

SECTION 23 07 00 _ SUMMARY

PART 1 – GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Piping system insulation.
 - 2. Equipment insulation.
 - 3. Pipe insulation jackets.
 - 4. Equipment insulation jackets.
 - 5. Ductwork insulation.
 - 6. Ductwork insulation jackets.
 - 7. Insulation accessories including vapor retarders and accessories.

- B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, material options and quality assurance to maintain the longevity of its assets.

1.2 REFERENCES

- A. Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment: Product and Execution requirements for inserts at hanger locations. (later)
- B. Section 23 05 53 - Identification for HVAC Piping and Equipment: Product requirements for HVAC piping and equipment identification. (later)

1.3 DESIGN REQUIREMENTS

- A. It is the responsibility of the consulting engineer or design build contractor to calculate the required thickness of the insulation. The insulation thickness must also conform to the latest version of the International Energy Conservation Code and to ASHRAE standard 62.1. The insulation thickness must conform to the most stringent requirement whether it be the calculated thickness or the code requirement.
- B. All insulation shall have a maximum flame spread index of 25.
- C. All insulation shall have a maximum smoke developed index of 50.
- D. Duct liner is not an acceptable method to insulate duct. Duct liner shall not be used on Campus.
- E. Plenums shall be fabricated from double wall insulated materials in lieu of insulation installed on the exterior of the plenum.

1.4 SUBMITTALS

- A. Product Data: Submit product description, thermal characteristics, flame spread index, smoke developed index and list of materials and thickness for each service, and location.
- B. Written certification that insulation materials do not contain asbestos.

1.5 CLOSE OUT SUBMITTALS

Not Applicable

1.6 QUALITY ASSURANCE

- A. Insulation shall be installed to provide an impenetrable vapor barrier around the object insulated. The insulation contractor shall fully adhere insulation to all surfaces so that there are no gaps between the insulation and the surface of the object insulated.

- B. Insulation shall not be compressed when installed upon objects. Insulator shall install insulation so that it maintains its original (specified) thickness.
- C. Insulation jacketing must maintain a continuous barrier around insulation. Insulation jacketing that has cuts, rips or breaks will not be accepted.
- D. Insulation jacketing must be clean and having its original reflectivity.
- E. Maintain temperature before, during and after installation for a minimum of 24 hours.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Install insulation only when ambient temperature and humidity conditions are within range recommended by manufacturer.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

1.9 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

PART 2 – PRODUCTS

2.1 MAN MADE MINERAL FIBER: **Insulation Code I-1**

- A. Insulation: ASTM C457, Type I - pipe and tubing insulation
Temperature ranges 0F to 850F
'K' factor: ASTM C177, 0.24 at 75 degrees F
ASJ Vapor Retarder Jacket
Moisture Vapor Transmission: 0.002 perm

2.2 MAN MADE MINERAL FIBER: Insulation Code I-2

- A. Insulation: ASTM C1393, Type I – semi rigid fibrous glass board, Class 2
 - 1. Temperature ranges 0F to 850F
 - 2. 'K' factor: ASTM C177, 0.27 at 75 degrees F
 - 3. ASJ Vapor Retarder Jacket
 - 4. Moisture Vapor Transmission: 0.002 perm

2.3 MAN MADE MINERAL FIBER: **Insulation Code I-3**

- A. Insulation: ASTM C612, Type IA – rigid board insulation
 - 1. Temperature ranges 0F to 1000F.
 - 2. 'K' factor: ASTM C177, 0.23 at 75 degrees F.
 - 3. Kraft paper bonded to aluminized film
 - 4. Moisture Vapor Transmission: 0.004 perm

2.4 MAN MADE MINERAL FIBER: Insulation Code I-4

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- A. Insulation: ASTM C553, Type I – batt insulation
 - 1. Temperature ranges 0F to 250F.
 - 2. 'K' factor: ASTM C177, 0.30 at 75 degrees F.
 - 3. FRK Vapor Retarder
 - 4. Moisture Vapor Transmission: 0.002 perm

 - 2.5 FOAM GLASS: Insulation Code I-5
 - A. Faced Rigid Cellular Phenolic Pipe Insulation, ASTM C1126, Type II and Type III

 - 2.6 CELLULAR POLYISOCYANURATE INSULATION: Insulation Code I-6
 - A. Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation: ASTM C591, Type III, compressive strength 50 psi
 - 1. Temperature ranges -297F to 250F
 - 2. 'K' factor: 0.19 at 75 degrees F.
 - 3. Fasteners: Fasten with fiber reinforced masking tape. For sized over 6" fasten with 18 gage stainless steel wires over fiber reinforced masking tape.

 - 2.7 ELASTOMERIC CELLULAR FOAM: Insulation Code I-7
 - A. Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular form: ASTM C534; Type I, Tubular form.
 - B. Elastomeric Foam Adhesive:
Air dried, contact adhesive, compatible with insulation.

 - 2.8 EXPANDED PERLITE: Insulation Code I-8
 - A. PVC Plastic Jacket: Insulation Jacket Code J-1
Product Description: Sheet material, color coded to match piping service.
Moisture Vapor Transmission: ASTM E96; 0.002 perm-inches.
Thickness: 30 mil.
Connections: Brush on welding adhesive.
Compatible with insulation.
 - B. VentureClad: Insulation Jacket Code J-2
VentureClad model 1579CW-E insulation jacketing tape with and aluminum stucco embossed finish.
 - C. Stainless Steel Pipe Jacket: **Insulation Jacket Code J-3**
 - 1. ASTM A167 Type 304 stainless steel
 - 2. Thickness: 0.18 inch thick
 - 3. Finish: Smooth
 - 4. Metal Jacket Bands: 3/8" wide; 0.010 inch thick stainless steel

 - 2.9 PUMP INSULATION
 - A. All pumps insulation shall be formed into a box surrounding the pump and fabricated from polystyrene board (engineer to determine required thickness). Polystyrene board shall be covered VentureClad model 1577CW-WM tape. Edges and corners of the box shall be connected via wooden skewers and shall be sealed with and adhesive similar to Childers CP-97 Fibros Adhesive. Tape all seams and joints with FSK tape. See attachments A and B for more detail.

2.10 VALVE INSULATION

- A. Gate and globe valves in heating water and steam systems shall be insulated with a prefabricated removable blanket with Velcro fasteners with the following characteristics:

1. Jacket: 17oz silicone impregnated fiberglass fabric
2. Liner: 17oz silicone impregnated fiberglass fabric
3. Insulation: 1" Type E Glass Mat
4. Fastening: 2" Nomex Velcro
5. Thread: Kevlar/Stainless Steel Threads

All steam and heating water butterfly valves shall be insulated as per steam and heating water systems insulation requirements.

All chilled water valves shall be insulated per chilled water systems insulation requirements.

2.11 APPROVED INSULATION MANUFACTURERS

- A.
1. Armstrong
 2. Certain-Teed
 3. Dow Chemical
 4. Fab-Rite
 5. HiTherm
 6. Johns Manville
 7. Owens Corning
 8. Pittsburg Corning
 9. Specialty Products & Insulation
 10. Techna-Duct
 11. Venture Products

PART 3- EXECUTION

3.1 EXAMINATION

- A. Verify piping, equipment and ductwork has been tested before applying insulation materials.
- B. Verify surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Verify field measurements prior to fabrication.
- B. Insulate entire piping system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints:
1. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with fitting covers.
- C. Inserts and Shields:
1. Application: Piping or Equipment
 2. Shields: Minimum 12inches Long Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 3. Insert location: Between support shield and piping and under finish jacket.
 4. Inserts (Chilled Water): Armaflex Ultima (Wood Dowels or Wood Blocking are not allowed)
 5. Inserts (Steam & Heating Water): 12" long minimum Calcium Silicate (Wood Dowels or Wood Blocking are not allowed)

- D. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent fire stopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions.
- E. All vapor barrier and jacket seams shall be located at 3 or 9 o'clock position on side of horizontal piping and with overlap facing down to shed water or on bottom side of horizontal duct.
- F. Heat Traced Piping: Size insulation large enough to enclose pipe and heat tracer.
- G. Factory Insulated Equipment: Do not insulate.
- H. Exposed Piping, Duct and Equipment: Locate insulation and cover seams in least visible locations.
- I. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- J. Finish insulation at supports, protrusions, and interruptions.
- K. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- L. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.
- M. All duct and piping routed interior to the building and in concealed spaces does not require a jacket.
- N. Fasten insulation to duct using spot welded pins or pins fastened with an adhesive. Self-sticking pins are not allowed.
- O. All fiberglass batt insulation shall be secured with wire at 2'-0" intervals.
- P. On ducts over 24" wide fiberglass batt insulation shall be pinned.
- Q. Do not insulate pressure relief valves.

3.3 SCHEDULES

- A. Pipe Insulation Schedule:

Piping System	Insulation Code	Jacket Code
Heating Water Supply and Return – Interior to Building Exposed	I-1	J-1 J-3*
Heating Water Supply and Return – Interior to Building Concealed	I-1	None Required
Heating Water Supply and Return – Exterior to Building	I-6	J-2
Heating Water Supply and Return – Inside of Manholes	I-5	J-3
Glycol Heat Recovery Piping – Interior to Building	I-1	J-1 J-3*
Glycol Heat Recovery Piping – Exterior to Building	I-6	J-2
15 PSIG Steam – Interior to Building	I-1	J-1 J-3*
15 PSIG Steam – Exterior to Building	I-8	J-3
Steam Condensate – Interior to Building	I-1	J-1

Steam Condensate – Exterior to Building	I-7	J-3
Steam Condensate – In Manholes	I-5	J-3
45 PSIG Pressure Steam – Interior to Building	I-1	J-1 J-3*
45 PSIG Pressure Steam – Exterior to Building	I-8	J-3
45 PSIG Pressure Steam – In Manholes	I-5	J-3
Chilled Water Supply and Return – Interior to Building	I-7	J-1 J-3*
Chilled Water Supply and Return – Exterior to Building	I-6	J-2
Chilled Water Supply and Return – In Manholes	I-5	J-3
Condensate Drains from Cooling Coil – Interior to Building	I-7	J-1 J-3*
Condensate Drains from Cooling Coil – Exterior to Building	I-6	J-2
Condenser Water – Interior to Building	I-7	J-1 J-3*
Condenser Water – Exterior to Building	I-6	J-2
Humidifier Piping – Interior to Building	I-1	J-1 J-3*
Humidifier Piping – Exterior to Building	I-8	J-2
Refrigerant Suction - Interior to Building Exposed	I-7	J-1
Refrigerant Suction - Interior to Building Concealed	I-7	None Required
Refrigerant Suction - Exterior to Building	I-7	J-2
Refrigerant Liquid – Interior to Building	I-7	J-1
Refrigerant Liquid – Interior to Building Concealed	I-7	None Required
Refrigerant Liquid – Exterior to Building	I-7	J-2

