PART I – GENERAL

[Note to PSC: This specification for Modular Air Handling Units applies to units with design airflow rate no greater than 5,000 CFM. Units with design airflow greater than 5,000 CFM will typically comply with requirements of specification Section 23 73 13 Custom Air Handling Units. However, in some cases it may be necessary to apply Custom Air Handling Unit specifications to smaller units to satisfy requirements not readily achievable with Modular Air Handling Units. Such requirements include:

- *Increased R value to satisfy more demanding interior and/or exterior ambient conditions*
- *Non-standard unit configurations*
- *Non-standard materials of construction or coatings*
- *Incorporation of custom heat recovery and/or auxiliary device requirements*

Owner is to be contacted to confirm AHU type for specific application.]

[Note to PSC: These specifications include numerous options for inclusion or exclusion of specific features. Review carefully and edit text as appropriate for each item for specific project.]

1.1 SECTION INCLUDES

A. Modular (Semi-Custom) Air Handling Units (AHU)

B. Modular Dedicated Outdoor Air Units (DOAU)

[Note to PSC: DOAU is to be treated as project-specific AHU. Separate DOAU specifications have not been provided nor are they needed. Specifications provided herein apply equally to AHUs and DOAUs. As with AHUs, project specific requirements for DOAUs are to be incorporated into project documents.]

C. Plenums and Housings, including exhaust fan plenums

1.2 RELATED SECTIONS

Products provided under this section but specified under a separate section.

A. *23 09 13 – Instrumentation and Control Devices for HVAC*

B. *23 09 13.43 - Control Dampers*

C. *23 09 23 – Building Automation Systems*

D. *23 34 00 – HVAC Fans*

E. *23 40 00 – HVAC Air Cleaning Devices*

F. *23 82 16 – Air Coils*

G. *23 31 00 – HVAC Ducts*

H. *26 60 00 - Common Motor Requirements*

I. *26 29 23 - Variable Frequency Motor Controllers*

1.3 REFERENCES

A. *AHRI Standard 430 – Performance Rating of Central Station Air-Handling Units*

B. *AHRI Standard 1060 – Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment*

C. *AMCA Standard 311 – Certified Ratings Program – Product Rating Manual for Fan Sound Performance*

D. *ASTM E90-09 – Standard for Measurement of Airborne Sound Transmission Loss*

E. *ASHRAE Standard 62.1 – Standard for Indoor Ventilation for Indoor Air Quality*

F. *ASHRAE Standard 84 – Method of Testing Air-to-Air Heat/Energy Exchangers*

G. *ASHRAE Standard 90.1 – Energy Standard for Buildings*

H. ANSI/ASHRAE Standard 111 – Testing Adjusting and Balancing of HVAC Systems x

I. *ASHRAE Standard 1350 – Mechanical Performance Rating of Central Air-handling Unit Casings*

J. *SMACNA HVAC Air Duct Leakage Test Manual*

K. *NADCA Standard ACR 2013 - Assessment, Cleaning and Restoration of HVAC Systems*

L. *NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials*

M. *National Electric Code*

N. *International Mechanical Code*

1.4 QUALITY ASSURANCE

A. Unit shall bear ETL label.

B. Products and execution shall be in compliance with applicable codes and standards including those referenced above in Paragraph *1.3 REFERENCES*.

C. Installation, start-up and operation shall be in compliance with Manufacturer's requirements, recommendations, and Installation Operation and Maintenance guides (IOM).

1.5 SUBMITTALS

A. Dimensioned arrangement drawings of unit including plan, external elevations and internal sectional views and dimensions of overall unit, unit sections and significant components including:

1. Large scale detailed cross sectional views of joint construction including panel-to-panel, floor-to-structure and panel-floor-frame connections.

B. Component materials including insulation, metal gauge/thickness, finishes, coatings

C. Approximate shipping weight

D. Multi-section unit assembly details and instructions

E. Assembled unit installation instructions

F. Field piping and electrical power/control wiring instructions and diagrams

G. Recommended / required service and operation clearances

H. Damper size and performance data including air velocity and pressure drop

I. Fan data including following:

1. Fan type and class
2. Wheel type, size
3. Airflow (CFM), total static pressure (TSP), speed (RPM)
4. Motor input frequency (Hz)
5. Performance curves indicating specified operating point at design conditions
    a. Individual fans
    b. Grouped fans operating as unit
    c. Initial design operating conditions
    d. Future design operating conditions, as applicable

J. Fan motor data
    1. Type, rated BHP, RPM, electrical characteristics
K. Coil data
    1. Coil type, configuration, number of rows
    2. System fluid (water, % glycol)
    3. Tube material, size (diam.), wall thickness
    4. Fin type, material, thickness, density (FPI)
    5. Coating data as applicable
    6. Header material, connection size
    7. Water flow rate, EWT, LWT, tube velocity, pressure drop
    8. Airflow rate, EAT, LAT, face velocity, pressure drop
    9. Certified thermal performance
L. Filter data
    1. Type, size, efficiency, velocity, clean/dirty pressure drop
M. Energy recovery wheel data
    1. Dimensioned drawings
    2. Structural component materials, finishes
    3. Media
        a. Type, detailed description, manufacturing process
        b. Number, dimensions of segments
        c. Airflow rates, face velocities, pressure drops, both sides of wheel
        d. Purge angle, purge air flow rate
        e. Entering and leaving air conditions, both sides
    4. Belt, motor data
    5. VFD data
    6. Media segment installation / replacement instructions
N. Plate Heat Exchanger Data
    1. Dimensioned drawings
    2. Structural component materials, finishes
    3. Plate thickness, spacing
    4. Coating data, as applicable
    5. Airflow rates, face velocities, pressure drops, both sides of exchanger
    6. Entering and leaving air conditions, both sides
O. Heat Pipe Data
    1. Dimensioned drawings
    2. Structural component materials, finishes
    3. Tube, fin materials and thickness
    4. Coating data, as applicable

5. Airflow rate, EAT, LAT, face velocity, pressure drop
6. Certified thermal performance

P. Static pressure (SP) drops at operating conditions for each component (e.g. coils, energy recovery devices). Pressure drop for clean filters and separate pressure drop for loaded "dirty" filters

Q. Design external SP for system

R. Unit sound power levels, (8) octave

1. Discharge, inlet, radiated

S. Catalog data, brochures and illustrations for unit including all auxiliary devices (e.g. energy recovery wheel, humidifier, UV light)

T. Manufacturer's installation, operation and maintenance manuals for unit including all auxiliary devices

U. Complete structural drawings

1. Curbs, supports, platforms, ladders, railings

V. Test Reports

1. Certified factory test reports as applicable
   a. Fan balance
   b. Air leakage test
2. Field test reports as applicable
   a. Fan balance
   b. Air leakage

W. Startup report

X. Test and balance report

Y. Signed and dated warranty documents

1. Air handling unit
2. Energy recovery wheel(s)

1.6 DELIVERY, STORAGE, PROTECTION

A. AHU and associated equipment shall be delivered to job site suitably packaged and protected for overland trucking using heavy-duty protective shrink-wrap plastic.

1. All items shipped loose such as filters, steam humidifier assemblies, etc. shall be suitably secured in unit or on separate pallet similarly protected.

B. Unit shall be stored in clean, dry environment protected from exposure to dust, debris and fluids.

1. Temporary covers shall be maintained over openings in unit housing throughout storage and system installation to greatest degree possible.

