PART I - GENERAL

1.1 SECTION INCLUDES

A. Custom air handling units (AHU). [Note to AE: These specifications for custom equipment may be used as basis for specifying "packaged" air handling equipment. See Section 23 82 16 – Heating and Cooling Coils.]

B. Dedicated outdoor air units (DOAU). [Note to AE: DOAU shall be treated as project specific AHU. Same specifications shall apply.]

C. Related heat recovery equipment.

1.2 SUBMITTALS [Note to AE: Edit this section to make it project specific without deleting or omitting intent.]

A. Dimensioned arrangement drawings of unit including plan, external elevations and internal sectional views. Dimensions of overall unit, unit sections and significant components, including:
   1. Base frame and structural components, including vestibule as applicable.
   2. Curb and/or structural support indicating height requirement for condensate drain trap.
   3. Floor and drain pan(s).
   4. Wall, roof panels, including vestibule as applicable.
   5. Additional weather-proof roofing for exterior units.
   6. Doors, access panels, other access points.
   7. Inlet / discharge openings for duct / plenum connection.
   8. Fan(s)
   10. Energy recovery wheel(s) as applicable.
   11. Other heat recovery devices as applicable.
   12. Lights, switches.
   14. Factory installed piping, valves, wiring, junction boxes as applicable.
   15. Air blenders, humidifier, UV lighting, other specialty items as applicable.
   16. Attenuating devices as applicable.

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

C. Multi-section / knockdown unit assembly details and instructions.

D. Assembled unit installation instructions.

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

F. Recommended / required service and operation clearances.

G. Condensate drain trap detail drawing showing required dimensions.

H. Damper size and performance data.

I. Fan data including following:
1. Wheel type, size, class.
2. Airflow (CFM), total static pressure (TSP).
3. Performance curves indicating specified operating point at design conditions.
   a. Individual fans.
   b. All fans in group operating as unit.

J. Fan motor data
1. Type, rated BHP, RPM, electrical characteristics.

K. Coil data
1. Coil type, configuration, number rows.
2. System fluid (water, % glycol).
3. Tube material, size (diam.), wall thickness.
4. Fin type, material, thickness, density (FPI).
5. Header material, connection size.
7. Airflow rate, EAT, LAT, face velocity, pressure drop.

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.
   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. Programmable controller data.
7. Media segment installation / replacement instructions.

N. Static pressure (SP) drops at operating conditions for each component (e.g. coils, energy recovery wheel). Pressure drop for clean filters and separate pressure drop for loaded “dirty” filters.

O. Design external SP for system.

P. Unit sound power levels, (8) octave.
1. Discharge, inlet, radiated.

Q. Catalog data, brochures and illustrations for unit including all auxiliary devices (e.g. energy recovery wheel, humidifier, UV light).
1. Manufacturer’s installation, operation and maintenance manuals for unit including all auxiliary devices.
R. Certified factory leakage test results for unit cabinet.
S. Certified performance test results for energy recovery wheel.
   b. Cross contamination test.

1.3 WARRANTY
A. For installed air handling unit including energy recovery wheel(s) and other heat recovery devices, following warranty shall be provided:
   1. Manufacturer’s parts and labor warranty against defects in material and workmanship for period of one (1) year from date of start up.
   2. One (1) year extension of manufacturer’s parts and labor warranty identified above. [Note to AE: Some projects may not allow warranty extension. Delete as appropriate.]
B. For installed energy recovery wheel(s), additional warranty shall be provided:
   1. Manufacturer’s warranty of proper operation, specified thermodynamic performance and specified cross-contamination performance (for laboratory units) for period of five (5) years from date of start up. Warranty shall cover parts and labor required to correct any deficiencies. [Note to AE: Some projects may not allow five year warranty extension. Delete or edit as appropriate.]

1.4 STARTUP AND INSPECTION SERVICES
A. Services of AHU Manufacturer’s service technician shall be provided for preoperational inspection, startup of unit, and instruction of operating personnel.
B. Additionally, services of energy recovery wheel Manufacturer’s service technician shall be provided for preoperational inspection, startup of unit, adjustment, calibration of controls and instruction of operating personnel.
C. Additionally, for energy recovery wheels, annual inspection and written documentation of proper mechanical operation, thermodynamic performance and cross-contamination performance (for laboratory units) shall be provided for duration of warranty period.

1.5 EXTRA STOCK
A. In addition to filters provided with unit, 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 belts shall be provided for each fan once proper belt length has been determined by TAB Contractor.