B. Equipment Insulation Schedule:

Equipment	Insulation Code	Jacket Code
Shell & Tube Heat Exchanger	I-2	J-1 J-3*
Plate Heat Exchanger – Heating Systems	I-3	J-1 J-3*
Heating Air Separator	I-2	J-1 J-3*
Heating Expansion Tank	I-2	J-1 J-3*
Plate Heat Exchanger – Cooling Systems	I-7	J-1 J-3*
Chilled Water Air Separator	I-7	J-1 J-3*
Chilled Water Expansion Tank	I-7	J-1 J-3*
Chiller Surfaces not Factory Insulated	I-7	None Required

C. Duct Insulation Schedule:

Duct System	Insulation Code	Jacket Code
High Temperature Rectangular Exhaust Ducts – Interior to Building and Exposed	I-3	J-1 J-3*
High Temperature Rectangular Exhaust Ducts – Interior to Building and Concealed	I-4	None Required
High Temperature Round Exhaust Ducts – Interior to Building and Exposed	I-1 I-2	J-1 J-3*
High Temperature Round Exhaust Ducts – Interior to Building and Concealed	I-4	None Required
High Temperature Round Exhaust Ducts – Interior to Building and Exposed	I-2	J-1 J-3*
High Temperature Rectangular Exhaust Ducts – Exterior to Building	I-6	J-2
High Temperature Round Exhaust Ducts – Exterior to Building	I-5	J-2
Outside Air Intake Ducts	I-2	J-1 J-3*

Supply Air Ducts – Interior to the Building and Exposed	I-7	J-1 J-3*
Supply Air Ducts – Interior to the Building and Concealed	I-4	None Required
Supply Air Ducts – Exterior to the Building	I-6	J-2
Return/Relief Ducts in Mechanical Room	I-2	J-1 J-3*
Return Air Ducts – Exterior to the Building	I-4	J-2

*** Use stainless steel jacket if room temperature exceeds 120F and where volatile or corrosive chemicals are stored.**

PART 4 – ATTACHMENTS

- 4.1 Attachment A: PUMP INSULATION PHOTOGRAPH
- 4.2 Attachment B: PUMP INSULATION DETAIL

End of Section

SECTION 23 23 00 _ SUMMARY**PART 1 – GENERAL****1.1 SUMMARY**

- A. This standard includes refrigeration piping standards for use refrigeration piping used for DX based refrigeration heating and cooling systems.
- B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

1.2 REFERENCES

- A. HVAC Insulation, Section 23 07 00 (later)
- B. Mechanical Identification, Section 23 05 53 (later)
- C. Hangers and Supports for HVAC Piping and Equipment, Section 23 05 29 (later)
- D. DX Refrigeration Based Split Systems, Section 23 81 00

1.3 DESIGN REQUIREMENTS

- A. It is the responsibility of the consulting engineer or design build contractor to properly design and size the refrigerant piping. Refrigerant/HVAC equipment manufacturer must be consulted during the design process. The Refrigerant/HVAC equipment manufacturer must approve all refrigeration piping system design (including pipe sizes) prior to review and approval by the University of Delaware.
- B. Consulting engineer or design build contractor shall consult equipment manufacturer when determining the thickness of the refrigerant pipe. Equipment manufacturer shall calculate pipe size based on system pressure. Documentation shall be submitted that refrigerant pipe wall thickness is in compliance with equipment manufacturer's requirements.

1.4 SUBMITTALS

- A. Shop Drawings: Contractor shall supply for approval a shop drawing to scale of the refrigeration piping system 7 ½ tons are larger. Shop drawings shall include all equipment, valves and in line piping specialties. All refrigeration piping shall have their sizes indicated. Shop drawings shall indicate changes of elevation. Refrigeration/HVAC equipment manufacturer must approve shop drawings prior to submitting shop drawings prior for final approval.
- B. Product Data :
 - 1. Refrigerant Specialties: Submit manufacturers catalog information including capacity, component sizes, rough-in requirements, and service sizes for the following:
 - Refrigerant moisture and liquid indicators.
 - Refrigerant strainers.
 - Refrigerant pressure regulators.
 - Refrigerant pressure relief valves.
 - Refrigerant filter-driers.
 - Refrigerant solenoid valves.
 - Refrigerant expansion valves.
 - Electronic expansion valves.

1.5 CLOSE OUT SUBMITTALS

- A. Close out submittals must conform to standard XX – Close Out Submittals.

1.6 QUALITY ASSURANCE

- A. Verify field measurements prior to fabrication.
- B. Pressure test must comply with RSES standards and guidelines
- C. Press Test refrigeration system per RSES standards. Contractor must submit a report stating that the refrigeration system held pressure per RSES standards.
- D. Pressure test must be witnessed by a University of Delaware Maintenance & Operations Manager, Assigned Project Engineer or Commissioning Agent.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Dehydrate and charge refrigeration components including piping and receivers, seal prior to shipment. Maintain seal until connected into system.
Accept valves on site in shipping containers with labeling in place. Inspect for damage.
Accept equipment on site in factory packaging. Inspect for damage.

PART 2 – PRODUCTS

2.1 REFRIGERANT PIPING

- A. Copper Tubing: ASTM B280, ACR.
Fittings: ASME B16.22 wrought copper.
Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480 degrees F

2.2 REFRIGERANT MOISTURE AND LIQUID INDICATORS

- A. Indicators:
 1. Port: Single, UL listed.
 2. Body: Copper or brass, brazed ends.
 3. Sight glass: Color-coded paper moisture indicator with removable element cartridge and plastic cap.
 4. Maximum working pressure: 500 psig.
 5. Maximum working temperature: 200 degrees F.

2.3 VALVES

- A. Diaphragm Packless Valves:
 1. UL listed, globe or angle pattern, forged brass body and bonnet brazed ends.
 2. Phosphor bronze and stainless steel diaphragms, rising stem and hand wheel.
 3. Stainless steel spring, nylon seats, disc with positive back seating.
 4. Maximum working pressure: 500 psig.
 5. Maximum working temperature: 275 degrees F.
- B. Packed Angle Valves:
 1. Forged brass, brazed ends.
 2. Forged brass seal caps with copper gasket, rising stem and seat, molded stem packing.
 3. Maximum working pressure: 500 psig.
 4. Maximum working temperature: 275 degrees F.

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- C. Ball Valves:
 - 1. Two piece forged brass body with Teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals, brazed ends.
 - 2. Maximum working pressure: 500 psig
 - 3. Maximum working temperature 325 degrees F.
 - D. Service Valves:

Forged brass body with copper stubs, brass caps, removable valve core flared or brazed ends.
Maximum working pressure: 500 psig.
 - E. Refrigerant Check Valves:
 - 1. Globe Type:
 - o Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc.
 - o Maximum working pressure: 500 psig.
 - o Maximum working temperature: 300 degrees F.
 - 2. Straight Through Type:
 - o Spring, neoprene seat.
- 2.4 REFRIGERANT STRAINERS
- A. Straight Line or Angle Line Type:
 - 1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire reinforced with brass.
 - 2. Maximum working pressure: 430 psig
- 2.5 REFRIGERANT PRESSURE REGULATORS
- A. Brass body, stainless steel diaphragm, direct acting, adjustable over 0 to 80 psig range, for maximum working pressure of 450psig.
- 2.6 REFRIGERANT PRESSURE RELIEF VALVES
- A. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB; for standard 450 psig setting.
- 2.7 REFRIGERANT FILTER-DRIERS
- A. Replaceable Cartridge Angle Type:
 - 1. Shell: UL listed, brass removable cap, for maximum working pressure of 500 psig.
 - 2. Filter/Dryer Cartridge: Pleated media with solid core sieve with activated alumina.
 - B.
- 2.8 REFRIGERANT SOLENOID VALVES
- A. Valve: pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly, integral strainer, with brazed ends; for maximum working pressure of **500 psig**. Stem designed to allow manual operation in case of coil failure.
 - B. Coil Assembly: UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box with pilot light.

2.9 ELECTRONIC EXPANSION VALVES

- A. Valve:
 - 1. Brass bodies with brazed connection, needle valve with floating needle and machined seat, stepper motor drive.
- B. Evaporation Control System:
 - 1. Electronic microprocessor control is preferable.
- C. Refrigeration System Control: Electronic microprocessor control is preferable

2.10 REFRIGERANT RECEIVERS

- A. Internal Diameter 6 inch and Smaller: ARI 495, UL listed, steel, brazed; 400 psig maximum pressure rating, with taps for inlet, outlet, and pressure relief valve.
- B. Internal Diameter 6 inch and Larger: ARI 495, welded steel, tested and stamped in accordance with ASME Section VIII; 400 psig with taps for liquid inlet and outlet valves, pressure relief valve, and magnetic liquid level indicator.

PART 3- EXECUTION

3.1 INSTALLATION REFRIGERATION PIPING

- A. Install piping as per RSES
- B. All refrigeration piping must be properly supported with approved pipe supports or pipe hangers
- C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- D. Install piping to maintain headroom without interfering with use of space or taking more space than necessary.
- E. Sleeve pipe passing through partitions, walls and floors.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- H. Provide access doors where valves and fittings are not accessible.
- I. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.
- J. Install piping penetrating roofed areas to maintain integrity of roof assembly.
- K. Pay attention to oil trapping when routing refrigeration piping. Refrigeration piping shall be installed to insure lubricating oils are properly returned to the compressor.

3.2 INSTALLATION- REFRIGERANT SPECIALTIES

- A. Refrigerant Liquid Indicators:
 - 1. Install line size liquid indicators in main liquid line downstream of condenser.
 - 2. When receiver is provided, install line size liquid indicators in liquid line downstream of receiver.
 - 3. Install line size liquid indicators downstream of liquid solenoid valves.
- B. Refrigerant Valves:
 - 1. Install service valves on compressor suction and discharge.
 - 2. Install check valves on scroll and screw compressor discharge as per manufacturer's recommendations.
 - 3. Install check valves on condenser liquid lines on multiple condenser systems.
 - 4. Install refrigerant charging valve in liquid line between receiver shut-off valve and expansion valve.
 - 5.

- C. Strainers:
 - 1. Install line size strainer upstream of each automatic valve.
 - 2. Where multiple expansion valves with integral strainers are used, install single main liquid-line strainer.
 - 3. On steel piping systems, install strainer in suction line.
 - 4. Install shut-off valves on each side of strainer.
- D. Install pressure relief valves/rupture discs on ASME receivers. Install relief valve/rupture disc discharge piping to terminate outdoors above roof line. Manifold multiple relief devices so that maintenance can be performed on relief devices without removing refrigerant from the system.
- E. Filter-Dryers:
 - 1. Install permanent filter-dryer in systems containing hermetic compressors.
 - 2. Install replaceable cartridge filter-dryer vertically in liquid line adjacent to receivers.
 - 3. Install replaceable cartridge filter-dryer upstream of each solenoid valve.
 - 4. Install shut off valves on each side of the filter-dryer.
- F. Solenoid Valves:
 - 1. Install in liquid line of systems operating with single pump-out or pump-down compressor control.
 - 2. Install in liquid line of single or multiple evaporator systems.
 - 3. Install in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into suction line when system shuts down.

