Standardized Technical Specification

Bi-Level Passenger Rail Cars
for
Intercity Corridor Service

Chapter 10

HVAC System

Revision C

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Revision Status

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10.0 HVAC System

10.1 Overview

Each car shall be equipped with two identical units to provide Heating, Ventilation and Air Conditioning (HVAC) to the car. The HVAC units shall be removable and self-contained, and shall utilize scroll compressors and R400-series refrigerants for cooling.

Temperature control shall be provided by a microprocessor-based integrated HVAC control system that monitors ambient outside and inside temperatures and adjusts the system's cooling and heating functions to maintain a comfortable inside temperature and humidity level throughout the range of environmental and climatic conditions identified in Caltrans Specification 1-106.

Dampers on the fresh air intake vents shall control the amount of outside air taken in by the HVAC system. Diversion dampers at each end of the car shall control the amount of conditioned air being delivered to the upper or lower level, to adjust and maintain equal temperatures on both levels.

Heating shall be provided by overhead heat in the HVAC units, with additional heating provided by floor heaters along the base of the side walls in the car interiors.

Freeze protection shall be provided on the side door thresholds and all fresh water system components that may be exposed to freezing conditions.

10.2 General Requirements

The HVAC system shall provide a comfortable temperature controlled environment of the interior areas of all cars as follows:

- The cars shall be designed to operate in all environmental and climatic conditions identified in Caltrans Specification 1-106.
- The car's interior temperature, including the engineer's cab, shall be maintained to the specified value (68°F - 76°F) under all specified circumstances.
- The lower level shall receive adequate airflow from the HVAC to maintain the specified interior temperature and be able to restore the interior temperature after the side entrance doors are opened and the interior temperature is impacted by the ambient outside temperature without affecting the upper level temperatures.
- Passenger load shall be assumed to be AW3 for heat load calculations.
- Heat and cooling requirements shall include the opening of both sets of lower level side doors on alternating sides of the car every 15 minutes and held open for 2 minutes, to simulate passenger loading and unloading in all outside ambient temperatures identified in Caltrans Specification 1-106.
- Ambient conditions as specified and heat losses due to train motion shall be included in HVAC system performance evaluation.
- Air flow losses due to door and carbody leakage.

A microprocessor-based, integrated HVAC system shall be provided. The system shall be designed to maintain the specified interior passenger area temperature and humidity and to also assure adequate interior ventilation. The Contractor shall prepare, and submit for the Customer's approval during design review, a detailed heating and cooling load analysis along with recommended heating, cooling and ventilation capacities. **DR**

In no case shall the heating capacity be less than 40 kilowatt (kW) not including the forced air control cab heater, nor shall the refrigeration capacity be less than 244,000 BTU/Hr. The HVAC unit manufacturer shall conduct qualification testing to verify that the units provide the design heating and cooling capacity per ASHRAE Standard 37-05. This testing is further discussed in Chapter 19.

The HVAC system shall be powered primarily from the 480VAC, 3-phase, 60 Hz supply. The temperature controls shall operate from the 120VAC, 1-phase, 60 Hz supply, and the freeze protection circuits shall operate from the 120VAC, 3-phase, 60 Hz supply. The HVAC system shall be designed to perform at the nominal voltages and operate within the voltage and frequency tolerance ranges specified in Caltrans Specification 1-106.

To minimize the effects of motor inrush currents on the head end power system, the controls shall incorporate a method to provide staggered starting of the refrigerant compressor motors. The start up timing shall be set to stagger the startup of the A/F-end unit at least 15 seconds before the B-end unit.

Electric baseboard floor heaters, mounted behind stainless steel guards, shall be provided along both side walls, upper and lower levels. Baseboard heaters shall also be provided in the engineer’s cab in addition to the forced air heater described in Chapter 16.

Freeze protection is an essential function of the heating system. Freeze protection shall turn the heaters on when ambient outside temperatures drop below 40°F, and shut off when temperatures rise to 50°F.

The HVAC system shall be controlled by a solid-state temperature control using a sufficient number of temperature sensors to properly regulate heating and cooling in response to temperature changes inside and outside the car. Temperature sensors in the car body shall be located to accurately reflect temperature changes without being unduly influenced by external heat sources or solar radiation.

