adhesion: Coating cut into 1/16" squares and 3M #600 tape suddenly removed, no loss of adhesion.
- 3) Acid Resistance: Fifteen minute exposure to 10% hydrochloric acid, no effect.
- 4) Alkali Resistance: Fifteen minute exposure to 10% sodium hydroxide, no effect.

- c. Finish coat of paint shall be Glidden "Glid-Guard" epoxy paint, color shall be project specific.

10. Roof (Outdoor Units):

- a. Roof shall be as previously described for casing.
- b. The unit roof shall have an exterior sealing membrane of P-I-B or Hypalon to prevent water leakage. This membrane shall have a minimum elongation of 450% at break (ASTM D 412) to prevent damage from expansion and contraction of the housing, and shall not become brittle at temperatures down to -40°F.
- c. The roof system shall have a 20 year limited warranty.
- d. The unit roof shall be designed to support not less than 250 lbs point load or 35

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- e. psf superimposed snow load.
- e. The roof shall be pitched in a single direction with the low point occurring over the doors. Provide gutter for full length of unit with downspouts at both ends.

11. Safety Grate:

- a. For down flow units, provide floor grating in all return air and supply air openings in the floor of the unit.

12. Centrifugal Fans:

- a. Direct drive fans are preferred.
- b. Equivalent Fan Selections: Shall not increase motor horsepower, increase tip speed and outlet velocity by more than 10%, from that scheduled.
- c. Fan Performance: Based on altitude of 200' above sea level.
- d. Operation: Fan shall operate with a variable frequency drive.
- e. Fan Housing: Continuously welded steel, 12 gauge sides and 14 gauge scrolls for Class I and II up to size 27, 10 gauge sides and 12 gauge scrolls for larger housings.
- f. Fan Wheel: Double width, double inlet type with forward-curved blades or backward-curved airfoil blades as schedule.
- g. Fan Drive: V-belt, adjustable motor mount, self-aligning pillow block ball bearings with 200,000 hour life per ANSI B3.15, with external lubrication fittings, sheaves, and steel shaft.
- h. Balance Procedure: Balance to 1 mil peak-to-peak at 800 rpm, 0.8 mil at 1200 rpm, 0.4 mil at 2400 rpm, or equivalent intermediate point on Rathbone Balancing Chart, unless directed otherwise.
- i. Motor: Per applicable University Standards.
- j. Inlet vanes: Provide per manufacture requirements.
- k. Tests: Manufacturer shall witness test fan with the VFD inverter at full flow and design pressure per an AMCA 200 test set up. An Owner's representative shall verify fan design performance and BHP.
- l. Sound Power Data: Sound power data shall be collected in accordance with AMCA Standard 300. Any alternative technique that is used must be approved by the Engineer.
- m. Spot Check: Spot check units for the aforementioned conditions of construction and performance in the presence of the Engineer. Results shall be compared against the factory quality assurance records submitted with the fans. Comparisons must be favorable for acceptance. Fans shall have a minimum of 8 hours of continuous operation before final tests are conducted for acceptance.

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- n. Start-up: By qualified factory personnel, capable of field balance, if necessary. A record of field vibration tests shall be provided. The cost of the procedure shall be included in the price of the equipment.

13. Filters:

a. General:

- 1) Supply all filters of each style as product of 1 manufacturer.
- 2) Assemble filter components to form filter banks for each style from products of 1 manufacturer.
- 3) Size, media face area, NBS test efficiency, initial and final air resistance shall be as scheduled on the Contract Drawings or as specified herein.
- 4) Provide filter media that is UL 900, Class 1 listed and approved by local authorities. All filter efficiencies shall be in accordance with ASHRAE Standard 52 dust spot test.


b. Housings:

- 1) Design: Accommodate standard size filters of types specified, capable of providing interchangeability of filter media of other manufacturers. When scheduled, provide frames to retain both panel type prefilters and extended media filters.
- 2) Prefilter Housings: Where prefilters immediately precede other filters, the housings may be provided as a single composite assembly to accommodate both filter banks.