C. Construction Phase Operation

1. AHU shall not be operated during construction phase of project unless specifically indicated otherwise in project documents.
2. Unit shall not be operated in any manner that exposes it to inadequately filtered air flow. If unit is operated in dirty airflow conditions filters shall be changed frequently. Additional filtration shall be provided if practical.

1.7 EXTRA STOCK

A. In addition to filters provided with AHU, spare set of filters shall be provided. Performance of both sets of filters shall be adequate to satisfy LEED preoccupancy purge requirements.

B. For each belt driven fan, replacement set of matched belts shall be provided once proper belt length has been determined by TAB Contractor.

1.8 WARRANTY

A. Air handling unit including energy recovery wheel and other auxiliary devices shall be warranted by Manufacturer to be free from defects in material and workmanship and perform as specified for period of one year from date of startup or 18 months from date of delivery whichever occurs first. Manufacturer shall repair or replace unit or defective component(s) at no cost to Owner.

1. Repaired unit shall be like new with no cutting, patching or notable modification as determined by PSC or Owner.

B. Energy Recovery Wheel – Unconditional Ten Year Parts and Labor Warranty

1. Energy recovery wheel assembly in entirety including motor, belt(s), gear drive and electrical components shall be warranted by heat recovery wheel Manufacturer to be free from defects in material and workmanship and to perform as specified for period of ten years from date of startup.

2. Further, for same time period, warranty shall cover cost of parts and labor to repair, replace and/or adjust any and all components as required for proper operation and full functionality.

3. Warranty shall include conformance to specified maximum allowable wheel deflection of 1/32" at design airflow and pressure differential conditions throughout full term of warranty. Reference section below entitled *ENERGY RECOVERY WHEELS.*

4. Warranty shall apply unconditionally to required repair, replacement or adjustments resulting from normal wear as well as manufacturing-related causes. Normal wear shall include but not be limited to replacement of motors, belts and drive components.

5. If necessary to accomplish above stated warranty, Manufacturer shall replace entire wheel at no cost to Owner.

6. Repaired or replaced unit shall be like new with no cutting, caulking, patching or notable modification as determined by PSC or Owner

7. This warranty shall take precedence over Manufacturer's published warranty.

8. Full satisfaction of this warranty as detailed above shall be at no cost to Owner.

1.9 MANUFACTURER SERVICES

A. AHU Manufacturer authorized service technician shall provide:

1. Periodic observation and oversight during field assembly/installation of AHU as required to ensure proper installation

2. Preoperational inspection, oversite of startup and operator instruction including OIM. Submission of startup report and dated warranty document to Owner

3. Oversite and witness of all field tests specified herein. Submission of test reports to PSC and Owner

B. Energy recovery wheel Manufacturer's authorized service technician shall provide:

1. Preoperational inspection, oversite of startup and operator instruction including OIM. Submission of startup report and dated warranty document to Owner

2. Oversite and witness of all field tests specified herein. Submission of test reports to PSC and Owner

3. All services required to satisfy ten year unconditional warranty

1.10 APPROVED MANUFACTURERS

A. Air Handling Units and Dedicated Outdoor Air Units
   1. Basis of Design: Air Flow Equipment Company - E Series
   2. Also approved:
      a. York Solution Series
      b. Trane Performance Climate Changer
      c. Daikin Vision Series

B. Energy Recovery Wheels
   1. Standard applications, including laboratory general exhaust
      a. Thermotech
      b. Seibu Giken / SG America
      c. SEMCO

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS – INDOOR AIR HANDLING UNIT (STANDARD UNIT)

A. Basic Construction
   1. AHU shall consist of sectionalized casing panels and flooring mounted upon a structural base. Unit shall incorporate fans, coils, filters, dampers and other components as indicated within project documents.
   2. AHU, including structural base, flooring and casing panels, shall have adequate rigidity to satisfy specified deflection limits under all operating conditions.
   3. Unit shall be completely water tight and shall be air tight within specified leakage test limits in all operating conditions.
   4. Joints shall be sealed via inherent self-sealing design or with non-permeable gasket material. Caulk, butyl tape, mastic, etc. shall not be used as primary sealing method.
   5. Unit shall have true thermal break construction.

B. Dimensions
   1. Air handling unit selections indicated on project drawings are basis of design. Dimensions and other physical characteristics may slightly vary depending on manufacturer submitted. Such shall be fully coordinated with building/equipment room layout and available space.
   2. Contractor and manufacturer shall verify that layout and dimensions of installed unit allow adequate clearances for equipment access, pull space, door swings, etc. Such shall include coordination with other equipment and systems including ductwork, piping, electrical, etc.

C. Thermal Performance
   1. Exterior panels and floor of conditioned sections shall have minimum R value of 13 for 2” thick panels.
   2. Exterior surfaces and floor of conditioned sections shall not condense or frost given design operating temperature and humidity conditions, internal and external to unit.

      [Note to PSC: It is likely that a modular AHU with 2” wall panels will condense when located in an unconditioned area. Design accordingly.]

D. Deflection
   1. Deflection of components including wall, floor and roof panels shall not exceed 1/240th of span under full operating conditions unless specified otherwise.

E. Configuration

1. AHU shall be configured as shown on drawings. Unit shall be horizontal draw-through configuration as default. Alternate configuration may be presented to PSC for review and potential approval.

[Note to PSC: When achieving adequate mixing of airflow is of particular concern a blow-through configuration may be considered given that this configuration may be more effective in mixing air streams as they pass through the fan(s). In such case the supply plenum becomes a mixing box. The primary concern with blow-through configuration is that the supply airflow is near the saturation point, especially if there is any carry-over of mist or water droplets from the cooling coil. Thus, the supply plenum, final filters, if any, ductwork and downstream components may become wet and stay wet for extended periods of time.]

F. Additional Configuration Requirements

1. Mixed air units shall be configured to optimize mixing of return air and outdoor air over full range of velocities. *[Note to PSC: It is essential to "Do whatever it takes" to ensure good mixing of air streams without compromise. The University has found this to be, without question, the most important aspect of mixed air unit design.]*

2. To degree possible, outdoor air path shall be located above and centered upon return air path to minimize stratification. To degree possible, air streams shall enter mixing chamber from front, top or bottom rather than from either side. Coordination with Installing Contractor shall be provided. *[Note to PSC: To greatest degree possible coordinate ventilation system layout to conform to these recommendations.]*

3. Mixing chamber shall be of adequate length to ensure good mixing prior to filters. Dampers, including minimum OA damper shall be positioned and oriented to optimize mixing.

4. If indicated on drawings, air blending device(s) shall be provided to ensure thorough mixing of outdoor air and return air. *[Note to PSC: Evaluate need for air blenders and ensure coordination with drawings.]*

5. Velocity profile of air entering filter bank shall be such that maximum allowable airflow velocity is not exceeded at any point on downstream coil.