SECTION 23 30 00 _ SUMMARY

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Duct Materials.
2. Flexible ducts.
3. Insulated flexible ducts.
4. Spiral round ducts.
5. Spiral flat oval ducts.
6. Glass fiber reinforced plastic round ducts.
7. Transverse duct connection system.
8. Casings and Plenums.
9. Ductwork fabrication.
10. Kitchen hood exhaust ductwork fabrication.
11. Duct Mounted Air Silencers
12. Back-draft dampers.
13. Fire and smoke dampers.
14. Duct access doors.
15. Volume control dampers.
16. Flexible duct connections.
17. Diffusers, Registers and Grilles.
18. Laminar Flow Diffusers
19. HEPA Modules
20. Door grilles.
21. Louvers.
22. Louvered penthouses.
23. Roof hoods.
24. Goosenecks.

- B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

C. Related Sections:

- Section 23 05 29 - Hanger and Supports for HVAC Piping and Equipment
- Section 23 05 48 – Vibration and Seismic Controls
- Section 23 09 00 – Building Automation Systems
- Section 23 34 00 – HVAC Fans
- Section 23 73 00 – Air Handling Units
- Section 23 84 00 – Humidity Control Equipment

1.2 ENGINEERING AND DESIGN REQUIREMENTS

- A. Refer to the University Engineering Design Guidelines for all air distribution system engineering and design requirements

- B. Size louvers so that moisture will not enter the building.

1.3 SUBMITTALS

- A. Shop Drawings: Submit duct fabrication drawings, drawn to scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as Contract Documents, indicating:
 - 1. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.
 - 2. Duct layout, indicating pressure classifications and sizes in plan view. For exhaust duct systems, indicate classification of materials handled as defined in this section.
 - 3. Fittings.
 - 4. Reinforcing details and spacing.
 - 5. Seam and joint construction details.
 - 6. Penetrations through fire rated and other walls.
 - 7. Terminal unit, coil, and humidifier installations.
 - 8. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
- B. Product Data: Submit for the following. Include where applicable electrical characteristics and connection requirements.
 - 1. Duct connectors
 - 2. Volume control dampers
 - 3. Duct access doors
 - 4. Fire dampers including locations and ratings.
 - 5. Smoke dampers including locations and ratings.
 - 6. Backdraft dampers.
 - 7. Flexible duct connections.
 - 8. Volume control dampers.
 - 9. Duct access doors.
 - 10. Duct test holes.
- C. Product Data: For fire and smoke dampers submit the following:
 - 1. Include UL ratings, dynamic ratings, leakage, pressure drop and maximum pressure data.
 - 2. Indicate materials, construction, dimensions, and installation details.
 - 3. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.
- D. Product Data: Submit sizes, finish, and type of mounting. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- E. Manufacturer's Installation Instructions: Submit for Fire and Combination Smoke and Fire Dampers.
- F. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.
- G. Manufacturer's Installation Instructions: Submit special procedures for glass fiber ducts.

- 1.4 CLOSEOUT SUBMITTALS
 - A. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.
 - B. Project Record Documents: Record actual locations of air distribution devices such as access doors, volume dampers, smoke/fire dampers instruments, grilles, diffusers, louvers,...etc.
 - C. Operation and Maintenance Data: Submit for Combination Smoke and Fire Dampers.

- 1.5 QUALITY ASSURANCE
 - A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards - Metal and flexible.
 - B. Construct ductwork to NFPA 90A standards.
 - C. Construct commercial kitchen ductwork to NFPA 96 standard.
 - D. Dampers tested, rated and labeled in accordance with the latest UL requirements. Shop fabricated dampers are not allowed on University of Delaware projects.
 - E. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.
 - F. Test and rate diffuser, register, and grille performance in accordance with ASHRAE 70.
 - G. Test and rate louver performance in accordance with AMCA 500.

- 1.6 DELIVERY, STORAGE, AND HANDLING
 - A. Cover ends of ductwork with plastic prior to delivery to job site.
 - B. Protect dampers from damage to operating linkages and blades.
 - C. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.
 - D. Storage: Store materials in a dry area indoor, protected from damage.
 - E. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

- 1.7 ENVIRONMENTAL REQUIREMENTS
 - A. Do not install duct sealant when temperatures are less than those recommended by sealant manufacturers.
 - B. Maintain temperatures during and after installation of duct sealant.

- 1.8 FIELD MEASUREMENTS
 - A. Verify field measurements prior to fabrication.

- 1.9 COORDINATION
 - A. Coordinate Work with all other trades on the project.

PART 2 – PRODUCTS

- 2.1 DUCT MATERIALS
 - A. Galvanized Steel Ducts: ASTM A653/A653M galvanized steel sheet, lock-forming quality, having G90 zinc coating of in conformance with ASTM A90.

- B. Steel Ducts: ASTM A1008/ ASTM A1011/ ASTM A568.
- C. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.
- D. Stainless Steel Ducts: ASTM A167, Type 304.
- E. Fasteners: Rivets, bolts, or sheet metal screws.
- F. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 FLEXIBLE DUCTS

- A. Product Description: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helical-wound spring steel wire.
 - 1. Pressure Rating: 10 inches wg positive and 1.0 inches wg negative.
 - 2. Maximum Velocity: 4000 fpm.
 - 3. Temperature Range: -20 degrees F to 210 degrees F.

2.3 INSULATED FLEXIBLE DUCTS

- A. Product Description: Two ply vinyl film supported by helical wound spring steel wire; fiberglass insulation; polyethylene vapor barrier film.
Pressure Rating: 10 inches wg positive and 1.0 inches wg negative.
Maximum Velocity: 4000 fpm.
Temperature Range: -10 degrees F to 160 degrees F.
Thermal Resistance: 4.2square feet-hour-degree F per BTU.

2.4 SPIRAL ROUND DUCTS

- A. Product Description: UL 181, Class 1, round spiral lockseam duct.

2.5 SPIRAL FLAT OVAL DUCTS

- A. Product Description: Machine made from round spiral lockseam duct rated for 10 inches wg pressure.
- B. Joints: Either fully welded or bolted flange with gasket material in accordance with manufacturer's recommendations.

2.6 GLASS FIBER REINFORCED PLASTIC ROUND DUCTS

- A. Product Description: Filament wound glass fiber reinforced plastic with fire retardant thixotropic resin with flame spread less than 25 smoke developed less than 50 when tested in accordance with ASTM E84.
- B. Joints: 304 Stainless Steel sheet metal sleeve located inside duct, sealed and secured with screws.

2.7 TRANSVERSE DUCT CONNECTION SYSTEM

- A. Manufacturers:
 - 1. Ductmate.
 - 2. Nexus.
 - 3. Ruskin.
 - 4. Ward Industries
- B. Product Description: SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

2.8 CASINGS AND PLENUMS

- A. Fabricate casings and plenums in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and construct for operating pressures indicated.
- B. Reinforce access door frames with steel angles tied to horizontal and vertical plenum supporting angles. Furnish hinged access doors where indicated or required for access to equipment for cleaning and inspection.
- C. Fabricate acoustic casings with reinforcing turned inward. Furnish 16 gage back facing and 22 gage perforated front facing with 3/32 inch diameter holes on 5/32 inch centers. Construct panels 3 inches thick packed with 4.5 lb./cu ft minimum glass fiber media, on inverted channels of 16 gage.

2.9 DUCTWORK FABRICATION

- A. Fabricate and support rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Fabricate and support round ducts with longitudinal seams in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible (Round Duct Construction Standards). Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- C. Construct T's, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide airfoil turning vanes.
- D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- E. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.
- F. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections.
- G. Fabricate duct to achieve a maximum of 1% duct leakage.

2.10 GLASS FIBER DUCT FABRICATION

- A. Fabricate in accordance with SMACNA Fibrous Glass Duct Construction Standards.

- 2.11 KITCHEN HOOD EXHAUST DUCTWORK FABRICATION
- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and NFPA 96.
- 2.12 STANDARD DUCT MOUNTED AIR SILENCERS
- A. Manufacturers:
 - 1. Industrial Air Control (IAC)
 - 2. Engineered Acoustics
 - 3. Ruskin Manufacturing
 - 4. Semco
 - 5. United McGill
 - 6. Vibro Acoustics.
 - B. Configuration: Consulting engineering firm shall determine configuration
 - C. Fabricate in accordance with ASTM publication E-477-99, Standard Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers.
 - D. Internal liner shall be constructed of perforated metal.
 - E. Fill shall be an inorganic vermin and moisture proof sound absorption media compressed a minimum of 5%. Fill shall have a flame spread rating of 25 and smoke development rating of 50.
 - F. Duct connections shall be flanged.
- 2.13 FIRE AND SMOKE DAMPERS
- A. Acceptable Manufacturers:
 - 1. Arrow United Industries
 - 2. Cesco Products
 - 3. Lloyd Industries
 - 4. NCA Manufacturing.
 - 5. Ruskin Manufacturing.
 - 6. Vent Products
 - B. Fabricate in accordance with NFPA 90A, UL 555, and UL 555S.
 - C. Fire Resistance: Shall match or exceed the rating of the wall in which the damper is concealed
 - D. Leakage Rating: Class II, maximum of 20 cfm at 4 inches wg differential pressure.
 - E. Damper Temperature Rating: 350 degrees F.
 - F. Blades: Style: Airfoil-shaped, single piece, double skin.
 - G. Bearings: Stainless steel pressed into frame.
 - H. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.
 - I. Linkage: Concealed in frame.
 - J. Release Device: Close in controlled manner and allow damper to be automatically reset.
 - K. Actuator:
 - Type: Electric 24 volt, 60 hertz, two-position, fail close.
 - Mounting: External.

- L. Fusible Link Release Temperature: 165 degrees F.
- M. Factory installed sleeve and mounting angles. Furnish silicone caulk factory applied to sleeve at damper frame to comply with leakage rating requirements.

2.14 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.
- B. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, furnish minimum 1 inch thick insulation with sheet metal cover.
 - 1. Less than 12 inches square, secure with sash locks.
 - 2. Up to 18 inches Square: Furnish two hinges and two sash locks.
 - 3. Up to 24 x 48 inches: Three hinges and two compression latches with outside handles.
 - 4. Larger Sizes: Furnish additional hinge.
 - 5. Access panels with sheet metal screw fasteners are not acceptable.

2.15 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.
- B. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized frame channel with suitable hardware.
- C. End Bearings: Except in round ductwork 12 inches and smaller, furnish end bearings. On multiple blade dampers, furnish oil-impregnated nylon or sintered bronze bearings. Furnish closed end bearings on ducts having pressure classification over 2 inches wg.
- D. Quadrants:
 - 1. Furnish locking, indicating quadrant regulators on single and multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on standoff mounting brackets, bases, or adapters.
 - 3. Where rod lengths exceed 30 inches furnish regulator at both ends.