PART 2 – PRODUCTS

2.1 CERTIFICATION
A. Unit shall bear ETL label.

2.2 CONFIGURATION
A. Unit shall be horizontal draw-through configuration unless otherwise indicated in project documents.
B. Unit with energy recovery wheel(s) shall be configured such that supply air is maintained at positive pressure relative to contaminated exhaust air in all operating and failure conditions.
C. Various damper arrangements shall be provided as indicated in project documents. Options include steam coil face and bypass dampers, energy recovery wheel bypass dampers, cooling coil bypass dampers.

2.3 APPROVED MANUFACTURERS
A. Air Handling Units and Dedicated Outdoor Air Units.
1. Air Flow Equipment
2. ClimateCraft
4. Huntair
5. Ingenia
6. Marcraft
7. SEMCO
8. Ventrol

B. Energy Recovery Wheels
1. Standard applications, including laboratory general exhaust
   a. Seibu Giken / SG America
   b. SEMCO
   c. Thermotech
2. Laboratory applications (corrosive, toxic or noxious vapors)
   a. Manufacturers listed above for standard units:
      1) As fully compliant with performance specification provided.
      2) As approved in writing by UIUC F&S Safety and Compliance Division.
      3) As approved in writing by UIUC F&S Engineering and Campus Services Division,
         Code Compliance and Fire Safety Dept.
   b. Basis of design: SEMCO
   c. Note for clarification: As used throughout this specification “laboratory application”
      refers to systems with exhaust airflow contaminated with corrosive, toxic or noxious
      vapors not suitable for breathing. “Laboratory application” does not include general
      laboratory exhaust. General laboratory exhaust falls within “standard application”
      category.

2.4 GENERAL REQUIREMENTS – INDOOR AIR HANDLING UNITS
A. Assembled units for both indoor and outdoor applications shall be completely water tight and
   shall be air tight within leakage test limits in all operating conditions.
B. No component or assembly shall deflect more than 1/200 of span in full operating conditions.
C. All sheet metal components shall withstand 250 lb/sq ft point load at center of panel without
   “oil canning”.
D. Unit shall have true “thermal break” construction. Panel connections shall utilize non-
   permeable gaskets. Use of caulk or other sealant as primary sealing method not allowed.
E. Unit shall be designed and constructed such that major internal components including coils
   and fan motors shall be removable without significant unit disassembly.
F. All interior components shall be fully accessible. Access section with man door shall be
   provided between all major component sections. Full access shall be provided to rotating
   equipment (e.g. fans, energy recovery wheels) and auxiliary equipment (humidifiers, UV
   lights). Access door openings shall be nominal 24” wide x 60” high unless indicated
   otherwise in project documents.
G. Pipe, tubing and electrical conduit internal to unit shall be factory installed to greatest extent
   possible. Such shall be extended through wall/roof 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.
H. Wall sleeve with grommet, boot or similar sealing device shall be provided at each wall penetration. Sleeve shall pass through wall independently of piping, etc and shall be positively sealed to eliminate potential for ingress of air or water into insulated wall cavity. Use of caulk shall be minimal. Caulking shall not be primary sealing method.

I. To greatest extent possible, wall penetrations shall be located on same side of unit housing, same side as doors and fan motor.

J. All hardware, fasteners, gaskets required for field assembly shall be provided and clearly identified.

K. Fasteners and hardware shall be same material as connected components. Where connected components are dissimilar material, stainless steel hardware shall be used.

L. Assembled air handling unit and supplementary components shall have flame spread of less than 25 and smoke developed of less than 50 when rated in accordance with ASTM E-87, NFPA-255 and UL-723.

2.5 SPECIAL REQUIREMENTS

A. As required, due to unit transfer constraints provide knock-down construction for field assembly.

B. For fume hood exhaust or other aggressive/corrosive exhaust air streams, type 304 stainless steel inner liner shall be provided. Thickness (gauge) shall be same as thickness of material specified for standard applications (typically galvanized steel).

C. For outdoor applications, unit shall be specifically designed for exposure to harsh weather conditions, including high wind, torrential rain and UV exposure.
   1. Materials, finishes and construction details shall be specifically designed for service.
   2. Additional weather-proof roof, rain hood(s) and/or louvers shall be provided as specified. Standard indoor unit shall not be installed outdoors.
   3. Architectural siding shall be provided as indicated in project documents.

   [Note to AE: Edit above requirements as appropriate for specific project. Delete if not applicable. Add other special requirements as appropriate for project.]

2.6 THERMAL RESISTANCE

A. Unit exterior panels and floor of conditioned sections shall not condense given following conditions:
   1. Interior unit air conditions: 52 degrees F.
   2. Exterior unit conditions: 95 degrees F db / 78 degrees F wb.
   3. Manufacturer shall submit documentation demonstrating ability to prohibit condensing.

