D-7 OUTLINE SPECIFICATION FOR CUSTOM AIR HANDLING UNITS

PART 1 GENERAL

This document provides performance requirements for a custom air handling unit for Colorado College only, and is not intended for use, in whole or in part, as a specification. The purpose of providing this information is to communicate overall site-specific information and technical requirements for the Consultants review prior to the design phase of any project. The Owner believes this information will enhance the overall design of any mechanical project for Colorado College by keeping design solutions both simple and effective for the operations of the campus. Do not copy this information verbatim in specifications or in notes on drawings. Refer questions and comments regarding the content and use of this document to the Colorado College Facilities Services Representative.

1.01 SECTION INCLUDES

A. Design, performance criteria, controls, and installation requirements for Custom Air Handling Units. Information contained in this document was based upon Governair specifications dated October 14th, 2004 and is to be used as a guideline for Colorado College. Information is provided for basis of discussion with Facilities Services when considering specifying this type of equipment.

1.02 REFERENCES

B. AMCA /ANSI Standard 204: Balance Quality and Vibration Levels for Fans
C. AMCA Standard 210: Laboratory Methods of Testing Fans for Ratings
D. AMCA Standard 300: Reverberant Room Method for Sound Testing of Fans
E. AMCA Standard 500: Test Methods for Louvers, Dampers and Shutters
F. ARI Standard 410: Forced-Circulation Air-Cooling and Air-Heating Coil
H. ASHRAE Standard 52: Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
J. ASME Section VIII: Unified Pressure Vessel Code
L. ASTM A-525: Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
1.03 SUBMITTALS

A. Submit shop drawings and product data in accordance with Division 1.

B. Submittals shall include the following:
   
   1. Dimensioned plan and elevation view drawings, including motor starter/VFD and control cabinets, required clearances, and location of all field connections.
   
   2. Summary of all auxiliary utility requirements such as: electricity, water, compressed air, etc. Summary shall indicate quality and quantity of each required utility.
   
   3. Ladder type schematic drawing of the power and ancillary utility field hookup requirements, indicating all items that are furnished.
   
   4. Manufacturer’s performance of each unit. Selection shall indicate, as a minimum, the following:
      
      a. Input data used for selection.
      
      b. Model number of the unit.
      
      c. Net capacity.
      
      d. Rated load amp draw.
      
      e. Noise levels produced by equipment.
      
      f. Fan curves.
      
      g. Approximate unit shipping weight.

1.04 OPERATION AND MAINTENANCE DATA

A. Include data on design, inspection and procedures related to preventative maintenance. Operation and Maintenance manuals (including parts lists) shall be submitted in pdf format and hard copy at the time of unit shipment.

1.05 QUALIFICATIONS

A. Manufacturer shall be a company specializing in the design and manufacture of commercial / industrial custom HVAC equipment. Manufacturer shall have been in production of custom HVAC equipment for a minimum of 10 years.

B. Each unit shall bear an ETL or UL label under UL Standard 1995 indicating the complete unit is listed as an assembly. ETL or UL listing of individual components, or control panels only, is not acceptable.

C. The Design Engineer shall determine, in advance, if other manufacturers meet the intent of this specification before specifying “equal” manufacturers in the specifications and/or drawings.
1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under the supervision of the owner. All equipment openings and exterior finish are required to be protected from the elements during shipping and storage of unit.

1.07 SEQUENCING AND SCHEDULING

A. Coordinate work performed under this section with work performed under the separate installation contract.

1.08 WARRANTY

A. The complete unit shall be covered by a parts warranty issued by the manufacturer covering the first year of operation. This warranty period shall start on the date at which the owner takes occupancy of the Building.

B. The installing contractor shall provide labor warranty during the unit’s same first year of operation.
PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Governair, Pace, Temtrol, Energy Labs.

2.02 GENERAL

A. Industrial / commercial quality equipment shall be furnished and installed. Units shall be completely factory assembled and tested. The equipment's cooling, heating, humidifying, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and maintenance manuals shall be furnished with each unit.

2.03 CABINET CONSTRUCTION

A. Cabinets shall be constructed in a watertight and airtight manner. The manufacturer's standard cabinet construction shall result in an ASHRAE/ANSI Standard 111-88 Leakage Class of less than nine (9) as measured in accordance with AMCA Standard 210-85. Unit serial numbers shall be permanently welded into the base frame.

B. The unit shall be constructed on a welded tubular steel frame. The tubing shall be cold formed carbon steel electric resistant welded square and rectangular type complying to ASTM A-500 Grade B. Minimum yield strength shall be 46,000 psi. The unit’s upper structural tubing frame shall form an integral structure when assembled with the wall panels thus greatly increasing the rigidity of the unit. Floors and walls shall be designed to deflect no more than 1/240 of span at unit operating pressures. The base frame shall have integral lifting lugs. The lifting lugs shall be fabricated from structural steel with an appropriate rigging hole. The lifting lug shall be fixed bolt down type. Lifting lugs shall be located and sized to allow rigging and handling of the unit and shall be removed from the unit after installation. Steel internal base frame cross-members shall be internally recessed so the perimeter base can overhang the roof curb in a self-flashing manner.
C. Units shipped in multiple sections shall be engineered for field assembly. Demount sealing gasket shall be required and provided. Internal lifting eyes shall be provided so that mating sections can be set together in their proper location by the crane without dragging or pushing them together. The mating upper frame of each section shall also be fabricated with a flanged perimeter. The flanged perimeter shall be drilled with assembly clearance holes and be continuously gasketed. Demount gasket supplied with the unit shall be a high quality weather resistant closed cell type. Assembly lugs, fabricated from structural steel with appropriate assembly clearance holes, shall be electrically welded to the base frame. All gasket and necessary assembly hardware shall ship loose with unit. Junction boxes with a factory supplied numbered terminal strip shall be supplied at each shipping split for reconnection of control wiring. Label all external devices, fan sections and piping on exterior of the unit using 1”X 3” white lettering on black plastic placards where appropriate.