HVAC system circuit breakers and temperature control adjustment devices shall be located in the electrical locker and be accessible only to the operating crew. Circuit breakers, controls and relays shall be inaccessible to the passengers.

The HVAC unit shall be a fully hermetically sealed system, without threaded components, or other non-welded fittings, except for two service ports equipped with high quality industrial Schrader valves.

The performance of the entire assembled HVAC system as installed in a completed car shall be verified at the Climate Room Test specified in Chapter 19.

10.3 Design Parameters

The following parameters are to be assumed in the design of the cooling system:

Ambient Temperature	110°F Dry Bulb/82°F Wet Bulb, with 125°F air entering the condenser
Solar Load	Equivalent to 35° North Latitude, maximum solar heat rate, in accordance with ASHRAE calculation methods
Passenger Heat Load	440 BTU/hr/person at a heat ratio of 0.60
Number of Passengers	90 seated passengers and up to 130 standees (load level AW3)
Carbody Heat Transmission	In accordance with the Contractor's car body insulation design to meet the requirements of this Specification, and not less than 1200 BTU/hr-°F
Maximum Infiltration (Fresh Air)	1,575 Cubic Feet per Minute (cfm)
Other Heat Loads	Normal car lighting, electrical equipment and appliance loads

The following parameters are to be assumed in design of the heating system:

Ambient Temperature	-30°F Dry Bulb
Carbody Heat Transmission	In accordance with the Contractor's car body insulation design to meet the requirements of this Specification, and not less than 1200 BTU/hr-°F
Maximum Infiltration (Fresh Air)	1575 cfm
Solar Load	None
Passenger Load	None
Other Heat Loads	"Quiet car" lighting only (see Chapter 11)

10.4 Comfort Requirements

10.4.1 Interior

The following temperatures shall be maintained within the car's upper and lower levels (including toilet rooms and cab) when the associated ambient outside temperatures are present:

Outside Ambient	Interior Car Temperature
Below -30°F	As system will provide
-30°F to +60°F	70°F ± 2°F
60°F to 130°F	74°F ± 2°F (depending on functioning with or without reheat cycle)
Above 130°F	As system will provide.
Layover Cool Mode	85°F ± 2°F
Layover Heat Mode	50°F ± 5°F

During all modes of air conditioning, the interior relative humidity shall not exceed 60%.

Except within the area of the side doors and vestibules, the HVAC system shall maintain a temperature variation, within both the upper and lower levels, of the following:

- Vertical variation: (On any vertical line, 4 in. above floor to 43 in. above floor, not closer than 6 in. from walls, and not closer than 20 in. from doors): 5°F maximum difference between end points of the vertical line.
- Horizontal variation: (horizontal planes measured 4 in., 43 in. and 67 in. from floor, not closer than 6 in. from walls and not closer than 20 in. from doors.): The temperature at any point within each plane should not exceed ± 3°F from the average temperature in that plane.
- The average car temperature, including the upper and lower levels, shall recover within 2°F of the required interior car temperature within three minutes maximum following a two minute door opening on one side of the vehicle. It shall be demonstrated that this requirement can be met during two hours of continuous door cycling of two minutes open and 15 minutes closed at the design conditions in both heating and cooling modes.

Temperature variation between the upper and lower levels shall not exceed 4°F at any time.

10.4.2 Noise

The overall HVAC system shall be designed to minimize noise in the passenger and crew areas of the car. The noise level from the HVAC system shall not exceed the values in the following table. Particular care shall be required at the return air grilles, cab supply vents and galley ceiling air diffusers.

With the car stationary and the HVAC unit in its loudest cooling mode:

Interior noise level: Coach seating areas, cab, toilet rooms and galley	As specified in Chapter 9.
Exterior noise level	75 Decibels (Acoustic) (dBA) max (15 ft from centerline of car)

10.5 Air Conditioning

The cars shall be cooled using electromechanical equipment that has been proven in rail service. Two self contained, hermetically sealed HVAC units shall be provided on each car. The HVAC units shall be identical, one located in each equipment room. The same unit shall be used on all car types. The units shall be designed for a 400-series refrigerant, conforming to 40CFR Part 82. All components within the unit, such as seals, shall be compatible with synthetic lubricants.

Each HVAC unit shall supply conditioned air to the entire car, upper and lower levels, through the use of a splitter in the supply air ducts. Separate car air temperature sensors shall be used to provide independent floor heat control for the upper and lower level. The control cab in the cab/baggage car shall also have its own local thermostat.

