Heating, Ventilation, and Air Conditioning

I. Heating, Ventilation, and Air-Conditioning (HVAC)

A. General

1. The purpose of this document is to standardize the basic elements of the HVAC system design process. This design standard has the purpose of creating a consistent application of HVAC system design throughout the Amtrak Facilities, therefore achieving a standard of quality for maintenance, energy efficiency, and reliability throughout all renovation and new building projects, as they are a long-term investment for Amtrak.
2. HVAC systems shall provide a safe, comfortable, and healthy environment for facility occupants while being energy efficient and inexpensive to maintain over the life of the building. Service life, energy efficiency, indoor air quality, comfort, maintenance cost, and flexibility are major considerations to be accounted for in the design of the HVAC system.
3. Design of Amtrak's original facilities date back as early as the 1900's. For current renovation and new building projects, the HVAC system and its controls are expected to reflect a forward-thinking, contemporary design philosophy and aesthetic rather than emulating existing technology from the mid-20th Century.

B. Preparation of Calculations

1. Utilize the following design conditions to the Local ASHRAE Climatic data 99.9%
   a. Indoor office areas and public spaces:
      i. Summer: 72 - 76°F , max humidity 60% rH
      ii. Winter: 68 - 72°F
   b. Shops, indoor maintenance and inspection facilities:
      i. Summer max: 90°F or 10 degrees above ambient temperature
      ii. Winter min: 60°F
   c. Storerooms, electrical/mechanical equipment rooms and other non-occupied spaces other than computer rooms and telephone equipment rooms, using thermostatically controlled exhaust fans if needed:
      i. Summer max: 90°F or 10 degrees above ambient temperature
      ii. Winter min: 50°F
   d. Server rooms, MPOE, MDF and IDF spaces:
      i. Max: 85°F
      ii. Min: 50°F, max humidity: 95% non-condensing
2. Lighting Load Calculations:
   a. Lighting loads shall be calculated at Local Code Watt per square foot values during preliminary design. Engineers shall execute final calculations upon selection of final lighting fixture selections.
3. Equipment Load Calculations:
   a. Equipment loads are variable and should be based on actual equipment to be installed in each location, or 1.5 watts per sq ft, whichever is greater. Apply diversity factors so as not to oversize central HVAC systems.

4. U-Values for Walls and Roofs:
   a. Loads shall be calculated at building code minimum allowances during preliminary design. Engineers shall execute final calculations upon selection of final building façade materials.
5. U-Values for Solar Heat gain Factors for Windows:
   a. Loads shall be calculated at ASHRAE allowances during preliminary design. Engineers shall execute final. Calculations upon selection of final building façade materials. Internal shading shall not be used to reduce the load calculated. Fixed exterior shading shall be allowed to reduce calculated cooling load.
6. Cooling system spare capacity:
   a. 10% of total load
7. Fan system spare capacity
   a. 15% of total airflow
8. Heating system spare capacity:
   a. 25% of total load
9. All calculations shall be completed utilizing DOE approved calculation software.
10. Pipe sizing calculations:
    a. Design based on ASHRAE guidelines
11. Duct sizing calculations:
    a. equal friction method - 0.1”/100’ for main ductwork (never exceed 2,000 feet per minute); 0.08”/100’ for low pressure branch ductwork (never exceed 800 feet per minute). Lower velocities may be needed for acoustical purposes.
12. Return Air Systems
    a. Return air ducts shall be sized on the equal friction method at 0.08”/100’ (never exceed 1,500 feet per minute). Design plenum return air systems for low pressure drops. Design transfer air systems at 250 feet per minute to minimize pressure drop at grille faces, and at 500 fpm at open air spaces across the net free area. For multiple, cascading transfer openings the total pressure drop shall not exceed the allowable pressure drop for an individual opening.
13. Acoustical and Vibration Calculations:
    a. Acoustical calculations shall be completed by a professional specializing in the science of sound transmission, acoustics, and vibration.
    b. Design shall conform to ASHRAE Chapter “Sound and Vibration Control”, latest edition.
14. Outside Air Make-up and Ventilation
    a. Utilize ASHRAE Standard 62, latest edition, to determine outside air ventilation flow rates. Indicate quantities of minimum outside air on all equipment schedules.
    b. Outside air for ventilation and make-up shall be brought from a fresh source of air. Outside air openings and operable building systems shall be at least 18” above adjacent surfaces and located at a minimum of 15’-0” from any permanent or temporary points of exhaust air. Or combustion.