D. Floors shall be screwed down and shall be fabricated of 16 gauge {14-gauge} \{10 gauge\} G-90 galvanized minimum sheet steel. All floors shall be turned-up 2” around the perimeter. All joints shall be sealed with an industrial gasket for water and air tightness. All floors shall be double-wall, 4” minimum. 

Option - Tack Welded Galvanized (Consult with Facilities Services)

Floors shall be tack welded and shall be fabricated of 14-gauge \{10-gauge\} G-90 galvanized minimum sheet steel. All floors shall be turned-up 2” around the perimeter. All joints shall be sealed with an industrial grade sealant for water and air tightness.

Option - Tack Welded Galvanized or Aluminum Tread Plate (Consult with Facilities Services)

Floors shall be tack welded and shall be fabricated of 3/16” OD treadplate minimum hot dipped galvanized sheet steel \{6061-T6 Aluminum\}. All welds shall be coated with cold galvanizing compound conforming to MIL-P46105. All joints shall be sealed with an industrial grade sealant for water and air tightness.

Option - Tack Welded Treadplate (Painted) (Consult with Facilities Services)

Floors shall be tack welded and shall be fabricated of 3/16” OD treadplate minimum sheet steel. All welds shall be coated with cold galvanizing compound conforming to MIL-P46105 weld through primer. All joints shall be sealed with an industrial grade sealant for water and air tightness. Floors shall be completely coated with 1.5 mils of corrosion resistant phenolic primer after fabrication and welding. This coating shall exhibit a pencil hardness of B. (See section on Corrosion Protection Systems for coating specification.)
Option - Full Welded Galvanized or Aluminum Treadplate (Consult with Facilities Services)

{Floors shall be fully welded and shall be fabricated of 3/16” OD hot dipped galvanized {6061-T6 aluminum} treadplate. All welds shall be coated with cold galvanizing compound conforming to MIL-P46105 weld through primer.

Option Full Welded Treadplate (Painted) (Consult with Facilities Services)

{Floors shall be fully welded and shall be fabricated of 3/16” OD treadplate minimum sheet steel. All welds shall be coated with cold galvanizing compound conforming to MIL-P46105 weld through primer. Floors shall be completely coated with 1.5 mils of corrosion resistant phenolic primer after fabrication and welding. This coating shall exhibit a pencil hardness of B. (See section on Corrosion Protection Systems for coating specification.)

Option Full Welded Galvanized (Consult with Facilities Services)

{Floors shall be fully welded and shall be fabricated of 16 gauge {14 gauge} {10 gauge} G-90 galvanized minimum sheet. All zinc coating thickness shall conform to ASTM A-527 for lock-former quality. All welds shall be coated with cold galvanizing compound conforming to MIL-P46105 weld through primer}

Option – Floor Drains

Only one floor drain should be required for each unit. Avoid placing drain lines above finished floor areas in traffic locations causing trip hazards. Coordinate the drainage of all coils and pans in advance to the proper side of each unit and indicate on the drawings.

E. All panels shall be of thermal break construction. All air tunnel panels shall be double wall and fabricated of 16 gauge galvanized sheet steel outer shell with a 20 gauge {16 gauge} solid {22 gauge perforated} galvanized sheet steel inner liner. The steel shall conform to ASTM A-527 for lock-former quality. Outer shell shall have a 5-step baked-on corrosion protection system applied. (See section on Corrosion Protection Systems for coating specification.) All panel corners will be internally caulked with sealant. Panels shall be sealed to the structural frame with an industrial gasket to form a water and airtight seal with the panel. Fasteners used to attach the panel will pass through into one side of the tube but not penetrate into the air tunnel. Panels shall not exceed 24" without a structural steel support member in at least one axis.

Option – Non-coated Outer Shell (Consult with Facilities Services)
All panels shall be of thermal break construction. All air tunnel panels shall be double wall and shall be fabricated of 16 gauge G-90 galvanized sheet steel outer shell with a 20 gauge 16 gauge solid 22 gauge perforated G-90 sheet steel inner liner. The steel shall conform to ASTM A-527 for lock-former quality. All panel corners will be internally caulked with sealant. Panels shall be sealed to the structural frame with an industrial gasket to form a water and airtight seal with the panel. Fasteners used to attach the panel shall be gasketed washer type and will pass through into one side of the tube but not penetrate into the air tunnel. Panels shall not exceed 24" without a structural steel support member in at least one axis.