The air conditioning system shall be designed and adequately sized to maintain interior car temperature as specified measured at the return air grille at the normal ambient conditions. For ambient temperatures greater than 130°F, the air conditioning system shall be capable of maintaining cooling at a reduced capacity. Application and integration of the system is to be in

accordance with the recommendation of the air conditioning manufacturer who shall also specify air flow requirements.

Each HVAC unit shall be totally self-contained, easily removable, and shall consist of a compressor/condenser section and an evaporator section with electric heating units. Condenser air inlet shall be through the car sidewall, with discharge through the equipment room floor. A convenient means shall be provided to install and remove the units from the equipment room through the condenser air intake door opening using a fork lift truck. Tapered guide pins or other suitable method shall be provided to guide the unit into its position in the equipment room. The unit shall be properly supported on a fork lift compatible pallet so as to reduce the amount of wear and tear on the equipment as a function of removing and reinstalling the units over the vehicle's lifetime. The installation and removal process, including removing and installing all mounting hardware, and electrical connections, shall be demonstrated on each car equipment room type for Customer approval at the design review. **DR**

The HVAC unit shall be mounted above drip pans. The drip pans shall catch the moisture (condensate) created by the evaporator. The drip pans shall be designed and constructed to prevent sloshing of the condensate while maintaining equipment room pressurization. The drained condensate shall be directed to the roadbed through the equipment room floor structure without leakage into the equipment room or car structure and shall not be discharged on car structure, wheels, brakes or electrical equipment. The exit of the condensate drain lines under the car shall be arranged in an approved manner to be readily accessible for maintenance, be protected from clogging and rodent entry, and as required for servicing the HVAC units.

The refrigeration system shall include, at a minimum, the following components and features:

- The units shall be designed for an R400-series refrigerant, conforming to 40CFR Part 82. All components within the unit, such as seals, shall be compatible with synthetic lubricants.
- A single scroll with modulation of two scroll-type refrigerant compressors working in tandem shall provide, at a minimum, both 50% and 100% capacity control.
- Compressor shutdown control shall be by means of a pump down cycle that senses suction line pressure.
- Refrigerant compressor crankcase heaters.
- Refrigerant control box, containing, pressure switches, service switch, etc.
- Direct drive condenser fan and motor assemblies.
- Condenser coil assemblies with 0.008 in. thick copper fins on 0.38 in. diameter copper tubing at a spacing of 8 fins per in.
- One charging and one evacuation port equipped with high quality Schrader valves and sealing metal caps.
- Suction accumulator.
- Filter drier.
- Discharge line check valves, and moisture and liquid indicators.
- Direct drive supply air blower and motor assemblies.
- Liquid line solenoid valves (2 per unit).
- Thermal expansion valves (2 per unit).

- Evaporator coil assemblies with two horizontally split sections for modulated and full cooling. The assembly shall have 0.008 in. thick copper fins on 0.38 in. diameter copper tubing at a spacing of 10 fins per inch.
- High, low, and modulation pressure switches.
- Unit removal shall not require a full purge and charge of the refrigerant system. Means shall be incorporated to allow a full pump down of the system and isolation of the refrigerant circuit by use of permanently installed appropriate valves to allow efficient removal and reinstallation of the unit.

For cab compartment air conditioning, refer to Chapter 16.

10.6 Heating

The cars shall be electrically heated. The system shall compensate for carbody losses and fresh air heating loads.

The heating system shall be designed and adequately sized to maintain interior temperature as specified throughout the car measured at the return air grille at the normal ambient conditions. Overhead heat shall be divided into stages. The size of each stage shall be chosen and controlled so that cycling of the heating contactors is minimized.

The overhead heaters shall be protected against overheating caused by the loss of sufficient air over the heater elements. Two protection devices shall be installed adjacent to each heater element and shall be used as temperature sensing devices to detect an overheat condition. Together, these devices shall offer two levels of protection. The first device shall disable the overhead heater by disabling the control circuit to the heater. The second device shall be used for backup protection, set slightly higher than the first, and, upon detection of excessive temperature, shall disable overhead heater and energize the shunt trip coil of the overhead heat circuit breaker such that it will trip. The first device shall reset automatically, and the second device shall require a manual reset. The protection method shall be reviewed by the Customer at the design review. **DR**

The side wall heaters shall be enclosed by sloping top heater grilles with perforated holes. The grilles shall be designed to provide a smooth transition with the side wall. The grilles shall be designed to prevent debris from entering the heating space and contacting the heater elements. The grilles shall be fitted with interior baffles to assist the convective air flow. The temperature of any portion of the grilles that could come in contact with passengers shall not exceed 125°F at nominal supply voltage.