c. Panel Filters:

- 1) Media: Medium efficiency, pleated, disposable type, consisting of a nonwoven cotton and synthetic fabric, having an average efficiency as scheduled on Contract Drawings. Provide no less than 4.6 sq ft of effective media filter area for each square foot of filter face area. Pressure drop shall be 0.13" W.G. maximum at 250 fpm (Farr 30/30 or equal).
- 2) Media Support: Welded wire grid, formed to effect a radial pleat design, with media bonded thereto.
- 3) Enclosing Frame: Heavy duty beverage board having diagonal support members bonded to both sides of pleats. Bond the inside periphery of the frame to the filter pack.
- 4) Filter Housings: Construct of 16 gauge galvanized steel, factory assembled. Include side access doors, on both sides with inside and outside handles, extruded aluminum tracks and holding frames. Filters shall form a "V" shape with an average face velocity of 300 fpm or less.

d. Extended Media Filters:

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- 1) Media: High performance, 90% efficient, deep pleated, rigid, disposable type, consisting of high density microfine glass fiber media having an average efficiency as scheduled on Contract Drawings. Provide no less than 14.5 sq ft of effective media filter area for each square foot of filter face area. Pressure drop shall be .68" W.G. maximum at 500 fpm (Farr RIGA-FLO 200 12" or equal).
 - 2) Media Support: Welded wire grid, formed to effect a tapered radial pleat design with media bonded thereto. Provide contour stabilizers on both sides of filter pack.
 - 3) Enclosing Frame: Constructed of galvanized steel. Filter pack continuously bonded to the frame with diagonal support members provided on both sides of the filter.
 - 4) Filter Housings: Not less than 16 gauge galvanized steel, equipped with polyurethane foam gaskets, fasteners, and filter centering dimples. Secure flush mitered sealing corners to form a uniform sealing and gasketing surface. Provide in-line depth of not less than 2.69" to effect adequate bearing surface for filter banks. Filter fasteners shall be capable of being installed without requiring tools, nuts, or bolts. Include side access doors on both sides with inside and outside handles.
 - e. Filter Gauges:
 - 1) Provide 3-1/2" diameter diaphragm activated gauges to measure air flow resistance through the extended media filter bank. Provide with white dial, black figures and zero pointer adjustment. Include static pressure tips, tubing, mounting hardware, and suitable range.
 - f. Installation:
 - 1) All filter banks shall be constructed and assembled to prevent passage of unfiltered air. Provide appropriate rubber or neoprene gaskets as necessary. Seal frames to air handler to prevent air bypass.
 - g. Spare Sets:
 - 1) In addition to the filters provided with the air handler, 2 spare sets shall be provided. The first spare set shall be installed at substantial completion prior to final approval. The second spare set, in original cartons shall be turned over to the Owner for future use.
14. Sound Attenuators:
- a. Sound Attenuators: Construct in accordance with NFPA 90A standards. Provide outer casings and internal perforated sheet metal not less than 22 gauge and comply with high velocity ductwork recommendations of the current ASHRAE Guide.

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- b. Acoustical Fill Materials: Acoustical quality glass fiber packed behind partitions to eliminate voids caused by material settling. Provide a single 0.064" thick layer of plain weave glass cloth, 6 oz per sq yd weight between the acoustical fill and the air stream. Provide airtight construction, leakproof against a differential pressure of 8" wg.
- c. Losses: Provide as follows, or as project requirements require:

DIL (dB) Minimum									
Service	63 Hz	125	250	500	1K	2K	4K	L	Model
Supply	7	12	5	7	12	19	23	60	IAC-5ES
Fan Cone	3	11	17	18	16	12	11	43.5	IAC-D
Return	7	21	25	32	34	34	37	60	IAC-5S