Option – Double Wall Coated Liner for Corrosive Environments (Consult with Facilities Services)

All panels shall be of thermal break construction. All air tunnel panels shall be double wall and shall be fabricated of 16 gauge sheet steel outer shell with a 16 gauge sheet steel inner liner. The steel shall conform to ASTM A-527 for lock-former quality. Both shell and liner shall have a 5-step baked on corrosion protection system applied. (See section on Corrosion Protection Systems for coating specification.) All panel corners will be internally caulked with sealant. Panels shall be sealed to the structural frame with an industrial gasket to form a water and airtight seal with the panel. Fasteners used to attach the panel shall be gasketed washer type and will pass through into one side of the tube but not penetrate into the air tunnel. Panels shall not exceed 24" without a structural steel support member in at least one axis.

F. Option Double Wall Aluminum (Consult with Facilities Services)All panels shall be of thermal break construction. All air tunnel panels shall be double wall and panels shall be fabricated of textured 16-gauge .060 aluminum outer shell with an 18-gauge .050 aluminum inner liner. All sheet aluminum shall be Type 3003 with a minimum tensile strength of 17,000 psi. All panel corners will be internally caulked with sealant. Panels shall be sealed to the structural frame with an industrial gasket to form a water and airtight seal with the panel. Fasteners used to attach the panel shall be stainless steel gasketed washer type and will pass through into one side of the tube but not penetrate into the air tunnel. Panels shall not exceed 24" without a structural steel support member in at least one axis.

G. All exterior panels, roof and floor shall be insulated with 2" 4" with fiberglass insulation fill between the shell and liner. Insulation shall be Mylar faced behind perforated liners. Floors shall be insulated with a minimum of 4" of fiberglass insulation with a minimum R-value of 11. Insulation shall not exceed 25 flame spread, 50 fuel contribution, or 50 smoke generation when tested under ASTM E-84 and UL 723. The minimum R factor at 75°F shall be 4 per 1".
H. Durable access doors shall be provided for easy access to components. Access doors shall be double wall and completely insulated between the interior and exterior sheet metal of the door and attached to a 2” thick extruded aluminum frame that has an integral thermal break. Hinges shall be heavy duty {stainless steel} butt-type. High compression latches, operable from both sides of the door, shall be used. All access doors shall be gasketed around the complete perimeter. {All exterior doors shall have door tie backs.} {Door viewing windows shall be double-paned wire reinforced type and are required on every fan section door application. All windows shall be fabricated with an integral desiccant between the hermetically sealed panes.}

2.04 CORROSION PROTECTION SYSTEM

A. Coating adhesion shall comply with ASTM D-3359-B with no lifting of 1/8” squares of coating between scribe lines in cross hatch adhesion testing applied after a 2 x gauge reverse impact. No significant undercutting shall be exhibited on steel panels in a scribed condition after 1,000 hours in 5% salt spray testing at 95 °F and 95% relative humidity as per ASTM B-117. Gloss shall be 20-30% at 60 degrees. Film pencil hardness shall be in the F-H range. Film solvent resistance shall withstand 100 double rubs with MEK. Color shall be CES Sandstone {selected by architect}.

B. The base frame and upper structural frame {and non-galvanized floors} shall be completely coated with 1.5 mils of corrosion resistant phenolic primer after fabrication and welding. This coating shall exhibit a pencil hardness of B.

C. Exterior coated sheet metal shall be coated with a 5-step baked on coating system:

1. Galvanized zinc coating of G60 weight shall be applied as per ASTM A-525.

2. After galvanizing, the material shall be cleaned and immediately pretreated on both sides with Bonderite 1421 or approved equal.

3. The material shall then be immediately primed on with Morton 20Y128 epoxy primer applied at 0.15 to 0.26 mils on each side.

4. The primary finish coat shall be a baked on polyester coating equal to Morton Polyceram 3200 applied at 0.8 mils on the exterior exposed side and 0.3 mils on the reverse. The entire system shall be baked on for 25 seconds in a 650 °F oven. The peak metal temperature shall reach no less than 450 °F.

5. The final coat will be an air-dried acrylic modified alkyd coating.
2.05 FAN ASSEMBLIES

A. General: All fans shall meet the air flow performance specified and shall not exceed the break horsepower or sound power levels specified on the mechanical equipment schedule. Fan performance shall be based on testing and be in accordance with AMCA Standards 210 and 300. All fans shall have a steep pressure/volume curve. Completed isolated assemblies shall be dynamically balanced to category BU-2 for fan 5 hp or less and category BU-3 for fans greater than 5 hp as required by ANSI/AMCA Standard 204 in the horizontal, vertical and axial planes. Fan assemblies shall be designed for heavy-duty industrial applications. Fan framing assemblies shall be fabricated from structural steel. Formed members are not acceptable. This structural steel shall be electrically welded together to form a rigid integral base. Fan assemblies shall be independently isolated with spring-type vibration isolators. Inlet cones shall be precision spun or die formed. Inlet cones shall be aerodynamically matched to the wheel side plate to provide streamlined airflow in the wheel and ensure full loading of the blades. All fan access doors shall have one (1) latch which may or may not require a tool to open. Consult with Facilities Services.

B. Fans shall be single width airfoil centrifugal plenum type, designed for rugged industrial duty and suitable for continuous operation. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed (Consult with Facilities Services)

{Fans shall be airfoil or backwardly inclined centrifugal type, designed for rugged industrial duty and suitable for continuous operation. Fans shall be double width-double inlet as indicated on the fan equipment schedule. All housed fans that discharge internally to velocity sensitive components shall require discharge diffusers. The static pressure drop that the diffuser creates shall be incorporated into the static pressure analysis for the fan.}

C. The Mechanical Engineer is required to evaluate centrifugal vs. plug type plenum wheel type and make recommendations to the owner before specifying the fan type.