B. Interior panels and floor shall not frost given following conditions:
   1. Interior unit air conditions: 72 degrees F db, 40% rh.
   2. Exterior unit conditions: -10 degrees F.
   3. Manufacturer shall submit documentation demonstrating ability to prohibit frosting.
2.7 ALLOWABLE LEAKAGE
A. Unit housing shall be assembled and factory pressure tested prior to shipment.
B. Unit shall be field pressure tested after assembled/installed on site.
C. Testing shall be in compliance with ANSI/ASHRAE standard 111.
D. 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. [Note To AE: Edit test pressure as appropriate for specific project.]
E. Cabinet air leakage shall not exceed leak class 6 per ans/ashrae standard unless indicated otherwise within project documents.
   1. Allowable leakage calculation: maximum casing leakage (CFM per 100 sq ft casing surface area) = leak class x [(test pressure)(0.65 power)].

2.8 BASE FRAME
A. Base frame, cross members and structural reinforcement shall be welded construction using cold formed carbon steel standard shapes and sizes.
B. Base frame shall be 6" minimum height unless indicated otherwise in project documents.
   Base frame shall have removable lifting lugs.
C. After fabrication, frame shall be finished with corrosion resistant epoxy coating.

2.9 FLOOR
A. General
   1. Floor shall be double wall 4" minimum thickness.
   2. Floor shall be completely insulated with rigid two-part expanded urethane foam.
   3. Walk-on floor shall be aluminum tread plate with non-slip diamond pattern, 10 gauge minimum.
   4. Walk-on floor shall have welded floor seams with turned up lip around perimeter, tack welded to base.
   5. Sub-floor shall be G90 galvanized steel sheet, 16 gauge minimum.
B. Drain Pan
   1. Drain pan shall be provided in each cooling coil section, humidifier section and other section(s) as indicated in project documents. Drain pan shall be provided at locations where condensate is generated, where exposure to water or other fluids is anticipated and where periodic wash down may be required.
   2. Drain pan(s) shall be triple-sloped "IAQ" type, pitched 1/8" per foot minimum toward outlet. Drain pan shall be constructed of type 304 stainless steel sheet, 20 gauge minimum. Drain pan supports shall be constructed of same material.
   3. Drain pan shall extend full width and length of AHU section and shall be configured / positioned to capture all fluid / condensate.
   4. Drain pan shall incorporate 1 ½" NPT pipe connection of same material welded to lowest point. Connection shall be extended through unit frame and shall provide full drainage of pan.
   5. Drain trap shall be provided for each individual drain. Trap shall be of sufficient depth to ensure full drainage of pan during "worst-case" unit operation.
      [Note to AE: AHUs are often installed with insufficient vertical height to accommodate required trap depth. This happens all-to-frequently and is not easily remedied. Design shall incorporate generous AHU condensate outlet elevation relative to adjacent floor to ensure full drainage in worst case operating condition. Drawings shall clearly indicate this requirement.]
6. Drain pans shall be piped individually to floor drain.
7. Bottom of drain pan shall be fully insulated with two-part expanded urethane foam, 2” minimum thickness.

2.10 EXTERIOR PANEL
A. Formed and reinforced panel shall be double wall, 3 inches minimum thickness.
B. Outer casing shall be G90 galvanized steel sheet, 16 gauge minimum.
C. Interior liner shall be G90 galvanized steel sheet, 20 gauge minimum for standard applications.
D. For fume hood and similar lab applications, interior liner exposed to contaminated exhaust air shall be type 304 stainless steel, 20 gauge, minimum.
E. Panels shall form water airtight seal with adjacent panels. Fasteners shall not penetrate into air tunnel.

2.11 INTERIOR PANEL
A. Formed and reinforced panel shall be double wall construction with thickness and insulation same as specified for exterior panel.
B. Both sides of panel shall be constructed of 20 gauge minimum G90 galvanized steel sheet.
C. Internal panels shall be completely sealed at connections to adjoining surfaces with non-permeable gasket.

2.12 INTERIOR PANEL – SINGLE WALL
A. Interior panel may be single wall under follow conditions:
   1. No temperature differential exists across partition in any operating condition.
   2. Low differential pressure exists in all operating conditions.
   3. Requirements for structural integrity and allowable leakage can be fully satisfied.
   4. Single wall construction is indicated on drawings.
B. Panel shall be 16 gauge minimum G90 galvanized steel sheet.
C. Panel shall be completely sealed at connections to adjoining surfaces with non-permeable gasket.

2.13 MULTI-SECTION / KNOCK-DOWN UNITS
A. Unit components and pre-assembled sections shall be provided in sizes that can be readily transported to installed location based upon design documents and/or facility drawings.
B. Manufacturer site visit is recommended to confirm dimensions and clearances.
C. Unit shall be designed and constructed such that no field modification (e.g. re-drilling of holes) is required.
D. Non-permeable gaskets shall be provided at all connections. Holes in gaskets shall be pre-punched. Use of caulk or other sealant as primary sealing method not allowed.