2.16 ROUND AND RECTANGULAR DIFFUSERS AND CEILING MOUNTED GRILLES

- A. Acceptable Manufacturers:
 - 1. Carnes.
 - 2. Krueger
 - 3. MetalAire
 - 4. Nailor
 - 5. Price
 - 6. Titus
 - 7. Tuttle and Bailey
- B. Accessories: Butterfly damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.17 LINEAR SLOT DIFFUSERS AND GRILLES

- A. Acceptable Manufacturers:
 - 1. Carnes
 - 2. Krueger
 - 3. MetalAire
 - 4. Nailor
 - 5. Price
 - 6. Titus
 - 7. Tuttle and Bailey
- B. Plenum: Integral, galvanized steel, insulated.
- C. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.18 LAMINAR FLOW DIFFUSERS

- A. Acceptable Manufacturers:
 - 1. Carnes Model DLAC
 - 2. Krueger Model 5000
 - 3. Precision Air Products Model Lami-Vent
 - 4. Titus Model TLF
 - 5. Tuttle and Bailey Model CRD
- B. Type: non aspirating laminar flow, diffuser face assembly shall be one-piece design with integral solid perimeter frame, free area shall be no less than 22%
- C. Damper: Round Butterfly.

2.19 HEPA MODULES

- A. Acceptable Manufacturers:
 - 1. Carnes Model DLAC
 - 2. Krueger Model 5000
 - 3. Precision Air Products Model HEPA-Vent
 - 4. Titus Model TLF
 - 5. Tuttle and Bailey Model TENSOR
- B. Type: Laminar flow, diffuser face assembly shall be one-piece design with integral solid perimeter frame.
- C. Fabrication: Aluminum extrusions with factory off-white electrocoated finish.
- D. Frame: Flush Mounted
- E. Filter: 2" Thick HEPA filter

2.20 WALL SUPPLY, RETURN AND EXHAUST REGISTERS/GRILLES

- A. Acceptable Manufacturers:
 - 1. Carnes.
 - 2. Krueger
 - 3. Nailor
 - 4. Price
 - 5. Titus
 - 6. Tuttle and Bailey
- B. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.

2.21 DOOR GRILLES

- A. Acceptable Manufacturers:
 - 1. Carnes.
 - 2. Krueger
 - 3. MetalAire
 - 4. Nailor
 - 5. Price
 - 6. Titus

2.22 TUTTLE AND BAILEY LOUVERS

- A. Acceptable Manufacturers:
 - Arrow United Industries
 - Cesco Products
 - Lloyd Industries
 - NCA Manufacturing.
 - Ruskin Manufacturing.
- B. Product Description: Double drainable hurricane rated storm louvers
- C. Mounting: Furnish with angle flange or masonry strap anchors for installation.
- D. Bird Screen: Bird screen with 1/2 inch square mesh for exhaust and 3/4 inch for intake. Insect screens are not allowed.

2.23 LOUVERED PENTHOUSE

- A. Acceptable Manufacturers:
 - 1. Greenheck Corp.
 - 2. Penn Ventilator Company
- B. Provide with bird screen. Insect screens are not permitted.
- C. Roof Curb: 18 inch high, self-flashing galvanized steel construction with continuously welded seams, built-in cant strips, 1 inch insulation and curb bottom and factory installed nailer strip.

2.24 ROOF HOODS

- A. Acceptable Manufacturers:
 - 1. Greenheck Corp.
 - 2. Penn Ventilator Company
- B. Provide with bird screen. Insect screens are not permitted.
- C. Roof Curb 18 inch high self-flashing galvanized steel construction with continuously welded seams, built-in cant strips, 1 inch insulation and curb bottom and factory installed nailer strip.

2.25 GOOSENECKS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, of minimum 18 gage galvanized steel.
- B. Roof Curb 18 inch high self-flashing galvanized steel construction with continuously welded seams, built-in cant strips, 1 inch insulation and curb bottom and factory installed nailer strip.

PART 3- EXECUTION**3.1 EXAMINATION**

- A. Verify sizes of equipment connections before fabricating transitions.
- B. Verify rated walls are ready for fire damper installation.
- C. Verify ducts and equipment installation are ready for accessories.
- D. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
- E. Verify inlet and outlet locations.
- F. Verify ceiling and wall systems are ready for diffuser/grille installation

3.2 INSTALLATION

- A. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Install fibreglass ducts in accordance with SMACNA Fibrous Glass Duct Construction Standards. Obtain manufacturer's inspection and acceptance of fabrication and installation at beginning of installation.
- C. During construction, install temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Use crimp joints with or without bead or beaded sleeve couplings for joining round duct sizes 8 inch and smaller.
- E. Install duct hangers and supports in accordance with Section 23 05 29.
- F. Use double nuts and lock washers on threaded rod supports.
- G. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- H. Install kitchen range hoods in accordance with NFPA 96.
- I. Install in accordance with NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible.

- J. Access Doors: The following are the University of Delaware minimum requirements:
 - 1. Before and after each duct mounted filter.
 - 2. Before and after each duct mounted coil.
 - 3. Before and after each duct mounted fan.
 - 4. Before and after each automatic control damper.
 - 5. Before and after each fire damper/smoke damper/combo fire and smoke damper.
 - 6. Downstream of each VAV box.
 - 7. Install at locations for cleaning kitchen exhaust ductwork in accordance with NFPA 96.
- K. Install diffusers to ductwork with airtight connection.
- L. Install balancing dampers on all branch duct and on all duct take-off to diffusers, grilles, and registers, whether or not dampers are furnished as part of diffuser, grille, and register assembly.
- M. Flexible insulated duct shall be no longer than 6 feet in length.
- N. Fasten flexible duct to equipment, diffuser or grille with stainless steel draw bands.
- O. Do not use flexible duct to make 90 degree turns. Rigid elbows shall be used to make 90 degree turns.

3.3 DEMONSTRATION

- A. Demonstrate re-setting of fire dampers to Owner's representative.

3.4 INTERFACE WITH OTHER PRODUCTS

- A. Install openings in ductwork where required to accommodate thermometers and controllers. Install pitot tube openings for testing of systems. Install pitot tube complete with metal can with spring device or screw to prevent air leakage. Where openings are provided in insulated ductwork, install insulation material inside metal ring.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.5 CLEANING

- A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air flow, clean one half of system completely before proceeding to other half. Protect equipment with potential to be harmed by excessive dirt with temporary filters, or bypass during cleaning.
- B. Clean duct systems with high power vacuum machines. Protect equipment with potential to be harmed by excessive dirt with filters, or bypass during cleaning. Install access openings into ductwork for cleaning purposes.

PART 4 - ATTACHMENTS

- 4.1 No content.

End of Section

SECTION 23 34 00 _ SUMMARY

PART 1 – GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Centrifugal fans.
 - 2. Axial fans.
 - 3. Propeller fans.
 - 4. Downblast centrifugal roof fans.
 - 5. Upblast centrifugal roof fans.
 - 6. Centrifugal wall fans.
 - 7. Ceiling fans.
 - 8. Centrifugal square inline fans.
 - 9. Combination kitchen hood supply and exhaust fans.
 - 10. High Plume Dilution Exhaust Fans
 - 11. Roof ventilators.
- B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

1.2 REFERENCES

- A. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
- B. Section 23 05 29 - Hanger and Supports for HVAC Piping and Equipment
- C. Section 23 05 48 – Vibration and Seismic Controls
- D. Section 23 09 00 – Building Automation Systems
- E. Section 23 30 00 – Air Distribution Systems
- F. Variable Frequency Drives

1.3 DESIGN REQUIREMENTS

- A. Poor inlet and discharge conditions often lead to underperformance of fans in relation to design. Fan inlet and discharge duct shall be designed without abrupt transitions and have the required distance between inlet/outlet and any elbows or tees.
- B. High plume dilution fans shall be used to exhaust laboratory, pilot plant and process spaces. The University Energy and Engineering Department must be consulted when using other types of fans to exhaust these areas.
- C. All roof mounted fans shall be mounted on structural steel supports with an access platform for maintenance.
- D. Fan materials of construction shall be selected based on the explosive hazards and corrosiveness of the air stream through the fan.
- E. All fan motors shall be TEFC type and have NEMA explosive ratings based on the surrounding atmosphere and/or air stream through fan.

1.4 Submittals

- A. Shop Drawings: Indicate size and configuration of fan assembly, mountings, weights, duct, and accessory connections.
- B. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Submit fan manufacturers' instructions.

- 1.5 Closeout Submittals
 - A. Operation and Maintenance Data: Submit instructions for calibrating instruments, installation instructions, assembly views, servicing requirements, lubrication instruction, and replacement parts list.
 - B. Fan start up report
 - C. Completed Fan Data Sheet – Refer to Section 23 05 00 Project Documentation for template of Fan Data Sheet
 - D. As Built operating characteristics that are revised to include all changes to air system made during construction.
- 1.6 QUALITY ASSURANCE
- 1.7 DELIVERY, STORAGE, AND HANDLING
 - A. Protect motors, shafts, and bearings from weather and construction dust.
- 1.8 FIELD MEASUREMENTS
 - A. Verify field measurements prior to fabrication.
- 1.9 EXTRA MATERIALS
 - A. Furnish two sets of belts for each fan.
 - B. Furnish two sets of filters for all equipment containing filters

PART 2 – PRODUCTS

- 2.1 HIGH PLUME DILUTION EXHAUST FANS
 - A. Manufacturers:
 - 1. Greenheck Corp (Vortex)
 - 2. Harington Environmental
 - 3. MK Plastics
 - 4. Strobic Air
 - B. Fan assembly shall be minimum AMCA type C spark resistant construction unless stated otherwise on the drawings.
 - C. Fan Housing:
 - 1. Corrosion Resistance: Fan Housing shall be constructed of corrosion resistant materials such as FRP or polypropylene or steel with a corrosion resistant coating rated for a 4000 hour ASTM B117 Salt Spray Resistance.
 - 2. Fan housing shall be aerodynamically designed to reduce incoming air turbulence.
 - 3. Fan Housing shall allow all drive components including motors to serviced and maintained without contact with the contaminated airstream.
 - 4. Fan housing shall have an integral housing drain
 - 5. Fan housing shall have an access door for impeller inspections.
 - D. Induction Discharge Nozzle:
 - 1. Corrosion Resistance: Induction Discharge Nozzle shall be constructed of corrosion resistant materials such as FRP or polypropylene or steel with a corrosion resistant coating rated for a 4000 hour ASTM B117 Salt Spray Resistance.
 - 2. Induction Discharge Nozzle shall be integral to the body and be designed for outlet velocities of 7000fpm.