Antifreeze protection (activated at an outside temperature of 40°F) shall be provided for the side door thresholds, side door pockets, water tank and water drain valves, each protected by independent circuit breakers. Refer to Chapter 15 for Water and Waste System. In addition, each equipment room shall be equipped with its own self-contained heater unit that operates independently of the main HVAC temperature controls. The equipment room heaters shall turn on when the ambient temperature in the equipment room drops to 40°F, and shall turn off when the equipment room temperature rises to 50°F.

Layover heat shall be supplied by the sidewall floor heat and shall maintain an interior temperature of 50˚F ± 5˚F, including the cab. During layover heating, the evaporator fans shall not operate and the fresh air shall be shut off.

The heating system shall include, at a minimum, the following components and features:

- Staged forced air electrical overhead heat.
- Heater over temperature protection devices.
- Two stages of sidewall heaters.

For additional cab compartment heating requirements, refer to Chapter 16.

10.7 Ventilation

The ventilation system shall include, at a minimum, the following components and features:

- Exterior fresh air intakes with water eliminators and filters
- Electrically motorized fresh air dampers
- Frame type disposable air filters
- Air distribution ducts
- Electrically motorized supply air diversion dampers
- Air diffusers and grilles
- Exhaust ducts
- Exhaust fans
- Emergency fan switches

Ventilation of the car shall be accomplished by blower fans supplied as part of the HVAC units. Fresh air shall enter the car through stainless steel fresh air intakes and shall pass through stainless steel ducts which include drains for condensation and water to be diverted to the outside of the car.

Re-circulated air shall pass through a stainless steel grille(s) into a plenum chamber where it mixes with the fresh air, be filtered and pass to the HVAC unit blower. The blower fans shall move the mixed air through the cooling and heating coils and force the conditioned air into the upper and lower level, stainless steel supply air ducts. The duct shall be sized to minimize noise from air velocity.

Conditioned air is then delivered within the car through longitudinal, diagonally split supply air ducts to longitudinal diffusers which are located along the ceiling of the upper and lower levels of the car. Local diffusers shall also be provided for the operator cab, and galley in the café/lounge car.

The diffusers shall be designed to deliver equalized airflow through out the car and meet the temperature variation requirements specified. The maximum velocity of discharge air shall not exceed 100 feet per minute (fpm) at 6 in. below the face of the diffusers. Air delivery performance shall be verified during HVAC system proof-of-design testing. Refer to Chapter 19. The diffusers shall be fixed on all cars, except for the car designated for proof-of-design testing, where adjustable diffusers shall be used.

The total air flow from the evaporator blower fans on both HVAC units shall be determined by the Contractor to meet the interior requirements at the specified ambient temperatures, and shall not be less than 6300 cfm. The evaporator blower fans shall be sized to overcome the

high external static pressure determined by the Contractor. The blower shall be centrifugal type, directly driven from the motor shaft. The motor shall be TEFC, class H insulation, resiliently mounted, and equipped with permanently lubricated sealed bearings.

Intake of filtered fresh air shall be provided for each end of the car, the required fresh air volume being between 1200 cfm and 1400 cfm, regardless of car position in a train or the car speed and shall be adequate to maintain the positive pressurization requirements of the specification.

Baffle plates shall be used to set the volumes of fresh and re-circulated air. The baffle plates shall be fixed on all cars, except for the car designated for car level testing, where adjustable baffle plates shall be used.

Because the heating and cooling loads vary between upper and lower levels of the car, electric-operated diversion dampers shall be provided to adjust the amount of conditioned supply air between the upper and lower levels of the car to maintain required temperatures on both levels. These diversion dampers shall be independently controlled by the car temperature control unit.