c. Designers must allow adequate space for proper design of outside air and return air mixing. This includes space required for air blending devices that should be employed to prevent stratification where ideal mixing cannot be accomplished with ducting arrangement alone. Packaged mixing boxes from AHU manufacturers do not provide adequate mixing on their own. The importance of this criteria cannot be overemphasized since cold air stratification is a leading cause of frozen coils and nuisance low-limit freeze protection trips. The preferred method is to connect outside air and return ducts together prior to the AHU so mixing occurs in the mixed air duct prior to the AHU.

d. Design outside air intakes to eliminate the possibility of water carry over. Always utilize drainable weatherproof type louvers at intakes.

e. Units shall be equipped with a fully modulating 100% OA economizer and with a separate minimum OA intake system for guaranteeing proper levels of OA intake through all ranges of system operation.

f. Provide CO2 monitoring to accommodate demand-based ventilation to reduce energy use. Monitors shall be connected to the BMS. Consider for large occupancy areas such as:

i. Lunchrooms

ii. Large conference rooms, above 25 people

g. Determine if natural ventilation can be utilized for comfort cooling either by itself or as part of a mixed-mode system. Prior to locating intakes, consider:

i. pollution sources

ii. acoustical interferences

iii. security

iv. airflow patterns via CFD modeling

C. Ventilation During Construction

1. In order to improve indoor air quality, specify building flush-out during and after interior finish work. The ventilation system should be operational after drywall installation (but turned off during operations which generate high amounts of dust) and during painting, carpet, and furniture installation. The HVAC system must operate continuously, providing the maximum amount of outdoor air. The building shall continue to be flushed out for a period of not less than 30 days prior to occupancy. To the extent possible, all installations resulting in substantial generation of VOC's should be completed before this time frame.
2. The return inlets must be protected with filtration of sufficient efficiency so as not to contaminate the air distribution system. If continuous flush out is not possible, then temporary ventilation shall be provided to areas with high-VOC activities.
3. If temporary ventilation is not practical, then four days of continuous flush out shall be required after wet product application such as paints and caulks, and before the HVAC system is temporarily turned off for testing. Brief interruptions of a few hours would be acceptable in emergencies during the third or fourth day. The flush-out schedule shall be extended to compensate for delayed VOC-producing installations. HVAC systems must be reset to maximum OA after hours and when no testing is occurring.
4. The cost of power, equipment maintenance, etc. during this flush out shall be the contractor's responsibility. Following the completion of the minimum 30-day purge and prior to occupancy, the HVAC systems shall be returned to like new condition, filters replaced with new, and the contractual warranty period shall not be adversely affected.

D. Equipment Selection and Design Considerations

1. Specify system types based on:
   a. Lifecycle cost analysis to include first cost, operating cost, maintenance cost, and energy cost
   b. Reliability
   c. Temperature control
   d. Noise level
   e. System complexity appropriate to maintenance capacity
   f. Service life
   g. Susceptibility to vandalism and theft

E. General Requirements, Siting, Service Access

1. Provide an integrated design so that each element of the building is carefully considered. Produce a holistic solution.
2. Utilize shading, landscape, canopies, blinds, building thermal mass, etc. to reduce heating and cooling loads and minimize equipment sizes.
3. Locate equipment indoors wherever possible. Where it is not possible due to cost constraints, aesthetics or other hardship, equipment may be located outdoors obstructed from view and architecturally shielded.
4. Rooftop equipment:
   a. Rooftop equipment may attract birds that nest in/around the units, and damage insulation by using pieces to build nests. Designers who specify the installation or repair of rooftop equipment shall also specify the installation of enclosures to protect new and existing piping, motors, etc. from bird infiltration. Specify wire cages, solid metal, or any other material that will withstand the weather, moisture, etc.
   b. Specify hail guards to protect coils.
   c. Specify roofing system walk pads around units.
   d. Specify PVC condensate drains, to prevent copper theft.
5. Provide service disconnect switches immediately adjacent to units.
6. Provide elbow cleanouts at condensate drains, and a union between unit and inlet of trap.
7. Coils shall be designed with adequate service access for maintenance and replacement.
8. Ensure safe and reasonable service access. Provide labeling for ease of access in concealed conditions. This includes HVAC equipment concealed within suspended ceilings, hard lid ceilings, and other hidden conditions, and applies to any equipment requiring service access for maintenance or testing annually or more frequently (e.g., fire/smoke dampers). Conform to equipment manufacturers guidelines for recommended access.
9. Fans:
   a. Fans shall be selected on a stable point of operation of the fan curve. Fan selection shall be based on methods in the ASHRAE Handbook, most recent edition.
   b. Select fan sound and pressure levels to assure quiet operation per Local acoustical design requirements.

c. Provide explosion proof systems with appropriate coatings to prevent chemical action on fan and housing. Discharge shall be marked as hazardous and in a suitable location.