3. Induction Discharge Nozzle shall be integral to the body and be designed for outlet velocities of 7000fpm.
 4. Induction Discharge Nozzle shall induce ambient air up to 2.5 times the fan capacity.
- E. Fan :
1. Fan Unit: Direct Drive, airfoil blower, constructed of corrosion resistant materials such as FRP or polypropylene or steel with a corrosion resistant coating rated for a 4000 hour ASTM B117 Salt Spray Resistance; spring isolated; statically and dynamically balanced .
 2. Sheaves: dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position.
 3. Bearings: Ball or roller pillow block type: L-10 life of 200,000 hours; extended lines with Zerk fittings.
 4. Motor: Premium efficiency TEFC, Inverter Duty.
- F. Master Control Panel: Factory wired to disconnect switch for exhaust fan. Furnish with fused magnetic starters, overload protection, wiring terminals and weatherproof housing. Furnish with 120 volt control circuit transformer.
- G. Plenum Curb: Self-flashing of 12 gage galvanized steel construction with continuously welded seams, 1 inch thick sound insulation on inner surface, and factory installed nailer strip.
- H. Disconnect Switch: Factory wired, non-fusible, in fan housing for thermal overload protected motor, NEMA 250 Type 1, lockable enclosure.
- I. Bypass Air Plenum: [\(Constant Volume Units Only\)](#)
1. Corrosion Resistance: Fan Housing shall be constructed of corrosion resistant materials such as FRP or polypropylene or steel with a corrosion resistant coating rated for a 4000 hour ASTM B117 Salt Spray Resistance.
 2. Bypass Air & Fan Isolation Dampers: Opposed blade airfoil design suitable for 15" wg; Corrosion resistant materials; Blades shall have polymer damper edge seals; Stainless steel damper rods, bearings and jamb seals.
 3. Weatherhood: Construction to match bypass air plenum with stainless steel insect screen.
- J. Glycol Based Energy Recovery Coil:
1. Construction: 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
- K. Airflow Measuring Station: Calibrated nozzle type mounted on the inlet venturi of the fan.

2.2 CENTRIFUGAL FANS

- A. Manufacturers:
1. Harrington Environmental
 2. Howden Buffalo Fan Company
 3. New York Blower Company
 4. Twin City Fan Company
- B. Performance:
1. Performance Base: Sea level conditions.
 2. Temperature Limit: Maximum 600 degrees F.
 3. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.
- C. Wheel:
1. University of Delaware prefers Airfoil Wheels but will accept Backward Incline or Forward Curve if these fans produce better and more stable fan performances.
- D. Housing:
1. Factory finish before assembly to manufacturer's standard.
 2. Bolted construction with horizontal flanged split housing.

- E. Bearings and Sleeves:
 - 1. Bearings: Pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9, L-50 life at 100,000 hours.
 - 2. Shafts: Hot rolled steel, ground and polished, with key way, protectively coated with lubricating oil, and shaft guard.
- F. Drive: Direct Drive for use with variable frequency drive
- G. Motor: Totally enclosed fan cooled; motor should have NEMA hazard rating based on working conditions.

2.3 AXIAL FANS

- A. Manufacturers:
 - 1. Harrington Environmental
 - 2. Howden Buffalo Fan Company
 - 3. New York Blower Company
 - 4. Twin City Fan Company
- B. Hub and Impeller:
 - 1. Airfoil Impeller Blades: Adjustable
 - 2. Hub: hub bored and keyed to shaft; to facilitate indexing of blade angle with automatic adjustment stops.
 - 3. Controllable Pitch Assemblies: Incorporate ball bearing counterbalanced blade and variable pitch assembly into hub with mechanical link to casing exterior mounted actuator.
 - 4. Cast Components: X-ray components after fabrication and statically and dynamically balance assembly before attachment to motor or shaft.
- C. Casing:
 - 1. Casing with inlet and outlet flange connections, and motor or shaft supports. Incorporate flow straightening guide vanes for fans specified for static pressures greater than 2 inches wg.
 - 2. Finish with one coat enamel applied to interior and exterior.
- D. Bearings and Drives:
 - 1. Bearings: Pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-50 life at 100,000 hours.
 - 2. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil.
 - 3. Drive: Direct Drive for use with variable frequency drive.
 - 4. Lubrication: Extend lubrication fittings to outside of casing.
- E. Motor: Totally enclosed fan cooled; motor should have NEMA hazard rating based on working conditions.
- F. Accessories:
 - 1. Inlet Bell: Bell mouth inlet fabricated with flange.
 - 2. Outlet Cones: outlet area/inlet area ratio of 1.5, with center pod as recommended by manufacturer.
 - 3. Inlet Screens: Galvanized steel welded grid to fit inlet bell.
 - 4. Access Doors: Shaped to conform to casing with quick opening latches and gaskets.
 - 5. Blade Pitch Actuator: Factory mounted and calibrated, electric actuator requiring single phase power and accepting electric input
 - 6. Vibration Detector: Factory installed vibration switch to stop fan with extra set of contacts.

2.4 PROPELLER FANS

- A. Manufacturers:
 - 1. Greenheck Corp
 - 2. Howden Buffalo Fan Company

3. New York Blower Company
 4. Twin City Fan Company
 - B. Construction:
 1. Impeller: Shaped steel or steel reinforced aluminum blade with hubs, statically and dynamically balanced, keyed and locked to shaft, furnished with V-belt drive.
 2. Frame: One piece, square steel with die formed venturi orifice, mounting flanges and supports, with baked enamel finish.
 - C. Motor: Totally enclosed fan cooled; motor should have NEMA hazard rating based on working conditions.
 - D. Accessories:
 1. Back-draft Damper: Multiple blade with offset hinge pin, blades linked.
 2. Safety Screens: Expanded galvanized metal over inlet, motor, and drive and outlet; to comply with OSHA regulations.
 3. Hood: Weather shield, to exclude rain and snow.
- 2.5 UPBLAST AND DOWNBLAST CENTRIFUGAL ROOF FANS (For Kitchen and General Exhaust Only, These Fans Should Never Be Used to Exhaust Laboratory, Pilot Plant or Process Areas or Operations)
- A. Manufacturers:
 1. Greenheck Corp
 2. PennBarry Company
 3. Twin City Fan Company
 - B. Fan Unit: V-belt drive, with spun aluminum housing; resilient mounted motor; aluminum wire bird screen; square base to suit roof curb with continuous curb gaskets.
 - C. Sheaves: steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
 - D. Motor: Totally enclosed fan cooled
 - E. Roof Curb: 14 inch high self-flashing of galvanized steel construction with continuously welded seams, 1 inch insulation and curb bottom, and factory installed nailer strip.
 - F. Disconnect Switch: Factory wired, non-fusible, in fan housing for thermal overload protected motor, NEMA 250 Type 1, lockable enclosure.
 - G. Accessories:
 1. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, spring return.
 2. Fan speed controller.
- 2.6 CEILING MOUNTED BATHROOM EXHAUST FANS
- A. Manufacturers:
 1. Greenheck Corp
 2. PennBarry Company
 3. Twin City Fan Company
 - B. Centrifugal Fan Unit: Direct driven with galvanized steel lined with 1/2 inch acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge opening, integral outlet duct collar. Discharge position convertible by moving interchangeable panels.
 - C. Disconnect Switch: Fan mounted toggle switch for thermal overload protected motor.
 - D. Grille: Aluminum with baked white enamel finish.

- E. Wheel: DWDI or Centrifugal forward curved type constructed of injection molded or polypropylene resin.
- F. Motor: Open drip proof type with permanently lubricated sealed bearings and thermal overload protection.
- G. Accessories:
 - 1. Wall cap with damper
 - 2. Roof cap with roof curb.
 - 3. Brick vent constructed of extruded aluminum with bird screen.
 - 4. Rubber-in-shear vibration isolator.

2.7 CENTRIFUGAL SQUARE INLINE FANS

- A. Manufacturers:
 - 1. Greenheck Corp
 - 2. Howden Buffalo Fan Company
 - 3. New York Blower Company
 - 4. Twin City Fan Company
- B. Product Description: V-belt drive with galvanized steel housing lined with 1/2 inch acoustic glass, integral inlet cone, removable access doors on 3 sides, inlet and outlet duct collar, horizontal hanging brackets.
- C. Fan Wheel: Backward inclined centrifugal type.
- D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
- E. Motor and Drive Mounting: Out of air stream, direct drive for use with variable frequency drive
- F. Motor: Totally enclosed fan cooled; motor should have NEMA hazard rating based on working conditions.
- G. Bearings: ABMA 9 life at 200,000 hours.
- H. Accessories:
 - 1. Motor cover.
 - 2. Flexible duct connector.
 - 3. Flanged inlet and outlet.

2.8 COMBINATION KITCHEN HOOD SUPPLY AND EXHAUST FANS

- A. Manufacturers:
 - 1. CaptiveAire
 - 2. Gaylord Industries
 - 3. Grease Master
 - 4. Greenheck Corp
 - 5. Kees Inc.
- B. Exhaust Fan:
 - 1. Fan Unit: Upblast type. V-belt drive, spun aluminum housing with grease tray; resilient mounted motor; aluminum wire bird screen; square base to suit roof curb with continuous curb gaskets.
 - 2. Sheaves: steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
 - 3. Motor: Open drip proof
 - 4. Accessories:
 - o Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt

edged with offset hinge pin, nylon bearings, blades linked, spring return.

- o Fan speed controller.

C. Supply Fan:

1. Fan Unit: Belt driven, double width, double inlet centrifugal blower, galvanized steel housing with galvanized finish; resilient mounted motor; square base to suit roof curb.
2. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
3. Motor: Open drip proof.

D. Master Control Panel: Factory wired to disconnect switch for supply fan and disconnect switch for exhaust fan. Furnish with fused magnetic starters, overload protection, wiring terminals and weatherproof housing. Furnish with 120 volt control circuit transformer.

E. Fresh Air Intake Section: Constructed of galvanized steel. Size as indicated on Drawings. Galvanized steel duct support at end of intake duct.

F. Filters: 2inch thick polyester media, washable and cleanable. Furnish bird screen at filter opening.

G. Roof Curb: 14 inch high self-flashing of galvanized steel construction with continuously welded seams, 1 inch insulation and curb bottom, and factory installed nailer strip.

H. Curb Cap: Galvanized steel, welded construction. Fits over roof curb to accommodate supply fan and exhaust fan. Insulate with 1-1/2 inch, 3 pound per cubic foot density fiberglass insulation. Furnish vented extension for exhaust fan. Comply with NFPA 96 for fan spacing and vertical separation.

I. Damper: Motor operated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked and line voltage motor drive, power closed.

J. Disconnect Switch: Factory wired, non-fusible, in fan housing for thermal overload protected motor, NEMA 250 Type 1, lockable enclosure.

K. Hot Water Heating Coil:

1. Construction: Minimum 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.

2.9 GRAVITY ROOF VENTILATORS

A. Manufacturers:

1. Greenheck Corp
2. PennBarry Company

B. Product Description: Aluminum steel housing; aluminum wire bird screen; square base to suit roof curb with continuous curb gaskets.

C. Roof Curb: 14 inch high self-flashing of galvanized steel construction with continuously welded seams, 1 inch insulation and curb bottom, and factory installed nailer strip.

D. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.