An exhaust fan vented to the exterior of the car shell shall be provided in each toilet room to control odors. Toilet room exhaust shall, at all operating speeds, maintain a negative pressure in the toilet room at all times as compared to the rest of the car interior. An exhaust fan shall be provided in the electric locker to assist in exhausting stale warm air. The electric locker fans shall exhaust outlet air into the equipment room, both to provide pressurization and also ventilation with some heating/cooling value.

The temperature controls shall provide for ventilation with no heating or cooling when temperature conditions do not require heating or cooling.

Ventilation detection and interlocking devices shall be provided and installed such that there shall be no overhead heat and/or cooling when absence of ventilation is detected.

The ventilation system shall provide a minimum positive carbody pressurization of 0.1 in. water gage at full fresh air flow above ambient exterior pressure with all exterior doors and windows closed and the toilet room exhaust fans running.

Fresh and re-circulated air shall be filtered at the HVAC units with disposable pleated-type filters and disposable “synthetic bulk media”-type filters. The filters shall be located for ease of replacement from outside the car via the HVAC unit service access door. It is desirable to be able to change the filters with only minimal use of a ladder on the wayside; accordingly, air filter door latches shall be as low as practical on the door, while still providing proper air-tight seal. The air filter doors shall contain a nameplate showing the correct filter orientation and airflow direction. The filters shall meet the requirements specified in Amtrak Specification 685.

In addition to the disposable pleated-type unit filters, the fresh air exterior intakes shall be fitted with louvers or grilles to prevent ingress of water.

10.8 Dampers

10.8.1 Fresh Air Dampers

The Fresh Air Intakes shall be equipped with power-operated infinitely variable fresh air dampers, which can be in three different states: open, restricting and closed. Controlled by the car temperature control panel, the damper(s) are used to allow full fresh air into the car. The damper(s) will under moderate ambient temperatures, restrict fresh air to 10% of the volume to reduce fresh air intake and therefore HVAC load, during very high or very lower ambient temperatures and close completely during layover or loss of HEP. During moderate temperature the dampers will operate variably between open and closed to maximize outside air for the purpose of achieving the desired interior temperature.

The damper frame, blades and hardware shall be constructed of corrosion-resistant material so they will last the life of the car with no attention other than inspection and cleaning at 8-year car overhaul. The drive motor shall be robust and off the shelf readily available.

The dampers shall incorporate a spring close feature so that they self-close upon loss of power. They shall also incorporate a position sensor to provide a feedback signal to the temperature control panel. Design of the damper unit shall keep the minimum number of adjustments required to a minimum. Once settings are made, they shall be locked, so they remain fixed for the life of the damper. The damper shall not require any periodic adjustment over its life. Any adjustments shall be marked so that if components must be changed, the correct settings are identified for the new part automatically.

10.8.2 Diversion Dampers

Power-operated diversion dampers shall be provided in the supply air ducts to the upper and lower levels to allow the temperature control panel to adjust the ratio of supply air between the upper and lower levels of the car to maintain a small temperature difference between levels. A- and B-end dampers shall be independently controlled. If desired, the dampers can be two-state, with the control provided on a local basis from a self-contained control module, as part of the damper assembly. If the dampers are locally controlled, a means to test operation of the unit shall be included as part of the module.

The damper frame, blades and hardware shall be constructed of corrosion resistant material so they will last the life of the car with no attention other than inspection and cleaning at 8 year car overhaul. The drive motor shall be robust and readily available. It shall also incorporate a position sensor to provide a feedback signal to the temperature control panel. Design of the damper unit shall keep the minimum number of adjustments required to a minimum. Once settings are made, they shall be locked, so they remain fixed for the life of the damper. The damper shall not require any periodic adjustment over its life. Any adjustments shall be marked so that if components must be changed, the correct settings identified for the new part automatically.

10.9 Controls

Heating and cooling control shall be by a solid state controller using electronic sensors for temperature data. The output of the solid state controller shall drive electromechanical relays and contactors which shall, in turn, control electrical power to the heater elements, motors and various control devices. The changeover between heating and cooling shall be automatic and, except for the first stage of overhead heat (reheat), shall preclude the simultaneous operation of heating and air conditioning. A solid state or microprocessor based temperature controller providing software control and modification of temperature set points, as well as the control and modification of various functions such as reheat, is desired. Other proven solid state controller designs will be considered providing the design allows for field modification of the temperature set points and other functions.