- 15. Steam Injection Humidifier:
 - a. Refer to Humidifier Standard.
- 16. Mixing Box Section:
 - a. Construct per structural requirements specified herein.
 - b. Recirculation systems intended with mixing of air streams shall have a mixing section with necessary components specifically engineered to achieve evenly and thoroughly mixed conditions prior to entering heating or cooling coils. This is critical in cold climates to avoid stratification and nuisance freezestat tripping. Professional shall include in the engineered design the application of air blenders, directional deflectors/baffles designed to force air streams into each other to mix, and/or blow-through supply fan arrangements in which air is mixed prior to entering coils.
 - c. Wherever possible locate outside air and return dampers directly adjacent to one other and as far upstream of the connection to the AHU as possible to facilitate mixing.
 - d. The damper blades shall be arranged so that the air streams are directed at one another to facilitate mixing.
 - e. Damper linkage shall be extended outside the unit for external actuator mounting. Internal actuator mounting is not acceptable.
- 17. Coils:
 - a. General: Provide coils that are the product of a manufacturer regularly engaged in their production and regularly issues complete catalog data thereof. Coils shall be rated per ARI 410.

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- b. Construction: Refer to Air Coil Standard.
- c. Heating Coil Design Parameters: 200 psi and 300°F.
- d. Cooling Coil Design Parameters: 150 psi and 200°F.
- e. Coil Connections: Extend coil connections to exterior of indoor units or to vestibule of outdoor units for connection by others.

18. Drain Pans

- a. All coil, moisture eliminator, and intake modules shall be provided with an insulated, double-wall, stainless-steel drain pan.
- b. Fabricated with slopes in at least 2 planes to collect condensate from cooling coils including coil piping connections, coil headers and return bends, and a minimum of 6 inches downstream from cooling-coil face and from humidifiers.
- c. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
- d. A minimum of 2 inches deep, and complying with requirements in ASHRAE 62.1.
- e. Drain Connections: Both ends of pan with minimum NPS 1 threaded nipple, same material as drain pan.
- f. Pan-Top Surface Coating: Asphaltic waterproofing compound.
- g. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

19. Electrical Requirements:

- a. All requirements of the Connecticut Electrical Code and National Electrical Code and the following shall be met.
- b. All wiring shall be minimum 12 gauge copper conductor with insulation consistent with Yale Electrical Standards, and shall be contained within rigid galvanized steel conduit or liquid-tight flexible conduit of minimum 3/4" diameter.
- c. All fan motors shall be factory wired to nonfused disconnect switches mounted on the outside of the fan compartment. All lights shall be marine-type protected light fixtures with 120 volt LED light fixtures of sufficient wattage to attain 50 footcandles at all sections of the unit designed for personnel access, and shall be factory wired to a light switch mounted on the outside of the unit adjacent to the access door.
- d. All components shall be sized for the maximum voltage, amperage, and wattage they may experience under all phases of operation.
- e. Provide GFI receptacles at a minimum of 10 foot intervals along the perimeter exterior of unit.

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20. Factory and Field Tests Required:

a. Pressure Tests:

- 1) Each housing and blankoff wall shall be factory pressurized (or vacuum applied) to the pressures specified for a minimum of 2 hours to verify adequacy of the structural design.
- 2) Manufacturer shall record deflection of critical structural members and housing panels and compare to values originally calculated by manufacturer's structural engineer to verify adequacy of the design.
- 3) Test method, test results, and comparison shall be submitted for review and record.
- 4) Coils shall be pressure tested to 150% of design pressure.

21. Leakage Tests:


- a. Each housing and blankoff wall shall be pressurized (or vacuum applied) to the pressures specified and the leakage out from (or into) the housing shall be measured to verify compliance with the leakage criteria specified. Maximum leakage shall be 1% of unit flow.
- b. Manufacturer shall pressure test housings as specified prior to beginning leakage test.
- c. Manufacturer shall record actual leakage, pressure, and duration of test.
- d. Test method, test results, and comparison shall be submitted for review and record.