D. Fan shafts shall be solid AISI 1040 or 1045 steel. Shafts shall be turned, ground and polished to a minimum 16 micro-inch finish. Shafts shall be sized to run at a minimum of 20% greater than the maximum AMCA class speed.

E. Fan bearings shall be heavy-duty, pillow block, self aligning ball or roller type, and grease lubricated. Using AFBMA ratings, bearings shall be selected for a minimum L-10 life of 40,000 {200,000} hours. Both bearings shall have the same bore, type and manufacturer. At least one bearing shall be fixed. Both bearings being the floating type is not acceptable. Extended flexible lube lines shall be provided and extended to the drive side of the fan.
F. Sheaves and Belts: All sheaves shall be selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Drive belts shall be a V type. One variable pitched sheave shall be provided on motors from 1 to 15 horsepower. Fixed pitch sheaves shall be provided on motors larger than 15 horsepower. Where fixed sheaves are provided one sheave exchange shall be provided as required FOB the factory. Belts shall be oil and heat resistant. Owner prefers Direct Drive applications where possible and feasible. (Consult with Facilities Services)

G. Motors and Motor Bases: All motors shall be NEMA Class B insulation. Motors shall have electrical characteristics and horsepower as specified on the mechanical schedule. All motors shall have a minimum service factor of 1.15. Motors shall have ball bearings. Motors shall be open drip proof {TEFC} high efficiency and be designed for 1750 RPM for fan RPM’s less than 1800 RPM and 3550 RPM for fan RPM’s greater than 1800. Brake horsepower requirement of the fans shall not exceed 90% of the motor horsepower. The motor shall be located within the unit and mounted on an adjustable heavy steel base. The motor base shall be fastened securely to the structural steel framing of the fan assembly. This entire assembly shall have vibration isolators. Owner prefers Premium Grade Motors. (Consult with Facilities Services)

H. Fan unloading devices.

Option–VariCone(27"- 49"plenum fans)(Consult with Facilities Services)

{Plenum fan variable volume control shall be provided by a VariCone™ internal cone unloading system. The system shall provide stepless variable volume fan control from full flow to shut off. The system shall consist of a precision spun steel cone which rides on a stationary stainless steel sleeve over the fan shaft. Modulation of the cone position shall reduce the effective wheel width. Cone design shall not interfere with the fan inlet design by extending inlet cone length or causing sharp edge transition into the blades.}

Option Inlet Vanes (Consult with Facilities Services)

{Variable volume controls shall be provided with inlet vanes where indicated on the fan schedule. Inlet vane blades shall be supported between two permanently lubricated bearings. Cantilevered blades are not acceptable.}

Option – VFDs (Consult with Facilities Services)
{Each variable air volume supply and return fan shall be provided with separate variable frequency drives. Drives shall be factory mounted with adequate ventilation provided. The variable frequency drive shall convert 460 volt +/- 10%, three phase, 60 hertz (+/- 2 Hz.) utility power to adjustable voltage/frequency, three phase, A-C power stepless motor control from 5% to 105% of base speed. The variable frequency drive (VFD) shall produce an adjustable A-C voltage/frequency output of complete motor speed control and an input power factor near unity over the entire speed range. The VFD shall be automatically controlled by an control signal. The VFD shall be self contained, totally enclosed in a NEMA 1 ventilated cabinet and capable of operation between 0 and 40 ° Celsius. The VFD shall be UL listed. Components used in all options shall be UL listed. The VFD shall have a hand/off/auto operator switch, drive switch with run or stop command and panel mounted digital display capable of indicating unit status, frequency, and fault diagnostics.}

2.06 VIBRATION ISOLATION (CONSULT WITH FACILITIES SERVICES)

A. Fan assemblies shall be supplied with spring isolators in at least four appropriate points. Fan assemblies shall be supplied with seismic isolators. Springs shall be bolted securely to the fan assembly. Spring deflection shall be designed for one (1) inch deflection {two (2) inch deflection}.

Option - Inertia Bases Consult with Facilities Services

{All fan assemblies are to be supplied with inertia base assemblies. The inertia bases shall be designed for heavy industrial application. Bases shall be filled with concrete by the installing contractor after the units are set in place. Base weight when filled to specified level will, at minimum, equal the fan wheel weight. The base is to be constructed from structural steel. Formed members are not acceptable. Inertia base floor shall be no less than 16 gauge steel welded to the structural steel channel perimeter base. Structural steel angles shall be welded in appropriate locations and mounted on spring vibration isolators.}

B. Thrust restraints shall be supplied on all fans which will travel horizontally more than ¼” when in operation. Isolators shall be sized and adjusted so that the assembly floats when operating at design conditions.
2.07 COILS

A. All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Cooling coils shall be mounted in the unit for horizontal air flow. Coil air face velocities shall not exceed the specified velocities of the mechanical schedule. Coils shall be supported off the floor structure and mounted to air seal wall structure with high strength 0.25" bolts, lock washers and nuts. Air seal joints shall be completely sealed with industrial gasket.