2.14 DOORS
A. Doors shall be double wall. Wall thickness, materials of construction and metal gauge shall be equal to that of adjacent wall panels, minimum.
B. Doors shall be insulated with same material as surrounding walls and shall comply with same thermal resistance performance requirements.
C. Door frames shall be continuous welded and formed of same materials as adjacent walls.
D. Doors shall be fitted with continuous neoprene bulb type gaskets.
E. Each door shall have minimum of two (2), 6” butt hinges.
F. Each door shall have minimum two (2) high compression latches, operable from both sides. Exterior doors shall have securable padlock hardware.

G. Each door shall include double pane tempered, reinforced or safety glass window.

H. Door dimensions shall be nominal 24" wide x 60" high minimum, unless indicated otherwise. Door(s) at fan section(s) shall be sufficiently sized to allow motor replacement.

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

A. Fans

1. See Section 23 34 16 – Fans for fan requirements.

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

3. Fans shall be belt-driven housed centrifugal type or belt-driven open centrifugal (plenum) type. Exception: Fans may be direct drive type when coupled with motor size 10 HP or less. [Note to AE: The University is developing a more favorable view toward direct drive fans given the substantial inefficiency and maintenance requirements of belt drives. Use of motor(s) greater than 10 HP for specific direct drive application requires approval from F&S Engineering.]

4. Air handling unit may incorporate single fan or multiple fans including “fan array” configuration. Number and type of fans shall be as scheduled and/or indicated elsewhere within documents.

5. Units with multiple plenum fans or fan arrays shall have motors and associated variable frequency drives (VFDs) configured in accordance with project drawings and applicable specifications.
   a. Multiple fans may be served by single VFD up to maximum six fans per VFD.
   b. Reduced number of fans per VFD shall be provided as required to satisfy redundancy requirements.
   c. For critical applications (e.g. animal room) N+1 fans shall be provided. Dedicated VFD shall be provided for each fan. Automated discharge damper shall be provided for each fan.

[Note to AE: Provide clear direction regarding fan/VFD configuration. Discuss design with UIUC Engineering staff prior to document preparation. Ensure VFDs comply with UIUC Standards.]

6. Flexible duct connection shall be provided at discharge opening of each housed centrifugal fan within unit cabinet such that flexible duct connection is not required at unit exterior.

B. Motors

1. Motors shall be provided and installed by unit manufacturer. See Section 26 60 00 – Common Motor Requirements.

2. Permanently mounted frame rail shall be provided for use with hoist equipment to facilitate removal of motors in excess of 10 HP without removal of unit panel or roof section. Fan section access door shall be sized to accommodate motor exchange with aid of hoist equipment.

C. Vibration Isolators

1. Vibration isolators shall be provided and installed by unit manufacturer. See Section 23 34 16 – Fans for additional information regarding fan vibration isolation.

2. Fan(s) shall be sufficiently isolated such that isolation of unit assembly is typically not required.

D. Coils

1. See Section 23 82 16 – Heating and Cooling Coils for coil requirements.
2. 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.

3. Individual cooling coil sections (i.e. sections with continuous plate fins) shall not exceed 48” height.

4. Structure shall be provided to support all coil sections, particularly those in stacked coil arrangement. Structure shall be arranged such that any individual coil may be removed through face of structure without affecting other coils or cutting or removing housing panels. Coils shall be removable without disassembly of unit housing.

5. Coils shall be installed using removable fasteners of similar material as their respective coil mounts. When materials are dissimilar, stainless steel fasteners shall be used.

6. Coil header, drain and vent connections shall be extended full size to unit exterior, same side as supply fan motor unless otherwise indicated in project documents.
   a. Alternatively, vents and drains, complete with valves, may be configured to discharge into respective drain pans inside unit. In such case, valves shall be readily accessible to maintenance staff. See related specifications for valve requirements.

7. Coil shall be installed dead-level in unit to ensure complete drainage by gravity.

8. Cooling Coil Drain Pan
   a. Drain pan shall be provided in cooling coil section. See general drain pan specification above.
   b. Cooling coil drain pan shall extend from upstream face of coil to distance ½ vertical coil height downstream from downstream face of coil.
   c. Intermediate drain pan shall be provided between coils when two or more cooling coils are stacked in an assembly.
   d. Intermediate drain pan 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.
   e. Intermediate drain pan outlet shall be located at lowest point of pan and shall be sufficient diameter to preclude drain pan overflow under any operating condition.
   f. Intermediate drain pan shall include drain tube to direct condensate to primary drain pan.