22. Acoustical Tests:

- a. Tests will be carried out on each prototype unit under at least 3 flow rate conditions representative of the range to be encountered in final installation.
- b. The acoustic sound power radiated from the discharge opening shall be measured in accordance with AMCA Standard 300-85. If necessary, the measurements will be augmented or confirmed using acoustic intensity measurement techniques.

23. Component Testing:

- a. Manufacturer shall factory run test each fan after air handler has been completed to verify successful operation. Fan performance and vibration levels shall be verified as specified.
- b. Manufacturer shall energize all electrical devices installed to verify successful operation.
- c. Manufacturer shall submit checklist of all component tests made for review and

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record.

24. Right to Witness Tests:
 - a. Owner and Engineer shall be allowed to witness all tests. Testing shall not be accepted unless either (1) Owner or Engineer witnesses test, or (2) Owner and Engineer both waive right to witness tests.
 - b. Owner and Engineer shall be notified at least 10 days prior to test date.


25. Test Procedures:
 - a. All test procedures shall be submitted for review prior to test. Preliminary procedures shall be submitted at time of vendor's bid.
 - b. Installation Test and Inspection: The manufacturer will be responsible for inspecting, adjusting, and modifying, if necessary, the system balance and the vibration isolation for compliance with the noise and vibration requirements. The manufacturer will bear the cost of such modifications and any additional testing required.

C. AIR HANDLING UNIT – COMMODITY UNITS

1. Minimum Product Requirements
 - a. Provide factory-assembled central station units. Supply with fan sections, coil sections, low velocity angle bank filter sections, dampers and mixing box.

2. Casing/housing
 - a. Panels: Unit shall be heavy gauge, double wall, galvanized or approved non-ferrous assembly.
 - b. Portions of interior panel that are subject to moisture shall be SS, galvanized or non-ferrous material.
 - c. Performance of the casing shall conform to the following requirements.

Class Deflection, CD _x	Rating Differential, inches W.C.	Maximum Normalized Deflection, in/in of span	
CD _D	8	.0045 (L/220)	
Class Leakage, CD _x	Max. Casing Leakage Rate, cfm/100 Ft ²		
CD _L	1		

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Class Thermal Transmittance, CD _x	Thermal Transmittance w/o Leakage, Btu/hr/ft ² /F	Thermal Transmittance with Leakage, Btu/hr/ft ² /F	
CD _T	U ≤ 0.05	U ≤ 0.06	

3. Wall and Roof Panels: All such panels shall be double wall acoustical panels per the following:

- a. Acoustical panels for indoor units shall be minimum 2" nominal wall thickness. Outdoor units shall be minimum 4" wall thickness. Exterior panel shall be fabricated with galvanized sheet steel (or non-ferrous material) of sufficient gauge and reinforcement to meet the structural design criteria herein. Provide acoustical grade fill type insulation. All penetrations, access doors, etc., shall be equipped with gaskets or caulked air tight with resilient caulk. Minimum acoustic performance shall produce levels not exceeding PNC 65 outside the housing immediately adjacent to its exterior surfaces.


4. Structural Requirements:

- a. Each unit shall have a double wall airtight and weatherproof casing and shall be sectionalized for placement (indoors or outdoors) for all internal components. Provide a welded, full perimeter structural or tubular steel base frame with intermediate supports for all internal components.
- b. Provide thermal break construction between exterior panel, frame, floor, condensate pan, and any other component to prevent thermal bridging from the interior to the exterior of the assembly. Unit casings shall be insulated internally. Provide double bottom floor construction, floor shall be internally insulated and the underside shall be a minimum or equal galvanized 18-gauge metal.
- c. Component modules shall be constructed of sectionalized, formed panels. Panels shall be rigidly reinforced within the interior, and at the perimeter. Casing panels shall be removable for easy access to the unit for service and replacement of equipment, where required. Panels, at a minimum, shall be mill galvanized steel with factory enamel or a non-ferrous material of equal strength.
- d. All units shall have gasketed, and thermally broken joints between panels, frame, and other components
- e. Outdoor units shall be mounted on a 14" high prefabricated curb, NRCA approved, complete with gasketing. Curb to be supplied by the air-handling unit manufacturer, or a manufacturer approved equal. Outdoor units shall have

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roof constructed to prevent ponding or water leakage due to capillary action at seams and joints.