B. All hydronic coils shall be tested to 350 psig compressed air under water. Coils shall be designed to operate at 250 psig internal pressure and up to 300 °F. Internal tubes shall be round seamless 1/2", 0.017" {0.025} or 5/8", 0.020" {0.025}" {0.035"} {0.040"} wall copper tubes} which have been deoxidized by the addition of phosphorous. Coil casings shall be constructed of a minimum of 16 gauge continuous galvanized {type 304 stainless} steel. Coil casing reinforcements shall be required for fin lengths over 42". Coil fins shall be plate type, die-formed ripple edge corrugated 0.006" {0.008 for 5/8" tubes} aluminum with guide channels to create turbulent wiping behind the tubes with collars drawn and belled. Internal copper tubes shall be staggered in direction of air flow. The copper circuiting tubes shall be mechanically expanded to the aluminum {phenolic dip aluminum} {copper} fins. The fin spacing shall be as shown on the schedule. All hydronic coils shall be drainable with a 0.25" F.P.T. plugged drain or vent tap on the supply and return headers. Seamless copper tubes shall be brazed to the copper supply and return headers.

C. Cooling coil sections shall have a pitched drain pan constructed from 16 gauge galvanized steel with mastic coating {16 gauge type 304 stainless steel}. All corners shall be welded watertight. Drain pan is to be a minimum of 2" deep with a minimum pitch of 1" from high point to the drain outlet connection. Coil condensate drain pan shall be completely insulated. If coils are stacked, a sloped intermediate drain pan with recessed drain connection is required. This intermediate pan shall drain to the bottom main pan. Intermediate drain tubes shall be copper. Plastic drain pans and plastic lines shall not be acceptable. The coil main pan shall have a 1-1/4" M.P.T. drain extended to the exterior of the air handler.
2.08 FILTERS

A. Filter holding frames shall be of heavy duty construction designed for industrial applications. Holding frames applied in low efficiency filter applications will be either upstream or downstream accessible. Holding frames applied in high efficiency filter applications will be upstream accessible. Holding frames shall be constructed from no less than 18 gauge galvanized steel. They shall be equipped with foam gaskets and fasteners. Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. Holding frame assemblies shall meet or exceed area specified by the mechanical schedule.

B. Option Flat Racks (Consult with Facilities Services)

{Flat filter racks shall be completely factory assembled and designed for industrial applications. Filter racks shall be fabricated from no less than 16 gauge galvanized steel. Filter racks shall be applied in low efficiency filter applications and will be either upstream or side accessible. Side accessible filter racks shall have an oversized access door on the exterior of the air handler, centered on the filter rack for easy filter removal. Upstream access filter racks shall have one central access cover per row of filters centered in the unit for easy access. Filter racks over 72" in length shall require an angle center reinforcement support. Filter racks shall be designed for a maximum of 500 f.p.m., or meet or exceed the area specified in the mechanical schedule.}

Option – Angle Racks (Consult with Facilities Services)

{Angle filter racks shall be completely factory assembled and designed for industrial applications. Angle racks shall be fabricated from no less than 16 gauge galvanized steel. Angle racks shall be applied in low efficiency filter applications, and will be upstream accessible. Upstream access filter racks shall have one central access cover per row of filters, centered in the unit for easy access. Filter racks shall be designed for a maximum of 500 fpm or meet or exceed the area specified by the mechanical schedule.}

Option Medium Efficiency Pleated Filters

{Pleated filters shall be 4” thick, 65% efficient. Filter media shall be 100% synthetic. The filter shall have an average efficiency of 65% and an average arrestance of 90-92%. The filters shall be listed as Class II under UL Standard 900. Filters shall be tested per ASHRAE Standard 52-76.}

Filters shall be listed Class II under UL Standard 900 and tested per ASHRAE Standard 52.1-1996.}

Option – High Efficiency Bag Filters (Consult with Facilities Services)

{Bag filters shall be a high performance extended area disposable type. Each filter shall consist of high density glass fibers, reinforced to form a lofted filter
blanket. Filters shall be furnished with individual dust holding compartments and a corrosion resistant galvanized steel enclosing frame. Dust holding compartments shall consist of glass fibers bonded to a reinforced backing. The configuration of the dust holding compartments shall be controlled by means of progressive link stitching. The stitching shall be such that it forms a supported compartment resulting in uniform velocities in the passages of the entering air and exit air side of the filter. The dust holding compartment shall be equipped with a minimum of 48 support points per square foot of the filter media. All stitching points shall be sealed with a hot melt adhesive or equivalent. The dust holding compartment shall be equipped with a galvanized entry faceplate which becomes an integral part of the enclosing frame. The filter unit shall be completely factory assembled and shall be classified by UL as Class II under UL Standard 900. The filter efficiency shall be \{65\%\} \{85\%\} \{95\%\} meeting the efficiency specified by the mechanical schedule. The filter efficiency and arrestance shall be in accordance with ASHRAE Standard 52.1-1996.