10. Cooling Coils

a. Design direct expansion and chilled water coils on basis of a nominal 400- 500 foot per minute face velocity. Design heating water coils on basis of a nominal 600 foot per minute face velocity.

b. All cooling coils shall be piped counterflow of refrigerant against airflow.

c. Design with upward water flow through coil, provide air vents at all high points of coils to eliminate trapped air.

d. At a minimum design with isolation valves on supply and return, two- or three-way control valve based on pumping system design, drain, flexible connections, and temperature gage. Provide balancing valves as needed.

11. Air Distribution Devices

a. Supply Diffusers:

i. Preferred method of air distribution due to aspiration and entrainment of room air (reduction of drafts and more even room temperature profiles).

ii. Supply air grilles shall be sized based on manufacture's airflow, noise criteria, mounting height, and pressure drop data.

b. Supply Grilles:

i. Avoid wall grilles where possible. Wall grilles have a lack of aspirating qualities and when discharging in cooling can create a perceived feeling of drafts. Where designed, use care. Utilize a larger width to height aspect ratio for maximum induction of room air. Utilize double deflection type grilles to maximize adjustability. Supply air grilles shall be sized based on manufacture's airflow, noise criteria, mounting height, and pressure drop data.

c. Return Air Grilles

i. Locate to aid in contaminant displacement.

ii. Design for low pressure loss in return plenum systems to assure that rooms do not get over-pressurized.

iii. Return air grilles shall be sized based on manufacturer's airflow, noise criteria, mounting height, and pressure drop data. Do not exceed 400 feet per minute for ducted systems and 250 feet per minute for plenum return systems.

iv. If transfer grilles are used, they should be arranged with lined ductwork between to minimize noise and light transmittance. Transfer grilles and associated ductwork shall be sized for air velocities not exceeding 400 feet per minute.

F. Ductless Split System Air Conditioners for IT / Data Rooms

1. Site the unit above the entry door. By doing so, precious wall space in the room is preserved for technology equipment, any water leaks will not drip onto technology equipment, and the unit will have adequate service access.

2. Provide local, wired, wall-mounted thermostatic control.

3. Provide monitoring through the DDC EMS, with alarm notification above 80°F.

G. Sound Attenuation and Vibration Control

1. Design HVAC system to meet ASHRAE recommended NC levels in all spaces.
2. Utilize sound traps or acoustical duct lining to mitigate noise attributable to HVAC equipment where required.
3. Provide vibration isolation devices as required to meet ASHRAE recommendations for vibration transmission.

H. Pumps

1. Provide main building systems with redundant pumps. Zone pumps, dedicated boiler pumps, individual condensate pumps do not require redundant pumps. Review redundancy requirements of system with Amtrak.
2. Pumps shall be capable of being removed for maintenance without having to drain the entire system or remove piping.

I. Temperature Control and Zoning

a. Selected buildings, and/or areas within selected buildings, shall be connected to the campus DDC control network. Refer to Integrated Automation Facility Controls Design Standard for additional criteria. Areas not selected for automated controls will be designed with local controls. Coordinate design requirements early in the schematic design phase.

b. Individual temperature controls will be based on function, exposure, and Owner request.

c. Each corner exposure (NE, NW, SE, and SW) shall be on a separate temperature control zone.

d. Each conference room, lobby, break area shall be on a separate temperature control zone.

e. Perimeter closed office zones shall include no more than five offices along the same orientation. This requirement may be relaxed when utilizing variable volume diffusers and terminal units are used primarily as a means of pressure control and reheat; however, group variable volume diffusers along the same orientation.

f. Locate thermostats per mechanical engineering design best practice. Local thermostatic controls access is to be limited to authorized personnel (Maintenance personnel). Automated thermostatic controls may be provided with user override capability.

2. Sequence of Operations

a. Sequences shall be determined to minimize energy use and take advantage of low part-load conditions that occur frequently at Amtrak Facilities.

3. Specialty Pressure Requirements and Exhaust Systems

a. Specific rooms shall be designed to be at a negative pressure to adjoining spaces and to be exhausted 100%. These rooms include but are not limited to: restrooms, certain working area (confirm with activity and use), certain process (confirm with activity and use), kitchens, janitor closets, copy rooms, food service rooms, loading docks, locker rooms, shower facilities, (confirm with activity and use), refrigeration machinery rooms, boiler rooms, etc.

b. Areas with products of combustion need removal of the combustion byproducts and a source of combustion air.

