

9.4.6 Electrical Division of Safeguard Building Ventilation System (SBVSE)

The electrical division of the safeguard building (SB) ventilation system (SBVSE) is designed to maintain the ambient conditions for the safety-related electrical equipment, emergency feedwater pump rooms and component cooling water system component rooms in the SB during normal plant operation and accident conditions. The SBVSE also maintains the ambient conditions in the SB during maintenance operations and provides ventilation for the remote shutdown station (RSS) which is located in division 3 of the SB. Ventilation of the RSS can be provided by the SBVSE of the SB division 2 or division 3.

9.4.6.1 Design Bases

The SBVSE is primarily a safety-related system with portions serving non-safety-related functions. The safety-related portion is designed to Seismic Category I criteria. The non-safety-related portion of the SBVSE is designated as Non-Seismic category.

The U.S. EPR meets:

- GDC 2, as it relates to meeting the guidance of RG 1.29, position C.1 for the safety-related portions of the SBVSE and position C.2 for the non-safety-related portions.
- GDC 3, as it relates to the SBVSE remaining functional following the postulated hazards of a fire. The SBVSE accomplishes this by the design and location of the system components to minimize the effect of fires and explosions. Noncombustible and heat-resistant materials are used wherever practical.
- GDC 4, as it relates to the SBVSE, by design, to protect against adverse environmental conditions and dynamic effects. The SBVSE accommodates the effects of, and is compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.
- GDC 5, as it relates to the SBSVE system because safety-related components are not shared with any other nuclear power units.
- GDC 17, as it relates to the SBVSE because the U.S. EPR design has an onsite electric power system and an offsite electric power system to permit functioning of structures, systems, and components important to safety in the event of postulated accidents and anticipated operational occurrences. In addition, the SBVSE maintains a minimum of 20 feet from the bottom of all fresh air intakes to grade elevation and the electrical cabinets are provided with suitable seals or gaskets. This is provided to maintain the proper functioning of the essential electric power system by meeting the guidelines of NUREG-CR/0660 (Reference 1) as related to the accumulation of dust and particulate material.
- 10CFR 50.63, as it relates to the SBSVE because during a station blackout (SBO), two of the four SBs are backed up by the SBO diesel generators alternate AC (AAC)

power. An analysis to determine capability for withstanding or coping with a station blackout event as described by RG 1.155, position C.3.2.4, will be performed. The safety chilled water system (SCWS) chillers which provide cooling to the division 1 and 4 SBVSE air coolers and recirculation units are also powered by the SBO diesels and are available.

The SBVSE maintains acceptable ambient conditions in the SB during SBO conditions. It also ventilates the battery rooms and SCWS rooms in the SB during SBO conditions to maintain the hydrogen concentration and refrigerant concentration below the maximum allowable limits.

The SCWS chillers which provide cooling to the division 1 and 4 SBVSE air coolers and recirculation units are also powered by the SBO diesels and are available.

The SBVSE performs the following safety-related system functions:

- Maintains acceptable ambient conditions for the safety-related components in the electrical and instrumentation and controls (I&C) rooms in the SB during accident conditions, taking into account internal and external heat loads.
- Maintains acceptable ambient conditions inside the emergency feed water system (EFWS) pumps and component cooling water system (CCWS) component rooms of the SB during accident conditions, taking into account internal and external heat loads.
- Ventilates the battery rooms and SCWS rooms in the SB to maintain the hydrogen and refrigerant concentration below maximum allowable limits during accident conditions.

The SBVSE performs the following important non-safety-related system functions:

- Maintains acceptable ambient conditions (temperature and humidity) in the SB for equipment operation and personnel comfort during normal plant operation and plant maintenance.
- Ventilates the battery rooms and safety chilled water system rooms in the SB to maintain the hydrogen concentration and the refrigerant concentration below maximum allowable limits during normal plant operation and plant maintenance.