Option – High Efficiency Rigid Filters (Consult with Facilities Services)

{Rigid filters shall be 12" deep high performance, pleated, totally rigid and totally disposable type. Each filter shall consist of high density glass fiber media, media support grid, contour stabilizers and enclosing frame. Filter media shall be laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of 65\% \{85\%\} \{95\%\}. The media support shall be a metal grid with an effective open area of not less than 96\%. The metal grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull-away. The metal grid shall be formed in such a manner that it effects a tapered radial pleat design. The grid shall be designed to support the media both vertically and horizontally. Filters shall be listed Class II under UL Standard 900. Filters shall be tested per ASHRAE Standard 52.1-76. Contour stabilizers shall be permanently installed on both entering air and exit air sides of the filter media pack to ensure that the tapered radial pleat configuration is maintained throughout the life of the filter. The filter shall be capable of withstanding a 10" wg pressure drop without noticeable distortion of the media pack. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is effected. The periphery of the filter pack shall be continuously bonded to the inside of the enclosing frame, thus eliminating the possibility of air bypass. The enclosing frame shall be equipped with protective diagonal support members on both the entering air and air exit sides of the filters.}

Option – HEPA Filters (Consult with Facilities Services)

{HEPA filters shall meet or exceed \{99.97\%\} \{99.999\%\} efficiency on 0.3 micron particles when tested with thermally generated D.O.P. in accordance
with the latest industry and military standards. The clean static pressure shall be no greater than 1.0" wg when operated at rated airflow. The media shall be glass paper. Filters shall be factory constructed and assembled of presssed wood frames, corrugated aluminum separators and 100% solid resin sealant. Holding frames shall be upstream accessible and shall be designed for use with HEPA filters.

Option – Magnehelic™ Gauge

{A differential pressure gauge for measuring the pressure drop across each filter bank shall be installed. The gauge shall be diaphragm-actuated digital readout type.

2.09 DAMPERS (CONSULT WITH FACILITIES SERVICES)

Galvanized Low-Leak Dampers: Galvanized dampers shall be heavy duty construction designed for industrial applications and is normally not the preferred damper type at Colorado College. Blades shall be parallel blade type, in either horizontal or vertical arraigngment as required when blending two adjacent damper air streams. All other dampers shall be opposed blade type. The frame shall be fabricated from 16 gauge galvanized steel formed "C" channel. Side framing shall have extruded bearing holes to decrease wear and allow smooth rotation of the blade shaft bearing. Blade end seals shall be spring type tempered stainless steel. Damper linkage shall be concealed in the frame out of the air stream for reduced air turbulence. The linkage shall ride on self lubricated delrin type bearings contained within the quadrant clamp. Blades shall be fabricated from no less than 16 gauge galvanized steel. Blades shall utilize the triple-V-groove design, and be furnished with a low-leak blade edge seal. Drive shafts shall be square to insure proper alignment and positive locking connection between the blade, axle and linkage. Round drive shafts are unacceptable. Dampers shall be tested by an independent AMCA approved laboratory for leakage and air pressure drop in accordance with AMCA Standard 500. Testing reports shall be supplied with the submittal data. Leakage shall not exceed 4.6 CFM per square foot at 4" wg. Pressure drop shall not exceed 0.15" wg at 1000 fpm. Dampers blades shall be rated for a velocity of 1500 fpm without generating objectionable noise.

B. Aluminum airfoil low-leakage dampers shall be heavy duty construction for industrial application and is the preferred type of damper material. Blades
shall be parallel blade type, in either horizontal or vertical arrangement as required when blending two adjacent damper air streams. All other dampers shall be opposed blade type. The frame shall be fabricated from 16 gauge galvanized steel formed "C" channel. Side framing shall have extruded bearing holes which decrease wear and allow smooth rotation of the blade shaft bearing. Vertical damper blades shall be suspended so that the weight of the blade rides on the top bearing. Blades must be suspended so that blades are centered and bottom edge blade seals are not unduly compressed. Blade end seals shall be spring type tempered stainless steel. Damper linkage shall be concealed in the frame, out of the air stream, for reduced air turbulence. Low operating torque linkage rides on self lubricated delrin type bearings contained within the quadrant clamp. Rigid, low maintenance blades shall be fabricated from 6063-T6 heavy gauge extruded aluminum. Blades shall be airfoil in shape for smooth air passage. Extruded Santoprene low-leak blade edge blade seals shall be installed on each blade. Vinyl or PVC type extruded seals are unacceptable. Blade seals shall be locked in extruded blade slots without the use of cement. Drive shafts shall be square to ensure proper alignment and positive locking connection between the blade, axle and linkage. Round drive shafts are unacceptable. Dampers shall be tested by an independent AMCA approved laboratory for leakage and air pressure drop in accordance with AMCA Standard 500. Leakage shall not exceed 4.2 CFM per square foot at 4" wg. Pressure drop shall not exceed 15" wg at 1000 feet per minute. Damper shall be rated for a maximum velocity of 4000 fpm without generating objectionable noise. Use opposed blade type damper in applications where varying amounts of air quantities are required. Use parallel blade type where directional flow of air introduced into the mixing plenum is of major concern.

2.10 ROOF HOODS / LOUVERS (Consult with Facilities Services)

Outside and exhaust air rainhoods shall be a heavy duty construction. Hoods are to be fabricated from a minimum of 16 gauge galvanized steel {16 gauge aluminum}. All sheet steel shall be continuously hot dipped coated with a durable protective coating of zinc. The steel shall conform to ASTM A-527 for lock-former quality. Rain hoods shall extend past the entire opening perimeter by at least 1". Rainhood shall be furnished with a 1" rain gutter on the perimeter edge. A 1/2" wire mesh bird-screen shall be furnished with each hood.

Intake roof hoods should be sized not to exceed 250 FPM.