PART 3- EXECUTION

3.1 EXAMINATION

A. Verify roof curbs are installed and dimensions are as shown on shop drawings or as instructed by manufacture.

3.2 INSTALLATION

A. Secure roof and wall fans and gravity ventilators with cadmium plated steel lag screws to roof curb or structure.

B. Suspended Fans: Install flexible connections specified in Section 23 05 29 between fan and ductwork.

Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

- C. Install backdraft dampers on inlet to roof and wall exhaust fans and gravity ventilators used in relief air applications.
- D. Install safety screen where inlet or outlet is exposed.
- E. Pipe scroll drains to nearest floor drain.
- F. Install backdraft dampers on discharge of exhaust fans.
- G. Provide sheaves required for final air balance.
- H. Pipe housing drain to nearest drain.

3.3 CLEANING

- A. Vacuum clean coils and inside of fan cabinet.

3.4 DEMONSTRATION

- A. Demonstrate fan operation and maintenance procedures.

3.5 PROTECTION OF FINISHED WORK

- A. Do not operate fans until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

End of Section

SECTION 23 36 00 _ SUMMARY

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. Constant/Variable volume supply terminal units.
2. Fan powered terminal units.
3. Exhaust valves

B. Related Sections:

Section 23 05 29 - Hanger and Supports for HVAC Piping and Equipment (later)
Section 23 05 48 – Vibration and Seismic Controls (later)
Section 23 09 00 – Building Automation Systems (later)
Section 23 30 00 – Air Distribution Systems

1.2 ENGINEERING DESIGN GUIDELINES

A. No content.

1.3 SUBMITTALS

- A. Product Data: Submit data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings indicating airflow, static pressure, heating coil capacity and NC designation. Include electrical characteristics and connection requirements. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 inch to 4 inches wg.
- B. Manufacturer's Installation Instructions: Submit support and hanging details, and service clearances required.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Submit manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

1.5 QUALITY ASSURANCE

- A. Test and rate air terminal units' performance for air pressure drop, flow performance, and acoustical performance in accordance with ARI 880 and ARI 885. Attach ARI seal to each terminal unit.

1.6 FIELD MEASUREMENTS

- A. Verify field measurements prior to fabrication.

PART 2 – PRODUCTS

2.1 VARIABLE VOLUME AIR TERMINAL UNITS

- A. Acceptable Manufacturers:
 - 1. Carnes
 - 2. Krueger
 - 3. Metal Aire
 - 4. Titus Model.
 - 5. The Trane Co.
 - 6. Tuttle & Bailey
 - 7. York Inc.
- B. Identification: Furnish each air terminal unit with identification label and airflow indicator. Include unit nominal airflow, maximum factory-set airflow and minimum factory-set airflow and coil type.
- C. Basic Assembly:
 - 1. Casings: Casings shall be double wall.
 - 2. Insulation: Minimum 1inch thick closed cell insulation, meeting NFPA 90A requirements located between inner and outer casing walls.
- D. Basic Unit:
 - 1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
 - 2. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings; maximum damper leakage: 2 percent of design air flow at 3 inches inlet static pressure.
 - 3. Mount damper operator to position damper normally open.
 - 4. Access Door: Provide an access door in VAV terminals that have heating coils.
- E. Hot Water Heating Coil:
 - 1. Construction: Minimum 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
- F. Automatic Damper Operator:
 - 1. Electric Actuator: 24 volt with remote temperature read and reset capability.
 - 2. In laboratory applications the damper shall be fast actuating.

2.2 FAN POWERED VARIABLE VOLUME UNITS

- A. Manufacturers:
 - 1. Carnes
 - 2. Krueger
 - 3. Metal Aire
 - 4. Titus Model.
 - 5. The Trane Co.
 - 6. Tuttle & Bailey
 - 7. York Inc.

- B. Identification: Furnish each air terminal unit with identification label and airflow indicator. Include unit nominal airflow, maximum factory-set airflow and minimum factory-set airflow and coil type.
- C. Basic Assembly:
 - 1. Casings: Casing shall be double wall
 - 2. Lining: Minimum 1inch thick closed cell insulation, meeting NFPA 90A requirements located between inner and outer casing walls.
- D. Basic Unit:
 - 1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud.
 - 2. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings; maximum damper leakage: 2 percent of design air flow at 3 inches inlet static pressure.
 - 3. Mount damper operator to position damper normally open.
 - 4. Access Door: Provide an access door in VAV terminals that have heating coils.
- E. Automatic Damper Operator:
Electric Actuator: 24 volt with remote temperature read and reset capability.
- F. Fan Assembly:
 - 1. Fan: Forward curved centrifugal type with direct drive permanent-split-capacitor type, thermally protected motor.
 - 2. Speed Control: Infinitely adjustable through BAS system
 - 3. Isolation: Fan/motor assembly on rubber isolators.
- G. Hot Water Heating Coil:
 - 1. Construction: Minimum 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
- H. Wiring:
 - 1. Factory mount and wire controls. Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source.
 - 2. Factory mount transformer for control voltage on electric and electronic control units. Furnish terminal strip in control box for field wiring of thermostat and power source.
 - 3. Wiring Terminations: Wire fan and controls to terminal strip. Furnish terminal lugs to match branch-circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box.
 - 4. Disconnect Switch: Factory mount non-fused disconnect switch in control panel.
- I. Controls: Electronic Controls: Contain in NEMA 250 Type 1 enclosure with access panel sealed from airflow and mounted on side of unit. Factory mount controls.

2.3 LABORATORY AIR EXHAUST VALVES & LABORATORY AIR SUPPLY VALVES

- A. Manufacturers:
 - 1. Phoenix Controls Corp

- B. Product Description: Airflow volume control units for connection to critical exhaust systems, with electronic controls
- C. Identification: Furnish each air terminal unit with identification label and airflow indicator. Include unit rated airflow, maximum factory-set airflow and minimum factory-set airflow.
- D. Basic Assembly:
 - 1. Casings: 16 gage spun aluminum with continuous welded seam
 - 2. Composite Teflon shaft bearings
 - 3. Stainless steel springs and polyester slider assembly
- E. Performance:
 - 1. Pressure independent up to 3-0" static pressure drop across valve
 - 2. Volume control accurate to +/-5% of airflow command signal
 - 3. No additional straight runs needed before or after valve
 - 4. Response time to change in command signal less than one second
 - 5. Response time to change in duct static pressure less than one second

PART 3- EXECUTION

3.1 EXAMINATION

- A. Verify ductwork is ready for air terminal installation.

3.2 INSTALLATION

- A. Connect to ductwork in accordance with Section 23 30 00.
- B. Install ceiling access doors or locate units above easily removable ceiling components.
- C. Support units individually from structure. Do not support from adjacent ductwork.
- D. Support air terminal units connected by flexible duct independently of flexible duct. Flexible duct shall be no more than 6 feet in length. Connect air terminal unit to flexible duct with stainless steel draw bands. Do not use flexible duct to make 90 degree turns. Rigid elbows shall be used to make 90 degree turns.
- E. Install transition piece to match flexible duct size to inlet or outlet of variable air volume terminal.

PART 4 - ATTACHMENTS

- 4.1 No content.

End of Section

SECTION 23 73 00 _ SUMMARY

PART 1 – GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Modular custom & semi-custom built indoor air handling units
 - 2. Modular custom & semi-custom built outdoor air handling units
- B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

1.2 REFERENCES

- A. Section 23 05 13 - Common Motor Requirements for HVAC Equipment (Later)
- B. Section 23 05 29 - Hanger and Supports for HVAC Piping and Equipment (Later)
- C. Section 23 05 48 – Vibration and Seismic Controls (Later)
- D. Section 23 09 00 – Building Automation Systems (Later)
- E. Section 23 21 13.23 – Above Grade Hydronic Piping
- F. Section 23 22 15 – Above Grade Steam and Condensate Piping
- G. Section 23 30 00 – Air Distribution Systems
- H. Section 23 34 00 – HVAC Fans
- I. Section 23 84 00 – Humidity Control Equipment
- J. Variable Frequency Drives – See Electrical Standards

1.3 ENGINEERING AND DESIGN REQUIREMENTS

- A. Air handling units shall be designed to eliminate air stratification in the air handling unit.
- B. Maximum air velocity through the cooling coil is 500fpm.
- C. Maximum air velocity through the heating coil is 750fpm.
- D. Allow for dirty coils and filters when determining the air pressure drop through the air handling unit.
- E. Determine the condensate trap requirements using attachment 1. Allow for condensate trap installation when determining height of the base rail.
- F. Poor inlet and discharge conditions often lead to underperformance of air handling unit fans in relation to design. Air handling unit inlet and discharge duct shall be designed without abrupt transitions and have the required distance between inlet/outlet and any elbows or tees.
- G. Heating and cooling coils shall be selected to maintain a minimum water velocity of 3fps through the coil without the use of supplemental pumps.
- H. Hot water is the heating medium of choice for the University of Delaware. Consult the University of Delaware Energy and Engineering Department if steam heating is required.
- I. Hinged man way doors, lights and GFCI receptacles shall be supplied on all sections that require access. These include but not limited to sections that have filters, dampers, fans, UVC lights, and equipment and/or controls that need maintenance.

- J. Air handling units shall not be used to provide temporary heating and cooling during construction. Air handling units shall not be used to cure materials during the construction process. Temporary heating, cooling and dehumidification must be provided as part of the project.

1.4 SUBMITTALS

- A. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- B. Product Data, Submit the following:
 - 1. Published Literature: Indicate capacities, ratings, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Air handling performance parameters as listed on the air handling unit schedule
 - 3. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
 - 4. Fans: Performance and fan curves with specified operating point plotted, power, RPM.
 - 5. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
 - 6. Dampers: Include leakage, pressure drop, and sample calibration curves. Indicate materials, construction, dimensions, and installation details.
 - 7. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring. Indicate factory installed and field installed wiring.
- C. Manufacturer's Installation Instructions

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Submit instructions for calibrating instruments, lubrication, filter replacement, motor and drive replacement, spare parts lists, wiring diagrams, installation instructions and replacement parts list.
- B. Air Handling Unit start up report
- C. Completed Air Handling Unit Data Sheet
- D. As Built operating characteristics that are revised to include all changes to air system made during construction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Accept units and components on site in factory protective containers, with factory shipping skids and lifting lugs. Inspect for damage.
- B. Protect units from weather and construction traffic by storing in dry, roofed location.