10.9.1 Sensors

At a minimum, the following temperature sensors shall be required:

- Three interior temperature sensors located throughout the passenger seating area on each level.
- Return air sensor at each HVAC unit return air grille.
- Fresh air sensor at each HVAC unit fresh air inlet.
- Floor heat sensors at floor level in each sidewall heating control zones.
- Layover thermostat at floor level in one sidewall heating control zone.
- Freeze protection thermostat located in a position that accurately measures outside temperature.
- Evaporator coil sensors to detect ice build-up on the evaporator coils.
- Cab control compartment thermostat.

10.9.2 Use of Controls

The temperature control system shall operate automatically. When the car is put into service, the mode selector switches are placed in the NORMAL position. The panel then operates without further attention until the car is taken out of service, possibly many days later.

In normal car operation, the on-board crew (food service attendants, conductors, etc.) require only occasional access to the temperature control panel. If car equipment malfunctions, however, the above crew members may require access to the temperature control or HVAC contactor panel external controls to reset controls, etc.

The mode selector switches are crew-operated controls for the car temperature control system. These switches determine the operating mode of each of the two HVAC systems. The mode selector shall be able to switch from NORMAL to LAYOVER without cycling the HVAC through OFF.

Positions and functions are as follows:

Name	Function
NORMAL	Car HVAC set up shall provide normal occupied car environment. All systems operate.
LAYOVER	Used for car storage in summer to minimize energy consumption, yet still maintain interior temperature of 85°F. Used for car storage in winter to minimize energy consumption, yet still maintain interior temperature of 50°F. Only floor heat shall be available.
OFF	Used to shut off all car heating and cooling when car is being serviced or in storage. Does **not** shut off freeze protection.

10.9.3 Status Display

Each HVAC control panel shall include an indicator and monitor display which shall show the control logic state. Indications shall be by means of suitably labeled Light Emitting Diodes (LEDs) which shall display all calls for heating or cooling from the zones controlled from that panel. Fresh air temperature, supply air temperature, and return air temperature shall be displayed for each HVAC unit. Overload indicators and resets shall be available for use by the train crew without exposing the crew to hazardous voltages. All HVAC system test points shall be wired to a standard Universal Serial Bus (USB) receptacle installed on the panel for interface with a laptop computer loaded with the Contractor's HVAC diagnostic test software. The HVAC software shall have the capability to monitor the HVAC system, test the HVAC system and override the control system. It shall log all faults and download history.

The control system shall include, at a minimum, the following components and features:

- Temperature control panel
- Temperature sensors
- Motor starters
- Motor protective devices
- Heat contactors
- Diagnostics and test capabilities

The Contractor shall submit a temperature control schedule and a detailed description of operation for approval by the Customer at the HVAC system design review. **DR**

10.9.4 Ventilation Cut-Out Switch

A ventilation system isolation switch shall be located at each upper level end door passageway, and on the vestibule wall next to the electrical locker door. These switches shall turn off the HVAC system blowers on both HVAC units to prevent the circulation of smoke or fumes throughout the car in the event of an emergency. The switches shall be wired in series so that any one switch shall shut the system off. These switches shall be labeled VENTILATION CUT-OUT accordance with Figure 10-1 and Amtrak's interior signage manual. The switch shall be a two-position switch with a red spring-loaded flip-up cover that must be lifted to put the switch in the OFF position. Placing the cover in the closed position returns the switch to the on position.

10.9.5 Freeze Protection

The freeze protection system shall allow unrestricted vehicle operation of water, waste and door systems down to -30ºF ambient, under all weather and train operating conditions. See Chapter 15.