- f. Fan sections shall be constructed of galvanized steel and have a formed channel base for integral mounting of fan, motor, and casing panels. Fan scroll, wheel, shaft, and bearings are to be mounted on a structural steel A- or H-frame rigidly secured to the channel base. Refer to centrifugal fan for additional requirements.
 - g. Fan/motor assembly shall be mounted on a Mason Industries style WFSL isolator base with Mason style SLF springs with 4" deflection. Components may be equal of Amber/Booth, Korfund, Peabody, Vibration Mountings and Controls, or Vibration Eliminator Company.
 - h. All main load bearing structural steel shall be minimum 3" channel, tube steel, or angle.
 - i. Intermediate supports shall be per SMACNA or manufacturer's standard.
 - j. Module construction shall be suitable to withstand the rigors of shipping, rigging, and setting in place. Provide all necessary lifting lugs.
5. Flooring:
- a. Flooring system and material shall be galvanized, aluminum or equal installed to be airtight, smooth, water-tight, and equally strong as a 12 gauge steel floor.
 - b. Floor shall be insulated per same standard as casing.
6. Access Doors:
- a. Access doors shall be provided for every section of the AHU.
 - b. Access doors shall contain thermal pane viewing windows, with thermal breaks, and installed so that the inside surface is flush with the casing.
 - c. Swinging access doors shall open against fan pressure where possible. Material shall be same as for wall panels. Each door shall have a minimum 3 hinges, 1 door handle on each side, and 2 camlocks operable from each side. All hardware shall be zinc plated, or non-corrosive equal. All latches shall be suitable for locking with a padlock.
 - d. Where access doors are not provided, access panels shall be provided for equipment removal, where required. They shall be large enough to easily remove any section of serviceable and replaceable equipment. Preferred method of attachment to housing is by A-307 bolts threaded into structural steel housing frame from the outside.
 - e. All access doors and panels shall be double gasketed to limit air leakage.
7. Coil/Filter Supports:


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- a. All equipment supports shall be designed to support equipment during shipment and after being hooked up and placed in operation at the job site. All supports shall be arranged to allow disassembly and removal of coils, filters, and fans without disassembling supports. Supports shall not restrict air flow to coils, filters, or fans.

8. Insulation (Under Floor):
 - a. A minimum 24 gauge support pan under insulation shall be provided to protect insulation, for outdoor and indoor units.

9. Exterior Finish (Outdoor Units):
 - a. Exterior finish shall be phosphatized galvanized (or approved equal) and shall be factory painted.
 - b. The unit panel assembly shall be painted with a 2 part polyamide epoxy paint on the exterior surfaces. Before painting, surfaces shall be cleaned, and surfaces shall be treated with a phosphate rinse to assure paint adhesion. The painting system shall have been tested by an independent firm to applicable ASTM standards and the minimum properties shall be:
 - 1) Salt Spray: Five percent salt solution fog at 95°F for 500 hours, no deterioration.
 - 2) Adhesion: Coating cut into 1/16" squares and 3M #600 tape suddenly removed, no loss of adhesion.
 - 3) Acid Resistance: Fifteen minute exposure to 10% hydrochloric acid, no effect.
 - 4) Alkali Resistance: Fifteen minute exposure to 10% sodium hydroxide, no effect.
 - c. Finish coat of paint shall be Glidden "Glid-Guard" epoxy paint, color shall be project specific.