E. Filters
   1. See Section 23 40 00 – HVAC Air Cleaning Devices for filter requirements.
   2. Filters shall be front loading.
   3. Filter racks shall be provided by manufacturer and shall be factory mounted. Structural supports shall be provided as required for rigidity.
   4. Unless indicated otherwise in project documents, filters upstream of AHU coils shall be 4” pleated pre-filters, MERV 8. Pre-filters shall be followed by 22” bag filters, MERV 14. Filters upstream of energy recovery wheels shall be 4” pleated type, MERV 8.
   5. Filters used during pre-occupancy building purge shall satisfy LEED requirements.
   6. Differential pressure gauge shall be provided at each filter bank viewable on exterior of unit. See Section 23 09 13 - Instrumentation and Control Devices for HVAC for gauge requirements. Separate differential pressure transmitter shall be provided by Control Contractor for remote monitoring.

F. Control Dampers and Actuators
   1. Control dampers and actuators internal to unit, including face and bypass dampers if applicable, shall be provided and installed by unit manufacturer. Damper actuation/automation shall be provided by Temperature Control Contractor.
2. Control dampers shall fully comply with requirements of Section 23 09 13.43 - Control Dampers. 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. Proper sizing for adequate damper authority.
   d. Ease of damper removal/replacement.
   e. Access to damper linkage.
   f. Provision for proper actuator mounting.

3. Damper design and installation shall be coordinated with Temperature Control Contractor.

G. Electrical
   1. Electrical components and installation thereof shall comply with National Electric Code (NEC).
   2. Conduit, conductors
      a. Electrical conduit and conductors for power, lighting and other devices shall be provided by unit manufacturer, factory installed to degree practical. Conduit and wiring shall be terminated at junction box or approved enclosure on unit exterior.
      b. Conduit shall be metallic. Non-metallic conduit not allowed.
      c. Use of flexible conduit shall be limited to that required by NEC. Flexible conduit shall not exceed 3’ in length. Use of flexible conduit in lieu of EMT is not allowed.
      d. Where flexible conduit is required, liquid tight flexible metal conduit (Seal Tight) is preferred over flexible metallic conduit (Greenfield) and shall be provided where allowed by NEC. Non-metallic flexible conduit not allowed.
      e. Conduit shall be sealed in accordance with NEC to prevent moisture migration resulting in condensation within electrical components.
      f. Wall penetrations shall be sleeved and sealed as specified in General Requirements above to prevent air leakage and migration of moisture into insulated wall cavity.
      g. Motors, including dual voltage motors, shall be shipped with conductors connected at motor. Tag shall be provided at external junction box indicating voltage for which motor has been wired.
   3. Lighting
      a. Dedicated electric lighting shall be provided within each section of unit. Lighting shall be factory mounted replaceable fluorescent lamps within moisture tight corrosion resistant fixtures. Dedicated switch shall be provided for each unit section. Switch shall be spring return timer type.
   4. Auxiliary equipment
      a. Factory installed conduit and wiring shall be provided for auxiliary equipment (e.g. energy recovery wheel, UV light) and shall be terminated in junction box or approved enclosure on unit exterior. Conduit and conductors shall be provided for factory mounted controller as applicable.
   5. Outlet
      a. Provide 20 Amp 120 VAC duplex receptacle in NEMA 4 enclosure on unit exterior.

H. Hydronic Piping and Valves
   1. Hydronic piping and valves exterior to unit shall be provided by unit manufacturer only if specifically indicated within project documents. See related specifications for piping and valve requirements as appropriate.
I. Air Blenders
   1. Air blending / destratifying devices shall be provided as indicated in project documents.
   2. Air blending devices shall be positioned within air handling unit per manufacturer’s recommendations. Manufacturer’s recommended length of unobstructed air flow upstream and downstream of blending unit is typically marginal. Length shall be increased beyond these recommendations to degree practical, especially downstream of blender.

   [Note to AE: As reflected in the text above, it is the experience of the University that manufacturer’s recommended length of unobstructed area upstream and downstream of air blenders is marginal at best. Increased length of unobstructed area, especially downstream of the blender, is recommended.]