6. 100% outdoor air units (located indoors or outdoors) shall be configured to minimize ingress of snow and associated snow loading of filters. OA Intake plenum section with drain shall be provided upstream of filter section to serve as stilling basin for rain and snow. OA plenum shall be 4 ft. minimum length in direction of airflow. This dimension shall not be reduced without approval of PSC and Owner. *[Note to PSC: In some cases this dimension may need to be increased. Evaluate and edit accordingly. Ensure requirement is clearly reflected on drawings.]*

7. AHU Manufacturer shall contact PSC prior to bid to review any configuration deemed vulnerable to inadequate mixing or snow ingress. Recommended design changes shall be provided by Manufacturer to PSC. *[Note to PSC: Be creative and aggressive in achieving a design that maximizes mixing and minimizes snow ingress. A cookie cutter approach may be inadequate and may result in operational problems later.]*

G. Access

1. Access section with man door shall be provided between all major component sections. Access door opening shall be nominal 24" wide x 60" high. Height may be reduced only to degree limited by AHU dimension. In no case shall space between coils be less than 24".

2. All interior components shall be fully accessible including rotating equipment (e.g. fans, energy recovery wheels) and auxiliary equipment (humidifiers, UV lights).

3. All internal components including fans, motors and energy recovery wheels shall be removable without significant unit disassembly. Access doors and removable panels

shall be provided as required to provide such access without impacting structural integrity of unit.

H. Coatings

1. All non-galvanized steel components shall be primed and painted prior to assembly.

2.2 BASE

A. Base Rail Requirements

1. Structural base rail shall be provided under full perimeter of unit with cross supports provided as required for rigid assembly.

2. Base shall have factory fabricated lifting lugs.

2.4 FLOOR

A. General

1. Floor shall be completely insulated beneath with rigid two-part expanded urethane foam. Thickness of insulation shall be as required to satisfy specified thermal resistance, 2" minimum. Foam insulation may be injected or spray applied and shall completely fill all contours on underside of floor.

2. Sub-floor cover sheet shall be provided and shall completely encapsulate insulation. Sub-floor shall be G90 galvanized steel sheet.

B. Drain Pans

1. Pitched drainable stainless steel drain pans shall be provided in cooling coil, humidifier and heat recovery sections (located in outdoor air and exhaust air streams) in addition to other section(s) indicated on drawings.

2. Drain pans shall be double wall construction and shall be completely insulated with rigid two-part expanded urethane foam, 2" minimum thickness. Foam insulation may be injected or spray applied.

3. At no point shall fasters penetrate pan(s).

4. Drain pans shall be of sufficient depth and capacity to receive and drain by gravity "worst-case" water flow rate into pan.

5. Drain pans shall be double or triple sloped, pitched 1/8" per foot minimum toward outlet. Drain pans shall be IAQ compliant type and shall satisfy applicable requirements of ASHRAE Standard 62.1.

6. Drain pans and supports shall be constructed of type 304 stainless steel sheet.

7. Drain pans shall extend full width and length of AHU section and shall be configured / positioned to capture all fluid / condensate. Cooling coil drain pans shall extend 12" minimum downstream of leaving coil face.

8. Drain pans shall incorporate one or more 1.5" NPT pipe connection(s) of same material welded to lowest point. Connection shall be extended through unit frame to provide complete drainage.

9. Drain outlets shall be of adequate elevation for installation of drain trap of sufficient depth to ensure full drainage of pan during "worst- case" AHU operation.

10. Intermediate Drain Pans

a. Intermediate drain pans shall be provided between coils when two or more cooling coils are stacked in assembly.

b. Intermediate drain pans shall satisfy all requirements of primary drain pan.

c. Intermediate pans shall begin at leading face of coil and be of sufficient length extending downstream to prevent dripping or sheeting condensate from passing through air stream of coil below.

d. Intermediate pans shall include drain tube to direct condensate to primary drain pan. Drain tube shall be constructed of copper, aluminum or stainless steel.

e. Intermediate pan outlets shall be located at lowest point of pan and shall be sufficient diameter to preclude drain pan overflow under any operating condition.

2.5 CASING PANELS

A. Exterior Panels

1. Formed and reinforced panels shall be double wall, 2 inches minimum thickness.

2. Outer casing and inner liner shall be G90 galvanized steel sheet for standard applications. *[Note to PSC: Specify additional or optional coating as required.]*

3. Inner liner and all exposed inner components shall be 304 stainless steel if corrosive vapors will be present.

4. Inner liner shall be solid sheet. Perforated metal liner not allowed. Additional attenuation, if required, shall be provided via dedicated attenuator located within unit or within duct. *[Note to PSC: A perforated liner cannot be used with foam injected panels. For effective sound attenuation fibrous insulation must be used in conjunction with perforated panels. Neither is allowed.]*

5. Panels shall form water tight and airtight seal with adjacent panels. Fasteners shall not penetrate into air tunnel.

6. Panels shall be completely insulated with rigid two-part expanded urethane foam. Foam insulation shall be injected into cavity between outer casing and inner liner. Cavity shall be completely filled with no voids. Rigid board, semi-rigid board or spray applied insulation not acceptable.

B. Interior Panels (Partition Walls)

1. Formed and reinforced panels shall be double wall construction with thickness and insulation same as specified for exterior panels.

2. Internal panels shall be completely sealed at connections to adjoining surfaces with non-permeable gaskets.

C. Interior Blank-Offs and Safing

1. Blank-offs and safing shall be G90 galvanized steel sheet for standard applications. Such shall be type 304 stainless steel for corrosive exhaust applications.

D. Wall Penetrations

1. Wall penetrations shall be kept to minimum and to greatest extent possible shall be located on same side of unit housing as doors.

2. Pipe, tubing and electrical conduit shall be extended through wall of unit and properly terminated at unit exterior. Electric conduit and wiring shall be terminated in junction box or other approved enclosure mounted on unit exterior.

3. Wall penetrations shall be tightly sealed around components passing through wall.

4. Grommet shall be provided to provide tight seal around coil piping passing through panel opening.

E. Duct Connections

4. Flanged openings shall be provided for duct connections.

2.6 DOORS

A. Access doors shall be provided as indicated in project documents including drawings and shall satisfy following requirements:

3. Doors shall be hinged double wall construction.

4. Wall thickness, materials of construction and metal gauge shall be equal to that of corresponding wall panels, minimum.

5. Doors shall be insulated with same material as surrounding walls and shall comply with same thermal resistance performance requirements.

6. Doors shall incorporate continuous non-permeable gasket.

7. Each door shall have minimum of two (2) high compression latches, operable from both sides. Doors on outdoor units shall have securable padlock hardware.

8. Door dimensions shall be nominal 24" wide x 60" high minimum unless indicated otherwise on drawings. In no case shall door be less than 18" wide. Door(s) at fan section(s) shall be sufficiently sized to allow motor replacement. *[Note to PSC: Door width may be reduced to 18" only if absolutely required to shorten overall length of unit.]*

9. Each door servicing positive pressure section of AHU shall open inward. Each door servicing negative pressure section shall open outwards.

2.7 INTERNAL COMPONENTS

[Note to PSC: Edit for specific application. Provide specifications for additional components as appropriate (e.g. air blenders, humidifiers, UV lighting).]

A. Air Blending Devices

3. If indicated on drawings, air blending / destratifying device(s) shall be provided to ensure thorough mixing of outdoor air and return air. *[Note to PSC: Blending devices are typically required for mixed air units and are to be provided by default. If blending devices are clearly not needed, delete requirement.]*

4. Air blending device(s) shall be positioned within AHU per manufacturer's recommendations.

5. Air blending device(s) shall be sized and located within unit to optimize mixing for winter economizer operation. *[Note to PSC: Blenders become ineffective at low air velocities.]*

6. If winter airflow is less than maximum summer airflow, bypass damper shall be provided, located in parallel with blender to avoid excessive pressure drop and to facilitate air side economizer operation. Dampers shall be as shown on drawings.