10. Roof (Outdoor Units):
 - a. Roof shall be as previously described for casing.
 - b. The unit roof shall have an exterior sealing membrane of P-I-B or Hypalon to prevent water leakage. This membrane shall have a minimum elongation of 450% at break (ASTM D 412) to prevent damage from expansion and contraction of the housing, and shall not become brittle at temperatures down to -40°F.

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- c. The roof system shall have a 20 year limited warranty.
- d. The unit roof shall be designed to support not less than 250 lbs point load or 35 psf superimposed snow load.
- e. The roof shall be pitched in a single direction with the low point occurring over the doors. Provide gutter for full length of unit with downspouts at both ends.

11. Safety Grate:

- a. For down flow units, provide floor grating in all return air and supply air openings in the floor of the unit.

12. Centrifugal Fans:

- a. Array fan systems are acceptable.
- b. Direct-drive fans are preferred, belt driven fans require Yale Facility Engineering approval
- c. Fan housing and blades shall be welded construction. Fans are to be double width, double inlet type, with forward-curved blades or backward-curved airfoil section blades. Forward-curved wheels shall be bonderized steel painted with baked enamel, or galvanized steel. Airfoil wheels shall be steel painted with zinc chromate primer and an enamel finish coat.
- d. Fan shafts shall be solid steel, turned, ground, and polished.
- e. Fan wheels shall be keyed to the shaft and shall be designed for continuous operation at the maximum rated fan speed and motor horsepower. Fan wheels and shafts shall be selected to operate at least 25% below the first critical speed, and shall be statically and dynamically balanced as an assembly.
- f. Fan bearings shall be self-aligning, pillow block regreasable ball type selected for an average life of 200,000 hours at design operation conditions, per ANSI Code B3.15. Provide remote lube system, grease fittings shall extend to exterior of unit.
- g. Vibration isolation of the entire fan, motor, and drive assembly to be by use of 2" deflection springs, internally mounted at the factory, together with fan discharge flexible connection and thrust restraint springs.
- h. Fan motors are to be factory mounted inside the fan section casing, on slide rails having two (2) adjusting screws. Motors are to be open drip-proof type, refer to other applicable standards for additional requirements. Motors shall be 1750 rpm. Motors that exceed 1750 rpm shall require Yale Facility Engineering approval.
- i. Fan drives shall be factory mounted with final alignment and belt adjustment to be made by the Subcontractor after installation. Belt drives shall be variable


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pitch type up to and including 15 hp, fixed pitch type above 15 hp. Drive design shall provide a 1.4 service factor. Synchronous belts shall be specified for systems with VFD's.

- j. Variable speed drives be provided, refer to applicable standards for requirements. The variable speed drive system shall be capable of a minimum fan speed reduction to approximately 40% of design rpm.
- k. At a minimum, the fan drive assembly shall consist of a fan motor mounted on a movable base, spring-loaded variable-pitch drive pulley, two (2) fixed-pitch jackshaft pulleys and a fixed-pitch fan shaft pulley. The solid-steel jackshaft shall be supported by regreasable pillow block bearings, selected for an average life of 200,000 hours at design conditions per ANSI Code B3.15. All belts to be factory furnished.
- l. The movable motor base shall be fitted with permanently lubricated bronze bearings which shall ride on polished chrome rails.
- m. Variable speed drive shall be by factory-furnished electric control panel for field installation. At a minimum, the panel shall contain controller, control relays, manual fan speed switch, fan starter auxiliary contact, mode switch, control transformer, and terminal block. The VFD shall be controlled by the BMS, and duct-mounted static pressure controller furnished by the automatic control subcontractor.
- n. Variable Inlet Guide Vanes: Where required, units shall be provided with variable inlet vanes integral with the inlet bells of the fan. Vane operating shafts shall be connected to control ring by crankarms. Both sets of vanes are operated by a lever on the fan scroll with connecting shaft between inlets. Operators for inlet vane operation shall be provided by automatic temperature control subcontractor.