J. Humidifiers
   1. Humidifier shall be provided as indicated in project documents.
   2. Humidifier grid shall be positioned within air handling unit per manufacturer’s recommendations.
   3. Humidifier shall satisfy capacity and performance requirements indicated in project documents.
   4. Humidifier shall be steam-to-steam reboiler type.
   5. Humidifier shall consist of dispersion panel with steam supply header/separator and bank of steam dispersion tubes.
   6. Each active tube shall be fitted with series of nozzles which extend from center of tube. Nozzles shall be sized and spaced to accept steam from separator/header and provide dry and uniform discharge of steam.
   7. All wetted tubes and headers shall be stainless steel.
   8. Dispersion tubes shall be high efficiency type insulated with PVDF.
   9. Steam dispersion length shall be 12” maximum at design conditions.
   10. No component shall be located upstream of humidifier within 8” or downstream of humidifier within an absorption distance of 18”.
   11. Basis of design: Dristeam Ultrasorb/STS.

K. Ultraviolet (UV-C) Lights
   1. UV-C light shall be provided as indicated in project documents. UV-C fixtures and lamps shall be provided by unit manufacturer, factory installed.
   2. Performance
      a. Design of UV-C light array shall assure that UV-C energy striking intended coil and drain pan surfaces shall not be less than 200 microwatts / sq. centimeter and provide not less than 99 percent surface disinfection efficiency. Minimum intensity at any point on surface plane of coil must exceed 50 microwatts / sq. centimeter. Energy consumption at design intensity shall not exceed 13 watts / sq. ft. of treated, cross sectional plane.
   3. Lamps and Fixtures
      a. UV-C lamps and fixtures shall be positioned to provide equal distribution of UV-C energy and minimize shadowed areas.
      b. Fixtures and lamps shall be configured for easy lamp replacement. Lamps shall be field replaceable stock items.
      c. Fixtures shall meet UL drip-proof design criteria.
      d. Fixtures and racks shall be constructed of stainless steel.
4. Polymetric Materials
   a. All polymetric materials shall be fully shaded from direct or indirect exposure to UV-C light.

5. Safety
   a. Access doors that yield potential exposure of personnel to UV-C light shall be equipped with interlock switches to disable lights when opened.
   b. In addition to mechanical interlock switch, each unit shall be equipped with externally mounted switch that disconnects power to UV-C lights.
   c. Unit shall have a safety warning label applied to exterior of section containing UV-C lights.

2.16 ENERGY RECOVERY WHEEL(S)

A. 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 frame shall be hub spoke and rim system constructed of extruded aluminum designed and manufactured to limit rotor deflection to 1/32” at maximum rated airflow and pressure differential conditions.
   b. Rotor design shall allow replacement of media segments in field conditions without removal of rotor.
   c. 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.
   b. Seals shall be field adjustable non-contact labyrinth type.

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

6. Purge Sector
   a. Factory fabricated field adjustable purge unit shall be provided.
   b. Purge shall be designed to limit cross contamination to less than 0.04% of exhaust stream concentration at any operating condition.

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

9. Wheel Speed Control
   a. Variable speed control of wheel for capacity and frost control shall be accomplished by use of VFD. VFD must comply with University standards. See Section 26.29.23 - Variable Frequency Motor Controllers for VFD requirements.

10. Controls
    a. Single wheel applications
       1) 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.
       2) Manufacturer / Installing Contractor shall coordinate installation of controls and startup of unit with Temperature Control Contractor.
    b. Double wheel applications
       1) Manufacturer shall provide programmable controller, factory mounted. Controller shall be programmed by Manufacturer to provide specified performance.
       2) Programmable controller shall control operation of wheel start-stop, wheel speed, bypass damper position and other functions to maintain maximized overall heat transfer effectiveness in conjunction with minimized energy consumption while ensuring no frosting of wheel.
       3) Factory programming of unit controller shall include following:
          (a) Conversion of temperature and relative humidity readings into grains, dew point and enthalpy.
          (b) Conversion of pressure readings across wheel into supply and return airflow estimates.
          (c) Calculation and reporting of real time unit effectiveness.
          (d) Calculation and reporting of accumulation of energy (BTUs) recovered over time.
       4) All required sensors and instrumentation shall be provided, factory mounted and wired.
       5) All aspects of control system(s) shall be in accordance with Section 23.09.23 – Building Automation System (BAS) for HVAC and Section 23.09.13 – Instrumentation and Control Devices for HVAC.
       6) Manufacturer / Installing Contractor shall coordinate with Temperature Control Contractor regarding:
          (a) Installation of controls and startup of unit.
          (b) Interface and integration of control systems.
          (c) Ongoing full functionality of control systems and communication of information required to satisfy specified performance and intent.

B. 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 laboratory applications (corrosive, toxic or noxious vapors):
   (a) Molecular sieve desiccant internal pore diameter shall limit absorption to materials having 3 angstrom kinetic diameter or less.
   (b) Ion exchange resin shall provide same or better performance in all regards.

2) 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.

2.17 OUTDOOR AIR HANDLING UNIT

A. All requirements for indoor air handling unit shall be satisfied. [Note to AE: For upgraded construction, exterior aluminum sheet may be substituted for galvanized sheet. Aluminum sheet shall be 14 gauge minimum.]