[Note to PSC: If bypass dampers are clearly not needed delete requirement.]

B. Fans and Motors

1. Fans shall fully comply with requirements of *Section 23 34 00 – HVAC Fans*. Referenced section presents more complete and detailed specifications for fans. As such, it is incorporated in its entirety into this document, Reference *Section 23 73 23 – Custom Air Handling Units* by means of this reference.

2. Reference *Section 26 29 23 - Variable Frequency Motor Controllers* for VFD requirements.

3. Reference *Section 26 60 00 – Common Motor Requirements* for motor requirements.

4. Fans shall be housed centrifugal or plenum type, factory mounted complete with motor and drive.

5. Fans shall be selected for optimal efficiency at design operating point.

6. Number of fans shall be as indicated on drawings or schedule.

7. Plenum fans may be configured in "fan array" unless indicated otherwise in drawings or schedule.

8. Base support frame shall be provided for each fan.

9. Direct drive fans shall be selected such that at design conditions motor frequency shall be within 60-80Hz range if possible. In no case shall motor frequency under any condition exceed 90 Hz. *[Note to PSC: Given limited number of fan size options for a given application selection must be based upon optimal performance within allowable speed range (motor frequency range). Without belts and adjustable sheaves it is unlikely that optimal fan selection will be at nominal synchronous speed of motor (frequency = 60 Hz.)]*
10. Fan motors shall be 1,800 RPM synchronous speed unless indicated otherwise in schedule.
11. Motors for belt driven applications shall be provided with heavy duty slide bases.
12. For units with multiple parallel fans, each fan shall be provided with individual isolation damper to prevent reverse flow.
    a. Damper shall be constructed of aluminum and shall be specifically designed and configured to yield negligible impact on fan performance.
13. Flexible duct connector shall be provided between discharge of each housed centrifugal fan and associated duct opening in AHU cabinet such that flexible duct connection is not required at unit exterior.
14. OSHA approved guards shall be provided for fans, belts and sheaves as required for protection of service personnel. Guards shall be easily removable. Guards shall be designed to yield negligible impact on system performance.

C. Vibration Isolators
1. Fan vibration isolators shall be provided and installed by AHU manufacturer. Reference *Section 23 34 00 - HVAC Fans* regarding fan vibration isolation.
2. Fan(s) shall be sufficiently isolated such that isolation of AHU assembly is not required.

D. Field Balance
1. Field balance not required unless, if in judgment of PSC or Owner, vibration level is deemed questionable or unacceptable. In such case, vibration analysis and balancing shall be performed by qualified technician as specified above in *Section 23 34 00 - HVAC Fans.*
    a. Referenced section indicates maximum allowable fan vibration level as follows:
        1) Belt-driven fans: 0.15 in/sec peak velocity, filter in
        2) Direct drive fans: 0.10 in/sec peak velocity, filter in

E. Coils
1. Air coils, including heat pipe coils, shall fully comply with requirements of *Section 23 82 16 – Air Coils*. Referenced section presents more complete and detailed specifications for coils. As such, it shall be incorporated in its entirety into this document, *Section 23 73 23 – Custom Air Handling Units* by means of this reference.
2. Coils shall be positioned within air handling unit as specified and as shown on drawings.
3. Provision shall be made for coils of adequate size to satisfy specified face velocity and pressure drop limitations. Specified face velocity limitations shall not be exceeded.
4. For water coils, individual coil sections (i.e. sections with continuous plate fins) shall not exceed 48” in height.
5. Length of coil sections shall not exceed limitations of available coil pull space provided adjacent to unit.
6. Coils shall be completely enclosed within unit casing including all return bends and headers.

7. Fasteners and hardware shall be same material as connected components. Where connected components are dissimilar material, stainless steel fasteners shall be used.
8. Steam coil(s) and associated face-and-bypass dampers, as applicable, shall be positioned within unit such that elevation of condensate outlet is adequate for proper installation of steam trap assembly.

   [Note to PSC: As stated in referenced section steam heating coils are generally disallowed although in some cases are unavoidable. As addressed therein, steam preheat coils may be either integral face-and-bypass (IFB) or external bypass type/configuration. Indicate coil/damper type and clearly show on drawings. If external bypass, AHU housing design must accommodate bypass airflow.]
9. Coil piping, drain and vent connections shall be extended full size to unit exterior, same side as access doors unless otherwise indicated on drawings.
10. Coil headers and piping within unit shall be factory insulated as required to prevent undesirable heat transfer or condensation. Reference *Section 23 07 19 – HVAC Piping Insulation* for insulation requirements. Protective lagging shall be provided by unit manufacturer on all insulated piping within housing.
11. Coils shall be installed dead-level in unit to ensure complete drainage by gravity.
12. Moisture eliminators, if scheduled or shown on drawings, shall be chevron type.

F. Filters

1. Filters shall fully comply with requirements of Section 23 40 00 – HVAC Air Cleaning Devices. *[Note to PSC: At the time of this writing, reference to Section 23 40 00 serves as a place-holder. Section has been temporality removed from Standards pending updating.]*
2. Filters shall be front loading unless indicated otherwise on drawings.
3. To greatest extent possible filters shall be 24” x 24” nominal size. Otherwise filters shall be 24” x 12”.
4. Prefilters shall be 4” pleated type, MERV 8. Final filters shall be 22” bag type, MERV 11 for standard applications and MERV 14 for laboratory applications. Additionally filtration shall satisfy applicable LEED requirements. *[Note to PSC: Edit as appropriate for project and ensure coordination with drawings.]*
5. Prefilters and final filters shall be positioned within AHU to provide filtering of all air passing through coils, fans and auxiliary devices.
6. Final filters not required for units with design airflow rate no greater than 3,000 CFM.
7. If airflow entering heat recovery wheels, heat pipe coils, plate heat exchanger or run-around heat recovery coils is otherwise unfiltered, filter shall be provided upstream of such devices. Filters shall be 4” pleated type, MERV 8.
8. Filter frames shall be designed to hold specified prefilters and final filters in single frame. Filter frame assemblies shall be provided by Manufacturer and shall be factory installed.
9. Filter frames shall be assembled into racks. Structural supports shall be provided as required for rigidity.
10. Filter frames shall be standard universal clip type constructed of 16 gauge galvanized steel or .08” (12 gauge) aluminum for standard applications.
11. Filter frames shall incorporate sealing flange with replaceable gasket.
12. Filters used during pre-occupancy building purge shall satisfy LEED requirements.
13. Final filters located within AHU downstream of all other internal components shall be provided only as required for special application.