2.13 HUMIDIFIER (CONSULT WITH FACILITIES SERVICES)

A. Steam humidifier shall be a steam separator type providing full separation ahead of a control valve which discharges through an internal drying chamber.
Steam humidifier shall be electrically controlled. The humidifier capacity shall meet or exceed the capacity specified in the mechanical schedule. The size and number of distribution manifolds shall be sized so all steam is absorbed by the air before reaching the next component in the air stream. Humidifier shall receive steam at supply pressure and discharge at atmospheric pressure. Humidifier shall be furnished with inlet strainer and float and thermostatic traps or a bucket steam trap. Separating chambers shall be of a volume and design that will disengage and remove water droplets and particle matter when the humidifier is operating. The distribution manifold shall provide uniform distribution over its entire length and be jacketed by steam to assure that vapor discharged is free of water droplets. Humidifier shall be completely factory piped \{wired\}. Traps shall be shipped loose to avoid damage during shipment. All humidifiers shall be mounted above a pitched drain pan constructed from 16 gauge galvanized steel with mastic coating \{16 gauge type 304 stainless steel\}

2.16 ELECTRICAL POWER AND CONTROLS (CONSULT FACILITIES SERVICES)

A. General: Units shall be provided with temperature controls. Room thermostats shall be mounted and wired by the electrical contractor. Steam, hot water or chilled water valves shall be installed by the contractor as shown on the plans, and wired by the electrical contractor. The control system shall include all safety and operating controls required to meet the equipment’s ETL or UL listing and the requirements of UL 1995. Controls to include branch and sub-circuit fusing, contactors, relays and pressure controls. Panel to be constructed to NEMA 3R requirements and will have hinged access panels.

B. Motor Starters: Furnish solid state or electromechanical starters for all auxiliary electric motors required. Contactors for electromechanical starters shall be UL recognized for air conditioning and refrigeration (definite purpose) use and rated in voltage, continuous rated load amperes (RLA) and locked rotor amperes (LRA). The rating shall be equal to or greater than the requirements specified on the compressor motor nameplate.

C. Provide a non-fused disconnect of the proper amp rating in the starter cabinet. Starter shall be furnished with special terminals and internal wiring as required to accommodate controls and power wiring. Starter shall include overload protection devices in each of 3 phases.

D. Provide copper wires, bus bars, and fittings throughout, except internal wire of the control transformer may be aluminum, if copper termination is provided. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating.

E. Mount a permanent nameplate on the unit to display the manufacturer, serial number, model number, date of manufacture, and current and voltage readings and ETL or UL Listing.
F. Provide permanent schematic and connection wiring diagrams indicating exactly how the starter was manufactured and wired including the wire terminal numbers

G. Option – Smoke Detector (Consult with Facilities Services)
   {Smoke Detector: Factory mounted and wired reset ionization type smoke detector{ }located in return air stream {and discharge air stream} will be provided.}

H. Option – Freeze Stat (Consult with Facilities Services)
   {Freeze stat: The manual reset freeze stat located in downstream side of the cooling coil, shall de-energize the unit and close outdoor air dampers if the set point is reached.}

I. Option – Vapor Proof Service Lights (Required at all sections)
   {Vapor Proof Service Lights: Each section shall be equipped with a vapor-proof 100 watt {80 watt vaporproof fluorescent light} service light. All lights, switches and outlets shall be wired to a disconnect for a separate 120 volt external source. {Lights, switches and outlets shall be wired through a transformer and external light disconnect. Lights shall be wired to remain functional whether the main power disconnect is in the on or off position}.}

J. Electric/Electronic Actuators: The actuators for modulating service are direct-coupled electronic type. The actuators for the outside air and exhaust air are spring return type. The input signal is 0-10 vDC and power requirements are 24 vAC. (Consult with Facilities Services)

K. Pneumatic Actuators: The pneumatic piston actuator is used to operate ventilating dampers in response to the output signals of a pneumatic controller. The actuator will be connected by utilizing an adjustable shaft connected to swivel connections on each end of the shaft. The actuator will be sized larger than the required load. The actuator is available with a positive positioner. (Consult with Facilities Services)

L. The unit shall be provided with a Direct Digital Control system, including provisions for remote start/stop and set-point reset. Local display of all set-points and other user adjustable parameters will be provided. All safety controls shall be manual reset. (Consult with Facilities Services)

Each unit shall be furnished complete with all operational controls. All controls shall be factory installed and wired except for room thermostat which shall be field installed by the temperature control subcontractor. The control system shall be a DDC control system consisting of space control and economizer control. (Consult with Facilities Services)

{Economizer control shall include modulating, spring return, damper motors.} The damper motor shall open to the minimum position whenever the supply air fan is on during the Occupied Cycle. Discharge air sensor shall
modulate outdoor air and return air dampers to maintain desired setpoint. Outdoor air high limit shall return outside air damper to its minimum position when its setpoint is reached. In order to optimize the conservation of energy, the economizer cycle shall allow only enough outside air in the cooling cycle to satisfy the space temperature during the period of mild ambient conditions. (Consult with Facilities Services)

Option - Variable Air Volume Building Pressure Control (Consult with Facilities Services)

{The unit shall have factory mounted and wired VariCone™ and modulating electric damper motor for supply fan and VariCone™ with slave modulating electric motor for return fan. The static pressure controller, with static pressure sensor mounted shall modulate supply fan VariCone™ to maintain desired system static pressure. Secondary static pressure controller, with static pressure sensor located within the space, shall modulate return fan inlet vanes VariCone™ to maintain slightly positive space pressure. Static pressure high limit control shall de-energize supply and return fans should a high static pressure condition exist in the main supply air duct. Remote static pressure sensors shall be mounted by temperature control subcontractor.}

Option – Discharge Air Temperature Reset (Consult with Facilities Services)

{The discharge air temperature setpoint shall be capable of reset from outdoor temperature via the master control sequencer.}

Option - Morning Warm-up Control (Consult with Facilities Services)

{Factory provided morning warm-up thermostat located in return air stream to close outside air damper and open return air damper during morning warm-up cycle only will be provided.}

Option Night Stat (Consult with Facilities Services)

{Factory provided night stat (bulb located in RA or room type located in space) to close outside air damper and open return air damper during unoccupied mode. Night stat will be mounted and wired by the electrical subcontractor.}

2.16 UNIT TESTING AND QUALITY CONTROL

Standard Factory Tests: The fans shall be factory run tested to ensure structural integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass quality control and be thoroughly cleaned prior to shipment.