B. Support

1. Unit shall be supported by enclosed roof curb. Curb shall be of adequate structural strength to support unit. Curb shall support full perimeter of air handling unit including pipe chases. Coordinate with General Contractor as appropriate.

C. Roof

1. Unit shall be provided with heavy gauge structural standing seam metal roof above top panel (roof) of unit.
2. Standing seam roof panels shall be provided with weather-proof, UV resistant coating.

3. Each panel shall be continuous from one end/side of unit to other. Split joints not allowed.

4. Roof shall overhang all walls by 2” minimum to prevent water from sheeting from roof to side panel.

5. Roof shall be designed for heavy snow loading and high velocity wind. At minimum, requirements shall comply with local construction standards.

6. Roof shall be sloped ¼”/ft, minimum.

7. Air gap shall be provided between roof and outer casing to guarantee no water penetration.

D. Rain Hoods/Louvers

1. Rain hood and/or louvers shall be provided at outdoor intake and/or exhaust opening(s) as indicated elsewhere in project documents. [Note to AE: The University has repeatedly experienced problems with filters becoming clogged with snow as a result of inadequate outdoor air intake design.]

2. Intake hood or louver shall be specifically designed to prevent ingress of rain and snow. Intake louver shall be “wind driven rain” type. Roof hood shall be provided with 1” gutter around perimeter to convey water away from air path.

3. Airflow velocity across hood opening shall not exceed 250 FPM. Airflow velocity across louver net free area shall not exceed 500 FPM.

4. ½” bird screen shall be provided over hood opening and louver exterior.

E. Intake Plenum

1. Intake plenum section shall be provided upstream of filter section to serve as catch basin for rain and snow. Floor shall be aluminum tread plate, 10 gauge minimum. Floor shall be pitched 1/8 inch per foot minimum toward 1 ½” MPT drain connection. Drain connection shall be extended through unit wall to exterior and provided with FPT cap.

2. Outdoor air intake openings and plenum shall be sized and configuration to yield consistent air velocity across the full face of the filter bank.

F. Weather Protection

1. Gutters/channels shall be provided to shed water away from doors and other exterior components requiring such protection.

2. Exterior surfaces vulnerable to corrosion (i.e. those not constructed of galvanized steel, aluminum or stainless steel) shall be shall be coated with epoxy paint with appropriate primer.

G. Doors

1. Doors shall be as specified for indoor unit with following exception:
   a. Each door shall have single handle linking multiple latching points necessary to maintain specified air leakage integrity while maintaining ease of operation.

H. Electrical

1. Exterior electrical enclosures shall be NEMA 4.

2. Exterior lighting and associated switching shall be provided as indicated in project documents. Coordinate with Electrical Contractor.

I. Vestibule

1. Air handling unit shall incorporate vestibule with interior walkway as indicated in project documents.
2. Vestibule structure, panels, floors, components shall be of same material and construction as balance of air handling unit.

3. Configuration and dimensions of vestibule shall be indicated on unit drawings. Size and configuration of vestibule shall be adequate to satisfy all accessibility requirements specified for indoor unit. See specifications above.

4. One or more exterior doors shall be provided as indicated in other project documents. OSHA approved (if applicable) ladder or step device shall be provided for safe, convenient entry.

J. Interior lighting shall be provided as specified for indoor unit. Multiple fixtures shall be provided as needed for adequate lighting.

PART 3 – EXECUTION

3.1 PROTECTION

A. Air handling unit shall be protected from physical damage during delivery, storage and handling.

B. Unit shall be protected from exposure to dust, debris and fluids.

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

3.2 EQUIPMENT SUPPORT

A. Indoor Unit

1. Unit shall be placed on reinforced concrete pad provided by Others. Pad thickness shall be 6” minimum above finished floor level and shall provide adequate elevation for properly dimensioned cooling coil condensate drain trap(s) or steam condensate drip leg and trap.

B. Outdoor Unit

1. Unit shall be supported by enclosed roof curb. Exposed structural support not allowed. Curb shall be of adequate structural strength to support unit. Curb shall support full perimeter of air handling unit including pipe chases.

2. Top of roof curb shall be 12” minimum above roof surface.

3. Continuous welded stainless steel curb cap, 16 gauge minimum, shall be provided. Roof membrane termination and two piece flashing shall be provided as specified and detailed elsewhere within UIUC Facilities Standards.

4. Coordinate roof curb construction with General Contractor as appropriate.

3.3 INSTALLATION

A. Unit shall be leveled to ensure full drainage of coils by gravity and proper operation of rotating equipment. Ensure that support pad/curb is rigid and level prior to installation.