G. Control Dampers

1. Control dampers shall be provided as specified and as shown on drawings.
2. Control dampers shall include:
    a. Steam coil face-and-bypass dampers
    b. Cooling coil bypass dampers
    c. Energy recovery wheel bypass dampers
    d. Heat pipe face-and-bypass dampers
    e. Plate heat exchanger face-and-bypass dampers
    f. Air blender bypass dampers
3. Control dampers shall fully comply with requirements of *Section 23 09 13.43 - Control Dampers*. Referenced section presents more complete and detailed specifications for dampers. As such, it shall be incorporated in its entirety into this document, *Section 23 73 23 – Custom Air Handling Units* by means of this reference.
4. Special consideration shall be given to following:
    a. Damper placement/configuration for optimized airflow mixing
    b. Damper type (opposed vs. parallel blade) for optimized control.
    c. Adequate pressure rating for AHU test pressure
    d. Proper sizing for adequate damper authority
    e. Ease of damper removal/replacement
    f. Access to damper linkage
    g. Provision for proper actuator mounting

    [Note to PSC: Ensure that these items are adequately addressed within project design documents including drawings.]
5. Control dampers internal to unit shall be furnished and installed by AHU manufacturer. Damper actuation/automation shall be provided by Temperature Control Contractor.
6. Mixing dampers shall be configured to maximize mixing of outdoor air and return air.
7. “Minimum outdoor air dampers” shall be provided to ensure provision of and optimized control of ventilation and makeup air during periods of reduced total outdoor airflow.
8. When face-and-bypass dampers are provided with standard (non-IFB) steam preheat coil(s), bypass damper shall be “external” type. Bypass airflow shall be introduced back into air stream downstream of cooling coil. Configuration shall prevent “wiping” of downstream face of cooling coil with cold air. Face-and-bypass dampers with “internal” bypass around heating coil only not allowed.
9. In cooling mode, external bypass damper shall allow no air leakage resulting in bypass of unconditioned warm/humid around cooling coil.
10. Automated bypass damper shall be provided at air blending device to increase velocity when mixing of airstreams is required (closed position) and to decrease pressure drop when mixing is not required (open position). *[Note to PSC: Show damper on drawings. Damper is to be sized and placed to optimize both functions. If damper not required for proper air blender operation delete this paragraph. Damper typically required. Reference section above entitled Air Blending Devices.]*
11. Without exception, automated bypass damper shall be provided at each energy recovery wheel on supply and exhaust side of wheel to enable bypass of air when wheel is not active to reduce air pressure drop, facilitate economizer operation and

provide frost control. Dampers shall be sized such that combined airflow through damper and wheel is sufficient for 100% outdoor air economizer.

12. Automated face-and-bypass dampers shall be provided at heat pipe and plate heat exchangers to enable bypass of air when device is not active to reduce air pressure drop, facilitate economizer operation and provide frost control. Dampers shall be sized such that combined airflow through damper and heat exchange device is sufficient for 100% outdoor air economizer.
13. As stated above in section *Fans and Motors* fan isolation dampers shall be provided for multiple parallel fans to prevent reverse flow through an idle fan.
14. Damper design and installation shall be coordinated with Temperature Control Contractor.

H. Electrical

1. Electrical components and installation thereof shall comply with *National Electric Code (NEC).*
2. Electrical components and assemblies shall comply with *NEMA* standards.
3. Electrical components and assemblies shall comply with all requirements of *UIUC Facilities Standards – Division 26 – Electrical*

   [Note to PSC: Review applicable UIUC Standards and ensure that all requirements are incorporated into project documents.]

4. Conduit and Conductors

   a. Electrical conduit and conductors for power, lighting, and other devices shall be provided by AHU manufacturer, factory and/or field installed. Field installation of conduit and conductors at module splits shall be provided by Installing Contractor.

      1) Exception: Conduit, conductors and enclosures shall not be provided for motors served by VFDs. In such cases conduit, conductors and enclosures shall be furnished and field installed by Electrical Contractor.

   b. Separate circuits shall be provided for electrical power, lighting and controls/instrumentation.

   c. All conductors shall be enclosed within electrical conduit.

   d. Conduit and conductors shall be terminated at one or more junction boxes or approved enclosures on unit exterior.

   e. Size and location of conduits and electrical enclosures shall be coordinated with Electrical Contractor. Excess length of conductors shall be provided at each enclosure, coiled and tie wrapped.

   f. Conduit shall be EMT, ¾" minimum. Non-metallic conduit not allowed.

   g. Use of flexible conduit shall be limited to that required by NEC. Flexible conduit shall not exceed 3' in length and shall be as short as possible at AHU shipping splits.

   h. Use of flexible conduit in lieu of EMT not allowed.

   i. Exposed conduit shall be securely clamped and supported with metallic pipe supporting devices rigidly fastened to structure.

   j. Conduit shall be supported not more than 12" from points of connection to boxes and fittings. Conduit bends shall be supported not more than 12" from each change in direction.

   k. Conduit shall be sealed in accordance with *NEC* to prevent moisture migration resulting in condensation within electrical components.

   l. 20 Amp duplex electrical outlet shall be provided, mounted on unit exterior.

5. Auxiliary Equipment

    a. Factory installed conduit and wiring shall be provided for auxiliary equipment and shall be terminated in junction box or approved enclosure on AHU exterior.

        1) Exception: Conductors shall not be provided for VFD driven motors.

I. Controls

[Note to PSC: Owner is to be contacted to confirm control requirements for specific project. Sections below are to be edited as appropriate.]

1. Control dampers and actuators shall be furnished and factory installed by AHU manufacturer in compliance with referenced specifications.
2. Filter differential pressure gauge(s) shall be furnished and installed by AHU manufacturer in compliance with specification provided herein.
3. Ultraviolet light controls shall be provided by AHU manufacturer.
4. With exception of items listed above, controllers and associated devices for monitoring and control including sensors, tubing, conduit, conductors and enclosures shall be furnished and field installed by others. Programming shall be provided by others.

J. Hydronic Piping and Valves

1. Hydronic piping and valves exterior to AHU shall be provided by AHU manufacturer only if specifically indicated within project documents. Reference related specifications for piping and valve requirements as applicable.

K. Humidifiers

1. Humidifier shall be provided if indicated within project documents. Humidifier shall be steam-to-steam reboiler type consisting of steam generation unit, steam dispersion manifold and associated components.
2. Entire humidifier assembly including steam generation unit, dispersion manifold, associated components and controls shall be furnished by Heating Contractor unless indicated otherwise within project documents. Heating Contractor shall furnish dispersion manifold, mounting brackets and hardware to AHU manufacturer for factory installation within AHU.
3. Humidifier manifold shall be securely positioned within dedicated AHU section located between heating coil and following downstream component (typically cooling coil) unless indicated otherwise on drawings. *[Note to PSC: Humidifier manifold may be provided in heating coil section in lieu of dedicated humidifier section only if required to shorten unit. Stainless steel drain pan must still be provided in appropriate section(s) to capture water droplets.]*
4. Steam piping and manifold shall be insulated to provide burn protecting and minimize heat transfer to airstream. Insulation shall be provided by Installing Contractor.
5. Access section with man door shall be provided on downstream side of humidifier manifold unless indicated otherwise on drawings. In no case shall manifold be positioned less than 6” from upstream component or 18” from downstream component.
6. Steam shall be fully dispersed no less than 12” upstream of following component (typically cooling coil) under any operating condition. Undispersed water shall not impinge or condense upon said component.
7. Steam supply and condensate drain piping shall be extended through AHU housing and terminated outside unit.
8. Approved Manufacturers

    a. Dri-Steem

    b. Armstrong

c. Sarco

d. Nortek

L. Instrumentation

1. Differential pressure gauge

a. Differential pressure gauge shall be provided at each filter bank, viewable on exterior of unit.