13. Filters:

- a. General:
 - 1) Supply all filters of each style as product of 1 manufacturer.
 - 2) Assemble filter components to form filter banks for each style from products of 1 manufacturer.
 - 3) Size, media face area, NBS test efficiency, initial and final air resistance shall be as scheduled on the Contract Drawings or as specified herein.
 - 4) Provide filter media that is UL 900, Class 1 listed and approved by local authorities. All filter efficiencies shall be in accordance with ASHRAE Standard 52 dust spot test.
- b. Housings:
 - 1) Design: Accommodate standard size filters of types specified, capable of

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providing interchangeability of filter media of other manufacturers.
 When scheduled, provide frames to retain both panel type prefilters and extended media filters.

- 2) Prefilter Housings: Where prefilters immediately precede other filters, the housings may be provided as a single composite assembly to accommodate both filter banks.
- c. Panel Filters:
- 1) Media: Medium efficiency, pleated, disposable type, consisting of a nonwoven cotton and synthetic fabric, having an average efficiency as scheduled on Contract Drawings. Provide no less than 4.6 sq ft of effective media filter area for each square foot of filter face area. Pressure drop shall be 0.13" W.G. maximum at 250 fpm (Farr 30/30 or equal).
 - 2) Media Support: Welded wire grid, formed to effect a radial pleat design, with media bonded thereto.
 - 3) Enclosing Frame: Heavy duty beverage board having diagonal support members bonded to both sides of pleats. Bond the inside periphery of the frame to the filter pack.
 - 4) Filter Housings: Construct of 16 gauge galvanized steel, factory assembled. Include side access doors, on both sides with inside and outside handles, extruded aluminum tracks and holding frames. Filters shall form a "V" shape with an average face velocity of 300 fpm or less.
- d. Extended Media Filters:
- 1) Media: High performance, 90% efficient, deep pleated, rigid, disposable type, consisting of high density microfine glass fiber media having an average efficiency as scheduled on Contract Drawings. Provide no less than 14.5 sq ft of effective media filter area for each square foot of filter face area. Pressure drop shall be .68" W.G. maximum at 500 fpm (Farr RIGA-FLO 200 12" or equal).
 - 2) Media Support: Welded wire grid, formed to effect a tapered radial pleat design with media bonded thereto. Provide contour stabilizers on both sides of filter pack.
 - 3) Enclosing Frame: Constructed of galvanized steel. Filter pack continuously bonded to the frame with diagonal support members provided on both sides of the filter.
 - 4) Filter Housings: Not less than 16 gauge galvanized steel, equipped with polyurethane foam gaskets, fasteners, and filter centering dimples. Secure flush mitered sealing corners to form a uniform sealing and gasketing surface. Provide in-line depth of not less than 2.69" to effect adequate bearing surface for filter banks. Filter fasteners shall be capable of being

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installed without requiring tools, nuts, or bolts. Include side access doors on both sides with inside and outside handles.

- e. Filter Gauges:
 - 1) Provide 3-1/2" diameter diaphragm activated gauges to measure air flow resistance through the extended media filter bank. Provide with white dial, black figures and zero pointer adjustment. Include static pressure tips, tubing, mounting hardware, and suitable range.
- f. Installation:
 - 1) All filter banks shall be constructed and assembled to prevent passage of unfiltered air. Provide appropriate rubber or neoprene gaskets as necessary. Seal frames to air handler to prevent air bypass.
- g. Spare Sets:
 - 1) In addition to the filters provided with the air handler, 2 spare sets shall be provided. The first spare set shall be installed at substantial completion prior to final approval. The second spare set, in original cartons shall be turned over to the Owner for future use.