Option Cabinet Leak Testing (Required)
The cabinet shall be tested at the unit's design operating static pressures for both the high and low pressure sides. Cabinet leakage shall not exceed a Leakage Class rating of 9 as defined by ANSI/ASHRAE Standard 111. Leak testing shall be performed by measuring the airflow pumped into (or out of) the unit at the cabinet design operating static pressure. All supply and return air openings shall be sealed along with the air seal at the supply fan to isolate the high and low side of the unit. The air shall then be pumped into (or out of) the unit until the appropriate operating pressures are achieved. Air flow measurements shall be performed in compliance with AMCA Standard 210. The testing shall be performed at the factory {and witnessed by the owner's representatives}. A detailed report, including all data and test methods, shall be presented to the owner or his representative prior to equipment shipment.

Option Fan Vibration Testing (Consult with Facilities Services)

Fan wheel and shaft assemblies shall be dynamically analyzed after the fan, motor and drive assemblies have been installed in the unit. The fan is analyzed with an electronic balance analyzer with a tunable filter. Vibration measurements are taken on each bearing housing in the horizontal, vertical, and axial positions with the filter tuned to the fan RPM. The testing shall be performed at the factory {and witnessed by the owners representatives}. A detailed report, including all data and test methods, shall be presented to the owner or his representative prior to equipment shipment.

Option Sound Testing (Consult with Facilities Services)

The equipment manufacturer shall furnish calculations showing the estimated sound power levels at the supply and, return connections, as well as unit casing radiation for each air conditioning unit. Calculations shall be based on fan sound power levels which were determined in accordance with AMCA Standard 300 and 301. Sound power levels shall be determined for each octave band and shall not exceed the following:

| OCTAVE BAND SOUND POWER LEVEL, dB Re: 10^{12} WATTS |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|
| FREQ.      | 63       | 125      | 250      | 500      | 1000     | 2000     | 4000     | 8000     |

| AHU -x     |          |          |          |          |          |          |          |
| SUPPLY OUTLET | XX | XX | XX | XX | XX | XX | XX | XX |
| RETURN INLET | XX | XX | XX | XX | XX | XX | XX | XX |

| AHU -n     |          |          |          |          |          |          |          |
| SUPPLY OUTLET | XX | XX | XX | XX | XX | XX | XX | XX |
| RETURN INLET | XX | XX | XX | XX | XX | XX | XX | XX |

(Sound power values must be determined for each application)

In addition to the sound power level data included in the submittals, the manufacturer will perform a sound test for each representative testable size unit. Testable size units
shall be defined as units of less than 60,000 CFM that are less than 16 ft. wide and less than 65 ft. long. The tests will verify for each size unit that the inlet and outlet sound power levels do not exceed the specified levels - in the first five octave bands 63 through 8000 - by more than is allowed by AMCA 311. The manufacturer shall do whatever is necessary to achieve the specified levels at no additional cost to the owner. A detailed report, including all data and test methods, shall be presented to the owner or his representative(s) prior to equipment shipment.

Sound power shall be determined by the reverberation room method in an AMCA accredited laboratory as outlined in AMCA Standard 300-85. All sound pressure values shall be included in the final report, including Ambient, Reference Sound Source and measured values. Complete information showing the qualifications of the room shall be included.

Option Air Flow Testing (Consult with Facilities Services)

{On equipment less than 60,000 CFM, smaller than 65 feet long, 16 feet wide and 16 feet tall, and with a linear air flow path, the unit air flow performance shall be measured using the methods outlined in AMCA Standard 210. The testing shall be performed at the factory and witnessed by the owner’s representative(s).}

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in strict accordance with manufacturer’s requirements, shop drawings, and Contract Documents.
B. Adjust in alignment on concrete foundations, sole plates or other supporting structure. Level, grout, and bolt in place.

C. Furnish and install necessary auxiliary water piping for makeup and drain of the evaporative condensers as required.

D. Coordinate electrical installation with electrical contractor.

E. Coordinate controls with control contractor.

F. Provide all appurtenances required to ensure a fully operational and functional system.

3.02 START-UP

A. Factory Start-Up Services: Start-up is to be supervised by the unit manufacturer or a manufacturer certified service organization. Physical connections and start-up are provided by the installing contractor. Start-up services shall be provided for as long a period of time as is necessary to ensure proper operation of the unit. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. The start-up engineer shall submit a written report to the owner and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.

B. Operation and Maintenance Manuals: Manual shall be provided complete with descriptive literature, model, and serial number of all equipment, performance data, manufacturer’s instructions for operating and maintenance, lubrication recommendation and schedule, and winter shutdown procedure.