1) Die cast aluminum case and bezel with acrylic cover

2) 4" diameter face

3) ± 2% full scale accuracy

4) 0-2.0" w.c. range

5) Adjustable set point indicator

6) Static pressure probes

7) Mounting bracket

8) Basis of design: Dwyer Magnehelic Series 2000

b. Gauge shall be exterior bracket mounted for ease of removal and access to tubing connections.

c. Separate differential pressure transmitter shall be provided by Temperature Control Contractor for remote monitoring.

2.8 ENERGY RECOVERY WHEEL(S)

A. Performance

1. Manufacturer shall provide certified performance data in accordance with ASHRAE Standard 84 and AHRI 1060. Independent performance test results shall be used to rate product in accordance with AHRI Air-to-Air Energy Recovery Ventilation Equipment Program.

B. General Requirements

1. Casing

a. Rotor casing shall be provided with structural framework to rigidly support rotor.

b. Casing sheet metal shall be reinforced as required to provide solid mounting surface for peripheral and radial seals.

2. Rotor

a. Rotor shall not deflect in excess of 1/32" from no-flow condition to full design airflow condition. Deflection shall be measured at rim of wheel where exposed to greatest force of airflow. Deflection shall be measured relative to wheel support frame.

b. Rotor design shall allow replacement of media segments in field conditions without removal of rotor.

c. Anti-rotation feature shall be provided to prevent reverse rotation.

d. Energy recovery wheels that require field assembly shall be assembled by service personnel employed by manufacturer of heat transfer media such that warranty is maintained.

3. Rotor Bearings

a. Rotor shall be supported by two pillow block bearings that can be maintained and replaced without disassembly of rotor.

b. Bearings shall provide L10 life of 1,000,000 hours operation.

4. Rotor Seals

   a. Face seal and perimeter seal shall be provided to prevent cross leakage between two air streams.

5. Seals shall be field adjustable non-contact labyrinth type. Purge Sector

   a. Factory fabricated field adjustable purge unit shall be provided.

   b. Purge shall be designed to limit cross contamination to less than 0.5% of exhaust stream concentration at any operating condition for standard applications. Cross contamination shall be limited to 0.04% for laboratory fume hood applications or other systems conveying toxic or noxious vapors.

6. Drive

   a. Rotor shall be driven by belt system and electric motor.

   b. Variable speed control of wheel for capacity and frost control shall be accomplished via use of VFD. VFD shall comply with *Section 26 29 23 - Variable Frequency Motor Controllers* for VFD requirements.

   c. Motor shall comply with *Section 26 29 00 - Common Motor Requirements*.

7. Coating

   a. For non-laboratory applications, all metal surfaces shall be galvanized or provided with corrosion resistant coating.

   b. For laboratory applications, all metal surfaces exposed to airflow shall receive acid resistant epoxy or phenolic coating. *[Note to AE: If different material or coating is more appropriate for specific application such is to be identified and inserted into specification in lieu of specified coating.]*

8. Filters

   a. Filtration shall be provided upstream of energy recovery wheel in each air path. As indicated within filter specification above, filters shall be front loading 4" pleated type, MERV 8.

   b. Filter assembly shall comply with requirements presented above in paragraph entitled *Filters.*

9. Bypass Dampers

   [Note to PSC: Bypass dampers are to be shown on project drawings. Dampers may not be deleted from design without express approval of owner. Dampers are to be sized such that combined airflow through damper and wheel is sufficient for 100% outdoor air economizer.]

   a. Without exception, automated dampers shall be provided in both air streams at each energy recovery wheel (i.e. outdoor/supply, return/exhaust) to enable bypass of air when wheel is not active to reduce air pressure drop, facilitate economizer operation and provide frost control. Dampers shall be sized such that combined airflow through damper and wheel is sufficient for 100% outdoor air economizer.

   b. Bypass dampers shall comply with requirements presented above in paragraph entitled *Control Dampers and Actuators*.

10. Controls

    [Note to PSC: Owner is to be contacted to confirm control requirements for specific project. Sections below are tobe edited as appropriate.]

    a. All control devices and programming shall be provided by Temperature Control Contractor in accordance with requirements of *Section 23 09 23 – Building*

Automation System (BAS) for HVAC and *Section 23 09 13 – Instrumentation and Control Devices for HVAC*.

b. Manufacturer / Installing Contractor shall coordinate installation of controls and startup of AHU with Temperature Control Contractor.

C. Media

1. Total Enthalpy Wheel

a. Wheel shall provide both sensible and latent heat recovery. Sensible and latent heat transfer effectiveness shall meet or exceed scheduled values.

b. Energy recovery effectiveness values shall be tested in accordance with ASHRAE 84 and shall be certified in accordance with AHRI Standard 1060.

c. Media shall consist of corrugated aluminum foil substrate coated with molecular sieve desiccant or ion exchange resin configured into honeycomb structure. Edges shall have anti-corrosion coating.

d. Corrugations shall have high surface area per volume to ensure no fouling occurs on internal heat transfer surface. Dry particles up to 800 microns shall freely pass through media.

e. Molecular sieve and ion exchange resin coating shall be designed to selectively transfer water vapor while allowing other gaseous chemicals to pass.

1) For standard applications, including laboratory general exhaust:

(a) Molecular sieve desiccant internal pore diameter shall limit absorption to materials having 4 angstrom kinetic diameter or less.

(b) Ion resin shall provide same or better performance in all regards.

f. Media shall be cleanable with low temperature steam, hot water or light detergent solution without degrading latent recovery.

g. Media shall have flame spread of less than 25 and a smoke developed of less than 50 when rated in accordance with ASTM E-87.

2. Sensible Only Wheel

a. Wheel shall provide sensible heat recovery. Sensible heat transfer effectiveness shall meet or exceed scheduled values.

b. Heat recovery effectiveness values shall be tested in accordance with ASHRAE 84 and shall be certified in accordance with AHRI Standard 1060.

c. Media shall consist of corrugated aluminum foil substrate with corrosion resistant coating configured into honeycomb structure.

d. Corrugations shall have high surface area per volume to assure no fouling occurs on internal heat transfer surface. Dry particles up to 800 microns shall freely pass through media.

e. Media shall be cleanable with low temperature steam, hot water or light detergent solution without degrading latent recovery.

f. Media shall have flame spread of less than 25 and smoke developed of less than 50 when rated in accordance with ASTM E-87.

2.7 PLATE HEAT EXCHANGERS

[Note to PSC: Potential difficulty of cleaning plate heat exchangers is a significant concern when considering their use. The goal is that plate heat exchangers be designed and selected such that they are no more difficult to clean than an eight row air coil, 12 fins/inch. Cleaning method typically utilizes power washing.]

A. Description

1. Plate heat exchanger shall be stand-alone assembly of parallel heat transfer plates affixed within rigid supporting framework configured for installation within air handling unit.

B. Performance

1. Plate type air-to-air heat exchanger shall be AHRI Certified to *Standard 1060 – Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment* and shall bear the AHRI Certified Product Seal.

C. Materials of Construction

1. Clean air applications, including laboratory general exhaust:

a. Aluminum

D. Condensate Management

1. Heat exchanger shall be designed and oriented to facilitate condensate drainage to drain pan below without restricting airflow.
2. Heat exchanger shall be sized/selected to achieve design performance without condensate carryover into air stream. Face velocity shall typically not exceed that of associated cooling coil within AHU.