1.7 EXTRA MATERIALS

- A. Furnish three sets of filters for each unit. (one set for start-up and two spares)

PART 2 – PRODUCTS

- 2.1 DOUBLE WALL INDOOR & OUTDOOR AIR HANDLING UNITS (Single Wall Air Handling Units are Not Acceptable)
- A. Manufacturers:
1. Air Enterprises Inc. (Custom Unit Only)
 2. Buffalo Air Handling (Custom Unit Only)
 3. Governair Corporation (Custom Unit Only)
 4. Haakon Industries (Custom Unit Only)
 5. Ingenia Technologies (Custom Unit Only)
 6. Temtrol (Custom Unit Only)
 7. Trane
 8. York International/Miller Picking/Pace
- B. Configuration shall be based on the unique requirements of the project. Consult with University of Delaware Energy and Engineering Department when determining the configuration of the air handling unit.
- C. Fabrication: Conform to AMCA 99 and ARI 430.
- D. Casing materials will be based on air handling unit application and location. Consult with University of Delaware Energy and Engineering Department to determine materials of construction.
- E. Channel base of welded steel or aluminum with a minimum height of 12 inches. Variance from the minimum height will be considered if height constraints are present. Consult with University of Delaware Energy and Engineering Department to determine if a shorter base can be used.
- F. Insulation shall have the following operating characteristics:
'K' factor at 75 degrees F: Maximum 0.26 Btuh inch/ sq ft/ degrees F.
- G. Steel or aluminum constructed air handling units located outside shall have the following finish: Three coat system of epoxy applied over shot-blasted surface, to total thickness of 5-6 mils Finish: Manufacturers standard color on exterior.
- H. Walk-in Access Doors: 30 x 60 inch. Material same as cabinet insulated sandwich construction, for flush mounting, with hinges, gasket, latch, and handle assemblies , and 12 x 12 inch inspection window of 1/4 inch thick Plexiglas.
- I. Lights: Located in all accessible sections suitable for damp locations with wire guards, factory wired to weatherproof switch and duplex outlet mounted on casing exterior. In humidifier sections, furnish lights suitable for wet locations.
- J. Drain Pans: Double thickness stainless steel with insulation between layers with welded corners. Cross break and pitch to drain connection. Furnish drain pans cooling coil section and humidifier section.
- K. Bottom Inlet Units: Furnish stainless steel or aluminum walking grate on structural supports.
- L. Strength: Furnish structure to brace casings for design suction pressure with maximum deflection of 1 in 200.

M. OUTDOOR UNITS

1. Outdoor units shall be supplied as to be mounted on a structural steel platform.
2. Unit shall be thermally broken to minimize the conduction path from the inside of the casing to the outside.
3. Roof shall be double-wall, pitched to facilitate drainage at a minimum roof slope of 1/4-in. per foot across the width of the unit. No penetrations shall be made in pressure sensitive panels. Roof shall incorporate a standing top seam. All seams in the roof shall be gasketed and capped to prevent water infiltration into the unit.
4. Outdoor units shall be supplied with piping enclosures at each coil section to house coil piping connections. Piping enclosures shall be the same construction as the air handling unit.
5. Outdoor units shall have service corridors incorporated into the chassis and enclosure.

N. FANS

1. All fan types will be considered, however the University of Delaware has a preference for air foil and plug type fans.
2. Performance Ratings: Conform to AMCA 210 and label with AMCA Certified Rating Seal.
3. Sound Ratings: AMCA 301, tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
4. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with copper tube and grease fitting rigidly attached to casing.
5. Mounting: Locate fan and motor internally on welded steel base coated with corrosion resistant paint. Factory mount motor on slide rails. Furnish access to motor, drive, and bearings through removable casing panels or hinged access doors. Mount base on vibration isolators.
6. Fans shall be direct drive with no belts. Variance will require approval from the University of Delaware Energy and Engineering Department.
7. Fans speed shall be balanced and modulated via variable frequency drive.
8. Flexible Connection: Separate unit from connecting ductwork.
9. Variable frequency drives shall be mounted external to the air chamber.

O. MOTORS

1. Fan motors shall be rated for inverter duty.

P. BEARINGS AND DRIVES

1. Bearings: Pillow block type, self-aligning, grease-lubricated roller bearings, or ABMA 11, L-50 life at 400,000 hours.
2. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

Q. COILS

1. Casing with access to both sides of coils. Enclose coils with headers and return bends fully contained within casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.
2. Drain Pans: 24 inch downstream of coil and intermediate drain pans for cooling coil banks more than one coil high. Drain pans shall be construction of corrosion resistant material such a stainless steel or a composite material and be double wall insulated.
3. Eliminators: Type 304 stainless steel mounted over drain pan.
4. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.
5. Fabrication:
 - Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
 - Fins: Aluminum.
 - Casing: Die formed channel frame of galvanized steel/stainless steel/aluminum.
6. Water Heating Coils:
 - Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.
7. Steam Heating Coils: (The use of steam heating coils must be approved by the University of Delaware Engineering and Energy Department)
 - Headers: Cast iron with tubes expanded into header, seamless copper tube with silver brazed joints, or prime coated steel pipe with brazed joints.
 - Configuration: Drainable, with threaded plugs for drain and vent, threaded plugs in return bends and in headers opposite each tube, sloped within frame to condensate connection.
 - All steam coils shall have integral face and bypass dampers.
8. Water Cooling Coils:
 - Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.

R. FILTERS

1. Filter Box: Section with filter guides, access doors from one side for side loading with gaskets and blank-off plates.
2. Filter Media: Filter media will be selected based on the operating requirements of the space being conditioned. Consult with the University of Delaware Energy and Engineering Department when selecting filter media.
3. Magnehelic gages must be supplied for each filter bank.

S. UVC GERMICIDAL LAMPS

1. UVC germicidal lamps may be used to control biological growth on chilled water coils if required by the design.
2. Emitters and fixtures for UV-C lamps shall be designed for use inside an HVAC system. Individual lamp output shall be measured in an ASME nozzled test apparatus using a 45 F airstream moving at not less than 400 fpm. Lamp output at 253.7 nm shall not be less than 10 $\mu\text{W}/\text{cm}^2$ per inch of arc length measured at a distance of one meter.
3. Power supplies for UV-C lamps shall be a high-efficiency electronic type which are matched to the emitters and are capable of producing the specified output intensity with an input power no more than 80 watts.
4. Fixtures for UV-C lamps shall be factory installed and wired to a SPDT disconnect switch and door interlock switches in each door. Fixtures are wired for 120 v/single ph requiring a minimum circuit ampacity of 15 amps. Lamps shall ship separately for field installation to minimize the chance for bulb damage.
5. Emitters and fixtures shall be installed in sufficient quantity and arranged so as to provide an equal distribution of UV-C energy on the coil and drain pan.
6. The minimum UV-C energy striking the leading edge of the coil pan shall be not less than 820 $\mu\text{W}/\text{cm}^2$ at the closest point and through placement, not less than 60% of that value at the farthest point. Equal amounts are to strike the drain pan, either directly or indirectly through reflection.
7. Emitters and fixtures shall be installed such that UV-C energy strikes all surfaces of the coil, drain pan, and the available line of sight airstream.

T. DAMPERS

1. Dampers shall have edge seals and self-lubricating nylon bearings. Dampers shall have opposed blade arrangement with damper blades positioned across short air opening dimension. Furnish removable, full width support for freeze-protection thermostat, with removable end panel to permit support removal.
2. Outside Air Damper Leakage: Maximum 3.0 cfm per square foot at 1.0 inches wg pressure differential.
3. Return/Exhaust Damper Leakage: Maximum 2 percent at 4 inch wg differential pressure when sized for 2000 fpm face velocity.
4. Face and Bypass Dampers: Factory mount in casing with access doors, opposed blades, and edge seals, self-lubricating nylon bearings. Arrange to match coil face with bypass, blank-off and division sheets, internal linkage, access doors, and adjustable resistance plate.
5. Damper Actuators: Damper actuators shall be supplied by the BAS vendor (Tri-M) for factory mounting.

U. OUTSIDE AIR MEASURING DEVICE

1. Consult with the University of Delaware Energy and Engineering Department if outdoor air measuring is required.
2. Airflow measurement assembly shall be sized to accommodate minimum and economizer outside airflow.
3. Allow for air straightening into the airflow measuring station to maximize accuracy of the data

V. REFRIGERANT BASED ENERGY RECOVERY COILS

Advanced Cooling Technology and Heat Pipe Technologies are the vendors of choice for energy recovery coils for the University of Delaware. Please consult manufacturer as well as the University of Delaware Energy and Engineering Department for design of refrigerant based energy recovery coils

W. HUMIDIFIER SECTION

If humidifiers are required, humidifier dispersion tubes will be supplied with the humidifier. Dispersion tube section shall be long enough to allow for steam to be absorbed into the air stream.

PART 3- EXECUTION**3.1 INSTALLATION**

- A. Install in accordance with ARI 430.
- B. Install flexible connections between unit and inlet and discharge ductwork if not provided with air handling unit. Install metal bands of connectors parallel with minimum 1 inch flex between ductwork and fan while running.
- C. Install assembled units with vibration isolators. Install isolated fans with spring type isolators and flexible electrical leads. Install restraining.
- D. Install floor mounted units on concrete housekeeping pads at least 6 inches high and 6 inches wider and longer than unit.
- E. Install condensate piping with trap and route from drain pan to nearest floor drain. See attachment 1 for cooling coil trapping requirements.

3.2 INSTALLATION – REFRIGERANT ENERGY RECOVERY COILS

- A. Install sight glass in liquid line within 12 inches of coil. Refer to Section 23 63 00.
- B. Connect water supply to leaving airside of coil (counter flow arrangement).

3.3 INSTALLATION CHILLED WATER, COOLING COIL

- A. Make connections to coils with unions or flanges to accommodate removal of coils.
- B. Connect water supply to leaving airside of coil (counter flow arrangement).
- C. Locate water supply at bottom of supply header and return water connection at top.
- D. Install water coils to allow draining and install drain connection at low points.
- E. Install automatic air vents at high points complete with shutoff valve.

- 3.4 INSTALLATION HOT WATER HEATING COIL
 - A. Make connections to coils with unions or flanges to accommodate removal of coils.
 - B. Connect water supply to leaving airside of coil (counter flow arrangement).
 - C. Locate water supply at bottom of supply header and return water connection at top.
 - D. Install water coils to allow draining and install drain connection at low points.
 - E. Install automatic air vents at high points complete with shutoff valve.

- 3.5 INSTALLATION - STEAM HEATING COIL
 - A. Make connections to coils with unions or flanges to accommodate removal of coils
 - B. Install steam traps with outlet minimum 12 inches below coil return connection. Allow for enough elevation to gravity feed steam condensate to condensate receiver.
 - C. Install vacuum breaker at high points.

- 3.6 MANUFACTURER'S FIELD SERVICES
 - A. Furnish initial start-up of air handling units.

- 3.7 CLEANING
 - A. Vacuum clean coils and inside of unit cabinet.
 - B. Install temporary filters during construction period. Replace with permanent filters at Substantial Completion.

- 3.8 DEMONSTRATION
 - A. Demonstrate unit operation and maintenance.
 - B. Furnish services of manufacturer's technical representative for one 8 hour day to instruct Owner's personnel in operation and maintenance of units. Schedule training with Owner, provide at least 7 days notice to University of Delaware representative of training date.

- 3.9 PROTECTION OF FINISHED WORK
 - A. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

PART 4 - ATTACHMENTS

- 4.1 No content.

End of Section

SECTION 23 81 00 _ SUMMARY

PART 1 – GENERAL

1.1 SUMMARY

- A. This Standard Includes the Following:
 - 1. Air Cooled Condensing Units
 - 2. Duct Free Split Air Conditioning Systems
 - 3. Light Duty Ducted Split Air Conditioning Systems including condensing units, fan coil unit or gas fired furnace & evaporator coil (5 tons and less)
- B. The intent of these standards are to provide input to the design team on the University's preference of manufacturers, design, equipment options and quality assurance to maintain the longevity of its assets.