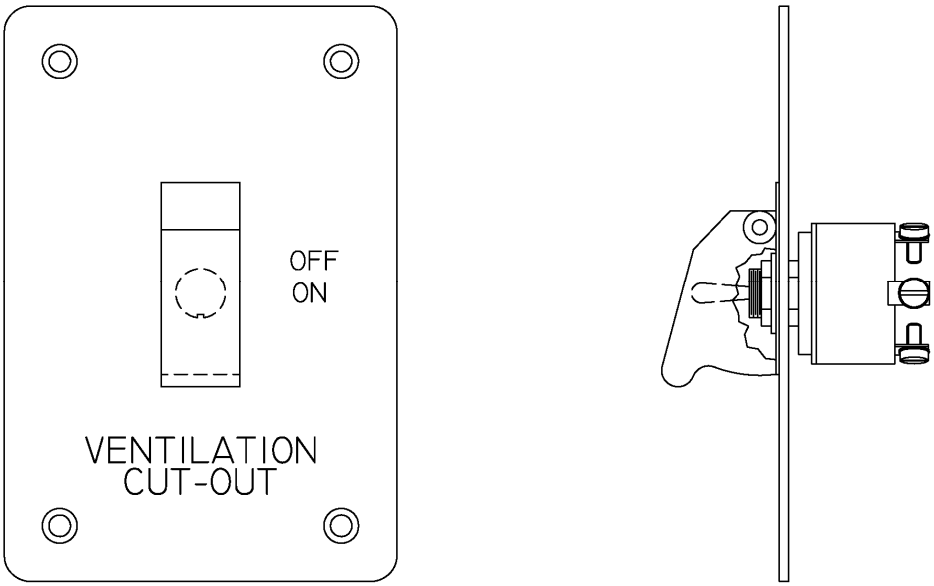

Figure 10-1: Emergency Fan Switch

SUGGESTED TEMPERATURE SCHEDULE

OUTSIDE AIR TEMPERATURE (FRESH AIR), DEG.F	cold 68 | 69	70 | 71	72 | 73	74 | 75	76 | 77	78 | 79 warm
hot – 101	If required Partial DH Partial FH FAD Closed	If required Partial DH Partial FH FAD Partial Open	Ventilation Only FAD Partial Open	Partial Cool Partial DH FAD Partial Open	Partial Cool FAD Partial Open	Full Cool FAD Partial Open	Full Cool FAD Closed
100 – 61	If required Partial DH Partial FH FAD Closed	If required Partial DH Partial FH FAD Full Open	Ventilation Only FAD Full Open	Partial Cool Partial DH FAD Full Open	Partial Cool FAD Full Open	Full Cool FAD Full Open	Full Cool FAD Closed
60 – 46	Partial DH Partial FH FAD Closed	Partial DH Partial FH FAD Full Open	Ventilation Only FAD Full Open	Partial Cool Partial DH FAD Full Open	Partial Cool FAD Full Open	Full Cool FAD Full Open	Full Cool FAD Closed
45 – 41	Partial DH Partial FH FAD Closed	Partial DH Partial FH FAD Full Open	Partial FH by CA FAD Full Open	Ventilation Only FAD Full Open	Ventilation Only FAD Full Open	Ventilation Only FAD Full Open	Ventilation Only FAD Closed
40 – 21	Full DH Partial FH FAD Closed	Full DH Partial FH FAD Full Open	Partial FH by CA FAD Full Open	Ventilation Only FAD Full Open	Ventilation Only FAD Full Open	Ventilation Only FAD Full Open	Ventilation Only FAD Closed
20 – cold	Full DH Full FH FAD Closed	Full DH Full FH FAD Partial Open	Partial FH by CA FAD Partial Open	Ventilation Only FAD Partial Open	Ventilation Only FAD Partial Open	Ventilation Only FAD Partial Open	Ventilation Only FAD Closed

RETURN AIR (or CAR AIR for Floor heat CONTROL) TEMPERATURE, DEG.F

FAD = Fresh Air Damper
FH = Floor Heating
DH = Duct Heating
CA = Car Air

46 Ascending temperature
45 Descending temperature

72 | 73
Ascending temperature | Descending temperature

Note: Both return air and car air thermostats must be satified within 1°F to turn off floor heat

SUGGESTED LAYOVER TEMPERATURE SCHEDULE

OUTSIDE AIR TEMPERATURE (FRESH AIR), DEG.F	cold – 50	51 – warm
21	Partial Floor Heat Fresh Air Dampers Closed Duct Heat OFF No Ventilation	Full Floor OFF Fresh Air Dampers Closed Duct Heat OFF No Ventilation
20 – cold	Full Floor Heat Fresh Air Dampers Closed Duct Heat OFF No Ventilation	Full Floor OFF Fresh Air Dampers Closed Duct Heat OFF No Ventilation

CAR AIR TEMPERATURE, DEG.F

21 Ascending temperature
20 Descending temperature

50 | 51
Ascending temperature | Descending temperature

Figure 10-2: Suggested Temperature Control Schedule Sample

* End of Chapter 10 *