E. Leakage

1. Clean air applications including laboratory general exhaust

a. 1% airflow at 1.5" w.c. differential pressure

F. Dampers

[Note to PSC: Bypass dampers are to be shown on project drawings. Dampers may not be deleted from design without express approval of owner.]

1. Automated face and bypass dampers shall be provided to enable bypass of air when heat exchanger is not active to reduce air pressure drop, facilitate economizer operation and provide frost control.
2. Dampers shall be sized such that combined airflow through bypass damper and heat exchanger is sufficient to provide 100% outdoor air economizer.
3. For laboratory fume hood or other corrosive vapor applications, dampers shall be constructed of type 304 or type 316 stainless steel and/or or coated with appropriate phenolic material (e.g. Heresite). *[Note to PSC: If different material or coating is more appropriate for specific application, such is to be identified and inserted into specification in lieu of specified coating (e.g. some applications may require type 316 stainless steel in lieu of type 304).]*
4. Dampers shall comply with requirements presented above in paragraph entitled *Control Dampers and Actuators*.
5. Dampers shall conform to requirements of *Section 23 09 23 – Control Dampers.*

2.9 OUTDOOR AIR HANDLING UNITS

A. Design of outdoor air handling unit shall be based upon "standard unit" as specified above.

B. Outdoor air handling unit shall satisfy all specified requirements for indoor air handling unit plus additional requirements as identified below. Indoor air handling unit shall not be installed outdoors.

C. Outdoor unit shall incorporate reach-in enclosure as specified below.

D. Outdoor AHU shall be specifically designed for exposure to harsh weather conditions, including high wind, heavy snow loading, torrential rain and UV exposure. At minimum, requirements shall comply with all applicable design and construction standards for geographic location.

E. Exterior surfaces:

1. All exposed steel components shall receive powder coat finish with UV protectant topcoat or backed enamel coating. Any scratches or defects in coating shall be touched up after installation per manufactures recommendations. Any coating substitution must be approved by PSC prior to unit construction. *[Note to PSC: Confirm with Manufacturers that specified coating is available and economically viable. Better to specify required coating prior to bid than to approve substitution after bid.]*

F. Enclosure, Reach-in

1. Exterior reach-in enclosure(s) shall be provided for each outdoor air handling unit. Multiple enclosures shall be provided as required to provide weather protection for all pumps, piping, valves, controls, electrical, VFDs, and other components as required and/or as indicated on drawings.
2. Enclosures shall be sized and configured in manner that provides adequate access for operation, maintenance and replacement of all housed components.
3. Enclosure structure, panels, doors and components shall be of same material and construction as balance of AHU. Enclosure shall satisfy specified requirements for base AHU. Exceptions:
4. One or more exterior doors with hinges and latches shall be provided as required for convenient access to all components. Door(s) shall be sized and configured as required to satisfy specified access requirements.
5. Provision shall be made for heating and cooling/ventilating vestibule(s) as required to maintain temperature within allowable limits.

   [Note to PSC: Method of active or passive heating/cooling requirements is to be identified and clarified in project documents. Reference related notes above regarding heating/cooling of walk-in vestibules.]

G. Component Location

1. AHU manufacturer shall determine location of field installed AHU components (e.g. VFD(s), electrical panels/devices, control panel(s)/devices, mechanical piping/devices) and shall coordinate with Installing Contractors as applicable.
2. Clear dimensions at electrical panels shall comply with requirements of NEC.
3. Provision shall be made to access drain piping and trap(s) for cooling coil condensate and other fluids as applicable. Piping and trap(s) shall be removable for cleaning and replacement of same.

F. Component Access

1. Outdoor AHU shall be configured to facilitate removal of coils and other internal components including fans, motors, energy recovery wheels, etc. without significant unit disassembly.

G. Roof

1. Roof shall cover entire unit.
2. Roof shall be sloped ¼”/ft., minimum.
3. Roof deflection shall not exceed 1/240th of span with applicable snow and wind loading.
   a. Minimum design snow load shall be 25 lbs./sq. ft.

b. Minimum design wind speed shall be 90 MPH.

H. Intake plenum

1. Intake air plenum section shall be provided upstream of filter section to serve as stilling basin for rain and snow.
2. Outdoor air plenum shall be configured to yield constant air velocity across full face of filter bank such that maximum allowable airflow velocity is not exceeded at any point on downstream coil face.
3. Plenum shall be 3 ft. minimum length in direction of airflow. *[Note to PSC: Increased length may be required for specific project.]*

I. Hoods and Louvers

1. Intake air hoods and louvers shall be provided to prevent ingress of rain and light powdery snow. *[Note to PSC: The University has repeatedly experienced problems with filters becoming clogged with snow as a result of inadequate outdoor air intake design.]*
2. Airflow velocity across net free area of each hood opening shall not exceed 400 FPM. Velocity across net free area of louvers shall not exceed 500 FPM.
3. Intake hood shall be same material, thickness and coating as unit exterior.
4. ½" bird screen shall be provided over exterior face of each louver.

J. Doors

1. Doors shall be as specified for indoor AHU.

K. Electrical

1. Electrical and control devices shall be located within reach-in enclosure unless NEC dictates otherwise.
2. Exterior electrical enclosures shall be NEMA 3R.
3. Duplex outlet shall be GFI protected.

2.10 PLENUMS AND HOUSINGS

A. Specifications provided herein shall be applied to following items as indicated within project documents to degree applicable

3. Plenums, including exhaust air fan plenums
4. Housings
5. Casings

2.11 FACTORY TESTING

A. Air Leakage Test

1. Air handling units that require no disassembly and reassembly shall be tested for air leakage at factory prior to shipment.
2. Testing shall be in compliance with *ANSI/ASHRAE Standard 111*.
3. Test pressure shall be 8" SP for positively pressurized unit sections and -8" SP for negatively pressurized unit sections unless indicated otherwise within project documents. Additionally, test pressure shall not be less than 1.25 x fan shut-off SP.
4. Cabinet air leakage shall not exceed 1% of design airflow rate at test pressure unless indicated otherwise within project documents.

B. Casing Deflection Test

1. In conjunction with air leakage testing, assembled unit shall be tested for casing deflection under leak testing conditions.

2. Under air leakage test conditions deflection of wall and top casing panels shall not exceed 1/240th of span.

2.12 FACTORY PREP

A. Units requiring field assembly shall be provided with factory blank-off panels at inlet openings, discharge openings, fan inlets and other locations required for field leak testing.

PART 3 – EXECUTION

3.1 EQUIPMENT LOCATION

A. Indoor unit shall be located to allow full access to all components.

B. Indoor and outdoor unit shall be located no less than 24" to nearest wall or obstruction. *[Note to PSC: This allows room for personnel to access the back side of the unit to inspect and facilitate various repairs including repair of coil return bends.]*

C. Outdoor unit shall be located no less than 48" from edge of roof.

3.2 EQUIPMENT SUPPORT

A. Indoor Unit

1. AHU shall be placed upon and firmly anchored to steel reinforced concrete pad provided by Installing Contractor.

a. Pad shall be anchored into concrete floor.

b. Pad shall be 6" minimum thickness.

c. Curb shall extend 6" beyond fan support frame on all sides, minimum.

d. Pad elevation shall be adequate to accommodate installation of cooling coil condensate drain trap and/or steam condensate drip trap at adequate elevation above floor to ensure full drainage during "worst- case" unit operation.