1.2 REFERENCES

- A. Refrigeration Piping & Specialties 23 23 00

1.3 DESIGN REQUIREMENTS

- A. DX refrigerant based comfort split systems shall be limited to 5 tons and below. Engineering Design firm shall explore all other options for providing cooling (ie. packaged systems, chilled water, etc) prior to considering a DX refrigerant based split system for cooling loads greater than 5 tons.
- B. Condensing units must not be located above evaporator coil unless specifically agreed to by the specified manufacturer of equipment.
- C. The specified equipment manufacturer shall either assist in the design of the refrigerant piping system or approve the design of the refrigerant piping system.
- D. In order to optimize performance, all split systems shall have consist of fan coil unit or furnace & evaporator coil matched to the condensing unit and be from the same manufacturer.

1.4 SUBMITTALS

- A. Shop Drawings: Indicate components, assembly, dimensions, weights and loading, required clearances, and location and size of field connections. Include schematic layouts showing condenser, refrigeration compressors, cooling coils, refrigerant piping and accessories required for complete system.
- B. Product Data Equipment:
 - 1. Cooling and heating capacities.
 - 2. Dimensions.
 - 3. Rough-in connections and connection requirements.
 - 4. Duct connections.
 - 5. Electrical requirements with electrical characteristics, connection requirements and wiring diagrams.
 - 6. Controls.
 - 7. Accessories.
 - 8. Weights.

- C. Product data sheets must be submitted for each device or equipment. Data sheets shall not contain information for multiple pieces of equipment.
- D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- E. Manufacturer's Field Reports: Submit start-up report for each piece of equipment.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Submit start-up instructions, maintenance instructions, parts lists, controls, and accessories.

1.6 QUALITY ASSURANCE

- A. Verify field measurements prior to fabrication.
- B. Coordinate wall openings, wall sleeve installation, sealing of louvers, piping rough-in locations and electrical rough-in locations to accommodate packaged terminal air conditioning units.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Dehydrate and charge refrigeration components including piping and receivers, seal prior to shipment. Maintain seal until connected into system.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Accept equipment on site in factory packaging. Inspect for damage.
- D. Comply with manufacturer's installation instruction for rigging, unloading and transporting units.
- E. Protect equipment from damage by providing temporary covers until construction is complete in adjacent space.
- F. Protect items shipped loose with units in original packaging and store in secured area.

PART 2 – PRODUCTS

2.1 DUCT FREE SPLIT AIR CONDITIONING OR HEAT PUMP UNITS

- A. Manufacturers:
 - 1. Daikan Corp.
 - 2. Mitsubishi.
- B. Indoor Unit Wall Mounted: Inverter duty wall mounted unit including mounting bracket, microprocessor controlled operation, air sweep control, quiet fan operation anti mold filter, built in drain pump, evaporator coil constructed of copper tubing with aluminum fins mechanically bonded to tubes, electric refrigerant control valve and electric heating coil.
- C. Indoor Unit Ceiling Mounted: Inverter duty ceiling mounted unit for mounting in 2x4 T-bar type ceiling, microprocessor controlled, air sweep control, quiet fan operation anti mold filter, built in drain pump, evaporator coil constructed of copper tubing with aluminum fins mechanically bonded to tubes, electric refrigerant control valve and electric heating coil.
- D. Outdoor Unit: Inverter duty, Hermetically sealed compressor with internal spring isolation, permanent split capacitor motor and overload protection, holding charge of refrigerant, crank case heater, condenser fan constructed of copper tubing and aluminum fins, electric refrigerant control valve, reversing valve (heat pumps) and propeller type condenser fan with separate permanent split capacitor motor.

- E. Low ambient control for operation down to 0 degrees Fahrenheit.
- F. Refrigerant Accessories: filter drier, sight glass, suction and liquid service valves.
- G. SEER rating of 16 or greater
- H. Condensing units must sit upon a prefabricated support or concrete pad approved by the University of Delaware.

2.2 LIGHT DUTY SPLIT SYSTEM AIR CONDITIONING & HEAT PUMP UNITS (UP TO 5 TONS)

- A. Manufacturers (Provide Matched Sets):
 - 1. Arco Aire
 - 2. Carrier
 - 3. Goodman
 - 4. Rheem
 - 5. Ruud
 - 6. York
- B. The University of Delaware prefers light duty heat pumps over light duty air conditioning with electric heat. The use of electric heat as a heat source must be approved by the University of Delaware prior to design.
- C. Product Description: Split system consisting of air handling unit and condensing unit including cabinet, evaporator fan, refrigerant cooling coil, compressor, refrigeration circuit, condenser, electric heating coil, air filters, air handling unit accessories, condensing unit accessories, and refrigeration specialties.
- D. AIR HANDLING UNIT – DX REFRIGERATION & ELECTRIC HEAT
 - 1. Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating element, controls, air filter, and accessories; wired for single power connection with control transformer.
 - 2. Configuration: Upflow, counterflow or horizontal air delivery as indicated on Drawings.
 - 3. Cabinet: Steel with baked enamel finish, easily removed and secured access-doors, glass fiber insulation and reflective liner.
 - 4. Supply Fan: Centrifugal type rubber-mounted with direct drive motor.
 - 5. Evaporator Coil: Constructed of copper tubes expanded onto aluminum fins. Factory leak tested under water. Removable, PVC construction, double-sloped drain pan with piping connections on both sides.
 - 6. Refrigeration System: Single refrigeration circuit controlled by factory installed thermal expansion valve.
 - 7. Electric Heater: Helix wound bare nichrome wire heating elements arranged in incremental stages of with porcelain insulators with single point electrical connection.

NOTE: USE ELECTRIC HEAT WHEN NO OTHER HEAT OR ENERGY SOURCE IS AVAILABLE.

8. Electric Heater Operating Controls:
 - o Low voltage adjustable room thermostat energized heater stages in sequence with pre-determined delay between heating stages.
 - o High limit temperature control de-energizes heating elements, automatic resets.
 - o Supply fan starts simultaneously with or after before electric elements are energized and continue operating until thermostat is satisfied or until outlet air temperature reaches minimum setting. Include manual switch for continuous fan operation.
 - o Outdoor thermostat locks out some heating elements until outdoor temperature drops.
 9. Air Filters: 1 inch thick glass fiber disposable media in metal frames. Furnish two sets of air filters
 10. Vibration Isolators: Neoprene-in-shear type.
- E. GAS FIRED FURNACES
1. AFUE of 96% or greater
 2. Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating element, controls, air filter and accessories; wired for single power connection with control transformer.
 3. Fuel: Natural gas fired
 4. Cabinet: Steel with baked enamel finish, easily removed and secured access panels with safety interlock switches for furnaces installed indoors, insulation. For downflow units, furnish base for combustible floors.
 5. Supply Fan: Centrifugal type rubber mounted with direct or belt drive.
 6. Motor: Direct drive; 1750 rpm variable speed, , permanently lubricated.
 7. Heat Exchanger: Aluminized steel crimped or welded construction Aluminized steel tubular type.
 8. Air Filters: 1 inch thick glass fiber disposable media in metal frames. Furnish two sets of air filters
 9. Vibration Isolators: Neoprene-in-shear.
- F. EVAPORATOR COIL UNITS
1. Evaporator Coil: Copper tube aluminum fin assembly, galvanized or polymeric drain pan, drain connection, refrigerant piping connections, thermostatic expansion valve, steel cabinet with baked enamel finish and insulation.
- G. CONDENSING UNITS
1. Compressor hermetic: resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Furnish time delay control to prevent short cycling and rapid speed changes.
 2. Refrigeration Accessories: Filter Drier, high-pressure switch (manual reset), low-pressure switch (automatic reset), filter-drier, sight glass, service valves and gage ports and thermometer well (in liquid line). Furnish thermostatic expansion valves. Furnish reversing valves on heat pump units.

3. Air Cooled Condenser: aluminum fin and copper tube coil, with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
 4. Low Ambient Kit: Furnish refrigerant pressure or temperature switch to cycle condenser fan motor on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.
 5. Minimum SEER rating of 16
 6. Condensing units must sit upon a prefabricated support approved by the University of Delaware.
- H. HUMIDIFIER (for use in Light Duty DX Split Systems Only)
1. Type: Self-contained steam.
- I. ELECTRONIC AIR CLEANERS (for use in Light Duty DX Split Systems Only)
1. Enameled steel assembly containing pre-filters, collecting cells and pre-wired power pack unit with on-off switch, test button, and integral air pressure switch. Provide optional wall mounted indicator showing 'on', 'wash', and 'check' functions.
- J. CONTROLS
1. Thermostat: Honeywell 8000 series only. Thermostat shall control all cooling, auxiliary heating and dehumidification/humidification functions.

PART 3- EXECUTION

- 3.1 INSTALLATION LIGHT DUTY SPLIT SYSTEM AIR CONDITIONING UNITS
- A. Mount air cooled condenser-compressor package on concrete pads or approved supporting devices.
 - B. Provide electrical interlock between condensing unit and air handling unit
 - C. Connect return air and supply duct to system ductwork with flexible duct connection.
- 3.2 CLEANING
- A. After construction is completed, including painting, clean exposed surfaces of units.
 - B. Vacuum clean coils and inside of cabinets.
 - C. Touch up marred or scratched surfaces of factory finished cabinets, using finish materials furnished by manufacturer.
 - D. Install temporary filters during construction period. Replace with permanent filters after Substantial Completion.
- 3.3 DEMONSTRATION AND TRAINING
- A. Demonstrate starting, maintenance, and operation of unit.
 - B. Demonstrate low ambient operation during winter testing or service specified above.

PART 4 - ATTACHMENTS

Sketches are included for clarity of content, not considered a final design product.

4.1 Attachment 1, "Condensing Unit Data Sheet"

4.2 Attachment 2, "Fan Coil Unit Data Sheet"

ATTACHMENT 1: CONDENSING UNIT DATA SHEET

Building Location/Room Number	
Equipment Type	
Equipment Tag Number	
Manufacturer	
Model Number	
Serial Number	
Service	
Attributes	Refrigerant Type
	Refrigerant Charge
	Unit Capacity in BTU's
	Amps
	Voltage
	Phase
	Heat Pump Y/N
Warrantee Exp. Date (mm/dd/yy)	
Warrantee Terms (months)	
Remarks	

ATTACHMENT 2: FAN COIL UNIT/FURNACE DATA SHEET

Building Location/Room Number	
Equipment Type	
Equipment Tag Number	
Manufacturer	
Model Number	
Serial Number	
Service	
Attributes	
Maximum Air Flow	
Filter Quantity and Size	
Cooling Coil Capacity in BTU's	
Heating Capacity in BTU's/KW	
Heat Source (Natural Gas/Electric)	
Amps	
Voltage	
Phase	
Warrantee Exp. Date (mm/dd/yy)	
Warrantee Terms (months)	
Remarks	

End of Section