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

C. Multi-section / knockdown units shall be assembled per Manufacturers instructions under supervision of Manufacturer’s service technician.

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

E. Ductwork connections shall be made as indicated in project documents.

F. Filter media shall be installed and cleaned.

3.4 CLEARANCES

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

B. Adequate clearance shall be provided for installed piping.
C. Adequate coil pull area shall be provided.

3.5 FINISHED OPENINGS

A. Provide properly finished openings in panels for pressure gauges, control devices, TAB devices and any appurtenance. Provide finished openings as required for balancing devices for testing systems. Seal all openings with proper SMACNA closures conforming to pressure class of housing. Coordinate with Temperature Control Contractor.

3.6 CLEANING

A. During construction provide temporary closures of metal or taped polyethylene over openings in housing and associated ducts to prevent dust from entering system.

B. When installation is complete, final cleaning of unit shall be provided. Unit shall be cleaned to satisfaction of AE and Owner. Cleaning requirement shall include coils and energy recovery wheel(s).

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

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

3.7 STARTUP

A. Air handling unit Manufacturer shall provide authorized service technician to supervise unit startup and provide User training. Startup report shall be provided to AE and Owner.

B. Energy recovery heel Manufacturer shall provide authorized service technician to supervise startup and perform testing. Startup and test report shall be provided to AE and Owner.

C. Prior to start-up Installing Contractor and Manufacturer’s service technician(s) shall verify following items have been completed:
   1. Unit is clean to satisfaction of AE and Owner.
   2. Spring-isolated components have had their shipping restraints removed and components have been leveled.
   3. All interconnections have been completed (i.e. electrical and control wiring, piping, casing joints, bolting, welding, etc).
   4. All water and steam piping connections have been completed hydrostatically tested and all water flow rates have been set in accordance with capacities scheduled.
   5. All power wiring, including motor starters and disconnects, serving unit has been completed.
   6. All ductwork connections have been completed and all ductwork has been pressure tested.
   7. All temperature control and safety systems are completed and functional.
   8. All dampers are fully operational.
   9. All filter media is installed and clean.
   10. Bearings are properly lubricated.
   11. Belts are properly aligned and tensioned.
   12. Fan(s), energy recovery wheel(s) turn freely.
   13. Energy recovery wheel purge(s) and seals are properly adjusted and secured.
   14. Condensate drain trap and piping are properly installed.

3.8 VIBRATION TESTING
A. Ensure no detectible vibration of installed operating unit and no significant vibration of individual components to satisfaction of AE and Owner.

B. If in judgment of AE or Owner, vibration level is deemed unacceptable, vibration analysis shall be performed by qualified technician. Field balance of fan(s) shall be provided as required to bring vibration level within specified limits.

3.9 LEAK TESTING

A. Unit shall be field pressure tested after installed and operational.

B. Leakage shall be determined by measuring airflow forced into (or out of) air handling unit at test pressure. Air flow measurements shall be in compliance with ANSI/ASHRAE Standard 111.

C. Cabinet 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. [Note to AE: Edit test pressure as appropriate for specific project.]

D. Positive pressure test may be substituted for negative test with approval of AE and Owner. [Note to AE: Delete if desired. Evaluate necessity of requiring separate test for positive and negative AHU sections. This may be difficult and/or unnecessary.]

E. Casing air leakage shall not exceed Leak Class 6 per same standard unless indicated otherwise within project documents.

   1. Allowable Leakage Calculation: Maximum casing leakage (CFM per 100 sq ft casing surface area) = Leak Class x [(test pressure)(0.65 power)].

F. Modifications shall be made as required to pass test. Modifications shall be approved by AE and Owner and shall be at Contractors expense. Use of caulk and other sealants shall be minimized.

3.10 ENERGY RECOVERY WHEEL TESTING

A. Testing of energy recovery wheel thermal performance shall be provided by wheel Manufacturer authorized service technician.

B. For units exposed to laboratory exhaust air stream, testing of energy recovery wheel cross-contamination shall be provided at time of startup and annually thereafter for period of 5 (five) years. Testing shall be conducted by recognized independent test agency at expense of Manufacturer. Testing at time of startup shall be witnessed by AE and Owner. Annual testing thereafter shall be witnessed by Owner.

   1. Test shall be conducted using SF-6 tracer gas testing procedure similar to that outlined by ASHRAE Standard 84.

3.11 CONSTRUCTION PHASE

A. Air handling unit shall not be operated during construction phase of project unless specifically indicated otherwise in project documents.

B. 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.

C. Openings in air handling unit and connected ductwork shall be sealed with temporary covers at all times possible.

END OF SECTION 23 73 23

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