II. Building Automation Systems—BAS

A. General:

1. The Building Automation Systems (BAS) should be Direct Digital Controller (DDC) based. The BAS should be capable of scheduling operations and maintenance, in addition to adjusting building and related process systems to optimize their performance to minimize overall power and energy consumption of the facility. Process systems include, but not limited to compressed air systems.
2. The BAS should use the BACnet open communication protocols to provide integration and interoperability between building systems and control vendors. The BAS should have energy management and monitoring software which shall be capable of appropriate site level integration with any Supervisory Control and Data Acquisition (SCADA). "Open Communication Protocols" means Vendor-independent, non-proprietary, computer system or device design based on prevailing official and/or popular standards.
3. Unless otherwise noted below, the BAS/DDC system should be integrated with all appropriate components or systems.
4. The security and related requirements of both Amtrak's IT / C&S departments shall be factored into the design of the BAS systems. The Amtrak Project Manager (APM) will arrange for the interface with these departments. The BAS shall be integrated in the Amtrak Ethernet to be accessible remotely
5. The BAS should consist of a series of DDC interconnected by a local area network using either hard- wired or wireless. The BAS shall be accessible through a Web browser. The BAS shall have a graphical user interface and shall provide trending, scheduling, downloading memory to field devices, real-time "live" graphic programs, parameter changes of properties, setpoint adjustments, alarm/event information, confirmation of operators, and execution of global commands. The BAS shall record and archive for a period of at least 90 calendar days all collected energy consumption data, alarms, etc. along with local degree-day values.

B. Level of Integration

Lighting systems, Fire alarm systems, security systems, and elevator systems should be independent and only be monitored by a BAS. These systems shall have independent control panels and networks. The BAS system shall only monitor the status of these systems.

C. Automatic Temperature and Humidity Controls

1. BAS shall control all HVAC equipment and temperature throughout the facility. System operator shall be able to monitor all sensor input an outpoint points and adjust setpoints.
2. Provide a DDC system with host computer monitoring and control.
3. Provide a preprogrammed stand-alone single or multiple loop microprocessor PID controllers to control all HVAC and plumbing subsystems, etc.
4. Use PID loops. All appropriate equipment or systems should have self-contained BACnet controllers, which shall communicate with the BAS. al.
5. Equipment Control Schematics:
   a. Provide equipment control schematics, points list, and sequence of operations.

D. Air Systems:

Systems supplying heated or cooled air to multiple zones should include controls that automatically reset supply air temperature required by building loads or by outdoor air temperature.

E. Hydronic Systems:

Systems supplying heated and/or chilled water to comfort conditioning systems should include controls that automatically reset supply water temperatures required by temperature changes responding to changes in building loads (including return water temperature) or by outdoor air temperature.

F. Energy Management and Energy Conservation:

1. The BAS should have the capability to allow building staff to monitor system performance and determine energy consumption. Electrical values, such as, but not limited to: V, A, kW, KVAR, KVA, PF, kWh, KVARH, frequency, and percent THD, should be measured, displayed analyzed and stored. Consumption of natural gas, water and other utilities should be similarly monitored.
2. Energy management measurements should be totalized and trended in both instantaneous and time- based numbers. Energy monitoring data shall be automatically converted to standard database and spreadsheet format and transmitted to a designated workstation. The measured energy data should be capable of being analyzed and compared with the calculated energy consumption estimated during design.

G. BAS Control and Monitoring Capabilities:

1. The systems and components that should be controlled or monitored by the central BAS are temperature and humidity for general occupied and non-occupied areas, computer rooms and other special / technical spaces, building pressurization, lighting, electrical power, and emergency generators, etc. Specific monitoring requirements to be developed as required for each project.
2. When remote monitoring is required by the project, the Design Consultant is responsible for coordinating with Amtrak Digital Technology during the design phase to prepare the proper network wired/wireless access points and associated security allowances such that the BAS equipment can be monitored remotely. The Bid Package shall include stipulations that the contractor will coordinate with Amtrak Digital Technology for clearance of the selected technology / vendor and coordination on commissioning of the remote access.

H. Maintenance

1. The BAS should have the capability to allow building staff to monitor system performance and develop maintenance scheduling for all equipment based on schedule, hours of operation and specific equipment characteristics.

I. Commissioning

1. The BAS shall be commissioned by an independent agency.
2. Commissioning protocol to be approved by Amtrak Engineering

III. Smoke Control, Smoke Exhaust, and Emergency Ventilation Systems

A. Air intakes and exhaust servicing the systems shall be located a minimum of 12 feet above grade in accordance with U.S. Department of Transportation, Transit Security Design Considerations, Final Report, November 2004 and Federal Emergency Management Agency, Risk Management Series Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks.

B. An egress analysis and time of tenability analysis may be required. Confirm with Amtrak PM and DM.