14. Sound Attenuators:

- a. Sound Attenuators: Construct in accordance with NFPA 90A standards. Provide outer casings and internal perforated sheet metal not less than 22 gauge and comply with high velocity ductwork recommendations of the current ASHRAE Guide.
- b. Acoustical Fill Materials: Acoustical quality glass fiber packed behind partitions to eliminate voids caused by material settling. Provide a single 0.064" thick layer of plain weave glass cloth, 6 oz per sq yd weight between the acoustical fill and the air stream. Provide airtight construction, leakproof against a differential pressure of 8" wg.
- c. Losses: Provide as follows, or as project requirements require:

DIL (dB) Minimum									
Service	63 Hz	125	250	500	1K	2K	4K	L	Model
Supply	7	12	5	7	12	19	23	60	IAC-5ES
Fan Cone	3	11	17	18	16	12	11	43.5	IAC-D
Return	7	21	25	32	34	34	37	60	IAC-5S

15. Steam Injection Humidifier:

- a. Refer to Humidifier Standard.

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16. Mixing Box Section:


- a. Construct per structural requirements specified herein.
- b. Recirculation systems intended with mixing of air streams shall have a mixing section with necessary components specifically engineered to achieve evenly and thoroughly mixed conditions prior to entering heating or cooling coils. This is critical in cold climates to avoid stratification and nuisance freezestat tripping. Professional shall include in the engineered design the application of air blenders, directional deflectors/baffles designed to force air streams into each other to mix, and/or blow-through supply fan arrangements in which air is mixed prior to entering coils.
- c. Wherever possible locate outside air and return dampers directly adjacent to one other and as far upstream of the connection to the AHU as possible to facilitate mixing.
- d. The damper blades shall be arranged so that the air streams are directed at one another to facilitate mixing.
- e. Damper linkage shall be extended outside the unit for external actuator mounting. Internal actuator mounting is not acceptable.

17. Coils:

- a. General: Provide coils that are the product of a manufacturer regularly engaged in their production and regularly issues complete catalog data thereof. Coils shall be rated per ARI 410.
- b. Construction: Refer to Air Coil Standard.
- c. Heating Coil Design Parameters: 200 psi and 300°F.
- d. Cooling Coil Design Parameters: 150 psi and 200°F.
- e. Coil Connections: Extend coil connections to exterior of indoor units or to vestibule of outdoor units for connection by others.

18. Drain Pans

- a. All coil, moisture eliminator, and intake modules shall be provided with an insulated, double-wall, stainless-steel drain pan.
- b. Fabricated with slopes in at least 2 planes to collect condensate from cooling coils including coil piping connections, coil headers and return bends, and a minimum of 6 inches downstream from cooling-coil face and from humidifiers.
- c. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
- d. A minimum of 2 inches deep, and complying with requirements in ASHRAE 62.1.
- e. Drain Connections: Both ends of pan with minimum NPS 1 threaded nipple,

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- same material as drain pan.
- f. Pan-Top Surface Coating: Per ASHRAE Guidelines.
- g. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

19. Electrical Requirements:

- a. All requirements of the Connecticut Electrical Code and National Electrical Code and the following shall be met.
- b. All wiring shall be minimum 12 gauge copper conductor with insulation consistent with Yale Electrical Standards, and shall be contained within rigid galvanized steel conduit or liquid-tight flexible conduit of minimum 3/4" diameter.
- c. All fan motors shall be factory wired to nonfused disconnect switches mounted on the outside of the fan compartment. All lights shall be marine-type protected light fixtures with 120 volt LED light fixtures of sufficient wattage to attain 50 footcandles at all sections of the unit designed for personnel access, and shall be factory wired to a light switch mounted on the outside of the unit adjacent to the access door.
- d. All components shall be sized for the maximum voltage, amperage, and wattage they may experience under all phases of operation.
- e. Provide GFI receptacles at a minimum of 10 foot intervals along the perimeter exterior of unit.

20. Humidifier:

- a. Provide in accordance with applicable standard.

21. Roof Curb:

- a. Roof curb shall be a minimum of 14" high and approved by the National Roofing Subcontractors Association. Seal between unit and curb shall be 2" wide high-density gasket material. Curb shall be thermally and acoustically insulated. Sound deadening material shall be added where required to prevent noise from transmitting to space below.