[Note to PSC: AHUs are often installed with insufficient vertical height to accommodate required trap depth. This happens all-to-frequently and is not easily remedied. Design is to incorporate generous AHU condensate outlet elevation relative to adjacent floor to ensure full drainage in worst case operating condition. Drawings must clearly indicate this requirement.]

B. Outdoor Unit

1. AHU support system shall be provided by Installing Contractor as specified and shown on drawings.

[Note to PSC: Show field fabricated structure on drawings. If structure is substantial it may be appropriate to retain services of Structural Engineer and assign work to General Contractor. In such case, structural requirement may be removed from AHU spec.]

2. AHU shall be firmly mounted upon enclosed and insulated roof curb or open structural support system of adequate strength and rigidity to support full operating weight of unit.

a. Curb and/or support system shall include support of full perimeter of unit including vestibule(s).

3. Roof Curb Requirements

a. Roof curb shall place AHU at 12" minimum height above roof surface.

b. Roof curb shall provide uninterrupted enclosure around entire perimeter of unit.

c. Roof membrane termination and two piece counterflashing shall be provided as specified and detailed elsewhere within project documents and in compliance with published *UIUC Facilities Standards.* *[Note to PSC: Review applicable UIUC*

Standards and ensure that comprehensive requirements have been incorporated into project documents.]

d. Curb shall incorporate continuous welded stainless steel cap, 16 gauge minimum. Horizontal surface of cap shall not be penetrated in any manner. Penetrations may be made through vertical portions of cap only. Attachment of structural members or hardware to horizontal surface of cap shall be made by means of welding only. All welded attachments shall be stainless steel.

e. Curb design shall be provided as specified and detailed elsewhere within project documents and in compliance with published *UIUC Facilities Standards*. *[Note to PSC: Review applicable UIUC Standards and ensure that comprehensive requirements have been incorporated into project documents.]*

4. Open Support Structure Requirements

a. Open support structure and associated access platform shall provide 36" minimum clearance between bottom of structure and roof surface to facilitate roof maintenance and future replacement of roof membrane.

b. Attachment of roof membrane to vertical supports shall be provided as specified and detailed elsewhere within project documents and in compliance with published *UIUC Facilities Standards*.

[Note to PSC: Review applicable UIUC Standards and ensure that comprehensive requirements have been incorporated into project documents.]

3.3 INSTALLATION

A. During site handling including crane transport, each factory assembled segment of air handling unit shall be structurally supported to prevent undo stress on unit components resulting in weakening or permanent deformation.

B. AHU shall be assembled per Manufacturer's instructions and shall satisfy following requirements:

1. AHU shall be leveled to ensure full drainage of coils by gravity and proper operation of rotating equipment. Support structure/pad shall be rigid and level prior to installation.

2. Unit shall be firmly anchored to structural support in compliance with applicable code requirements.

3. For AHUs supported upon concrete curb, base frame shall be grouted after leveling and anchoring.

4. Shipping restraints shall be removed (e.g. spring isolators, coil headers).

5. Ductwork connections shall be made as indicated on drawings.

a. Ductwork connections to AHU plenums shall utilize expanded area transition fittings.

6. Filter media shall be installed.

7. Drain pans shall be piped individually to unobscured floor drain.

a. Existing drain shall be relocated as required.

8. Clearances

a. Adequate clearance shall be provided for full functionality of access doors and removal/replacement of major components including coils and fans.

b. Adequate clearance shall be provided for installed piping.

c. Adequate coil pull area shall be provided.

d. Piping and other exterior system components shall be configured for disassembly without substantial modification to facilitate coil slide out. Coordination with other Contractors shall be provided.

9. Touch-up

a. After installation is complete exterior coating, if provided, shall be touched up per Manufacturer's recommendations.

3.4 CLEANING

A. When installation is complete, final cleaning of AHU shall be provided. AHU shall be cleaned to satisfaction of PSC and Owner. Cleaning requirement shall include coils and energy recovery wheel(s).

B. *NADCA Standard ACR 2013 Assessment, Cleaning and Restoration of HVAC Systems* shall be utilized by PSC as basis for determining need for cleaning, extent and methodology to be employed.

C. Only non-hazardous non-toxic cleaning agents and materials shall be used. MSDS cut sheets shall be provided upon request.

3.5 STARTUP

A. Prior to start-up Installing Contractor and Manufacturer's service technician(s) shall verify following items have been completed:

B. Unit is clean to satisfaction of PSC and Owner.

C. Spring isolator shipping restraints removed and components leveled.

D. All interconnections completed (i.e. electrical and control wiring, piping, casing joints, bolting, welding, etc.). Power wiring including motor starters and disconnects serving unit completed.

E. IFB steam coil lower header restraints removed.

F. All water and steam piping connections completed, hydrostatically tested and all water flow rates set in accordance with capacities scheduled.

G. All ductwork connections completed and all ductwork pressure tested.

H. All temperature control and safety systems completed and functional.

I. All dampers fully operational.

J. All filter media installed and clean.

K. All bearings properly lubricated.

L. Belts properly aligned and tensioned.

M. Fan(s), energy recovery wheel(s) turn freely.

N. Energy recovery wheel purge(s) and seals properly adjusted and secured.

O. Condensate drain trap and piping properly installed.

P. Labeling

1. After ventilating system balancing has been completed by TAB Contractor embossed label shall be permanently applied to front cover of VFD indicating airflow rate (CFM) and associated VFD output frequency (Hertz) as indicated within balance report.

Note to Contractor: This has not been a common practice but shall be performed before final approval.

3.6 FIELD TESTING

A. Air Leakage Test

1. Field assembled air handling units shall be tested for air leakage after assembly and prior to operation.
2. Testing shall be in compliance with ANSI/*ASHRAE Standard 111.*
3. Test pressure shall be 8" SP for positively pressurized unit sections and -8" SP for negatively pressurized unit sections unless indicated otherwise within project documents. Additionally, test pressure shall not be less than 1.25 x fan shut-off SP.
    a. Exception: For units with design airflow 10,000 CFM or less test pressure shall be 10" SP in lieu of 12" SP.
4. Cabinet air leakage shall not exceed 1% of design airflow rate at test pressure unless indicated otherwise within project documents.

    [Note to PSC: Test pressure and allowable leakage rate may be adjusted as appropriate for specific project.]
5. Modifications shall be made as required to pass test. Modifications shall be approved by PSC and Owner and shall be at Contractor's expense. Use of caulk and other sealants shall be minimized. Responsibility for providing corrective modifications falls jointly upon Ventilating Contractor and AHU Manufacturer.
6. Positive pressure test may be substituted for negative test only with approval of PSC and Owner. *[Note to PSC: Delete if desired. Evaluate difficulty of requiring separate test for positive and negative AHU sections.]*

B. Field Balance

1. Field balance of fan/motor assembly not required unless, if in judgment of PSC or Owner, vibration level is deemed questionable or unacceptable. In such case, vibration analysis and balancing shall be performed by qualified technician as specified above in section entitled *Factory Run Test / Balance*.
    a. Referenced section indicates maximum allowable fan vibration level as follows:
        1) Belt-driven fans: 0.15 in/sec peak velocity, filter in
        2) Direct drive fans: 0.10 in/sec peak velocity, filter in

END OF SECTION 23 73 13

This section of the *U of I Facilities Standards* establishes minimum requirements only.
It should not be used as a complete specification.