9.4.6.2 System Description

9.4.6.2.1 General Description

The heating, ventilation and air conditioning (HVAC) of each electrical division (SBs 1 through 4) is provided by a separate and independent SBVSE train. In the normal operation state of the system, these functions are provided by a safety-related train. The SBVSE schematic diagram is shown in Figure 9.4.6-1 through Figure 9.4.6-4. Figure 9.4.6-1 and Figure 9.4.6-2 are simplified diagrams of the air intake, and the air

supply and exhaust for SB divisions 1 and 4. Similarly, the simplified diagrams for SB divisions 2 and 3 are provided in Figure 9.4.6-3 and Figure 9.4.6-4.

During maintenance, the SBVSE functions are provided by a maintenance train. One maintenance train is located in division 1, the other in division 4. The maintenance train located in division 1 is common for divisions 1 and 2 and the maintenance train located in division 4 is common for divisions 3 and 4. An independent exhaust maintenance train is provided for the battery rooms and SCWS rooms for each division, 1 through 4.

The SBVSE consists of a supply and exhaust circuit with the ability to operate in recycling mode with fresh air makeup. The system can be operated with or without recycled air depending on the outside air temperature.

The system also ventilates the remote shutdown station (RSS) which is located in division 3. Ventilation of the RSS can be provided by SBVSE of division 2 or division 3.

The EFWS and CCWS pump rooms have high internal heat loads when the pumps are running and are provided with recirculation cooling units.

Additional electric heaters installed in supply air ducts are used to maintain the minimum temperatures in battery rooms and toilet rooms.

For each division, the SBVSE consists of:

- A single air intake equipped with a damper and grilles. The SBVSE air intakes in divisions 1 and 4 are common for the smoke confinement system (SCS) of the same division (refer to Section 9.4.13). Similarly, the SBVSE air intakes in divisions 2 and 3 are common for the main control room (MCR) air conditioning system (CRACS) (refer to Section 9.4.1) and SCS of the same division.
- A safety-related air conditioning train. Mixing is done with control dampers, filtration with filters, heating with electric air heater, cooling with air cooling coil, ventilation with supply air fan, and humidification with non-safety-related air humidifiers. The train also has the associated exhaust air train, with exhaust fan and control damper.
- A connection with a non-safety-related air conditioning train. Mixing is done with control dampers, filtration with filters, heating with electric air heater, cooling with air cooling coil, ventilation with supply air fan, and humidification with air humidifiers. The train also has the associated exhaust air train, with exhaust fan and control damper.
- Cross-connected ducts between divisions 1 and 2 and divisions 4 and 3 for the HVAC supply and exhaust with the non-safety-related maintenance trains for use when one SBVSE safety-related train of division 2 or 3 is unavailable. Manual

isolation dampers equipped with "opened" and "closed" limit switches are installed in the cross-connected ducts (i.e., supply and exhaust ducts of division 1 and 2 and division 3 and 4).

- Connections providing air to the mechanical controlled area (interface with SBVS).
- A single ductwork providing air to the electrical rooms and mechanical non-controlled rooms.
- Two independent exhaust ductworks:
 - The first exhaust ductwork is used for the rooms in the non-controlled area of the SB, except for rooms served by the second exhaust ductwork. It is connected to one of the two recirculation-exhaust fans. One of the fans is a safety-related fan and is located in the same division. The other is a non-safety-related fan for maintenance operation, which is common for the two combined divisions 1 and 2 (located in division 1) and the two combined divisions 3 and 4 (located in division 4). The exhaust air of transformers and inverters is directly exhausted through exhaust hoods connected to the top of the equipment.
 - The second exhaust ductwork is used for the rooms which could accumulate specific gas (hydrogen in the battery rooms and refrigerant gas in the rooms of the SCWS) and for the non-controlled mechanical area. The air is directly exhausted outside using one of two exhaust fans (one safety-related fan, or one non-safety-related maintenance fan). For the battery rooms, a bypass connection to the recirculation/exhaust air path is provided with an isolation damper.
- A single air outlet equipped with dampers and air intake grilles (common for the entire exhaust air of all non-controlled HVAC systems of the same division, except toilet exhaust air of divisions 1 and 4).
- One independent exhaust duct used for toilets, the air being exhausted outside using one non-safety-related exhaust fan via a separate air outlet (divisions 1 and 4 only).
- One safety-related recirculation cooling unit (equipped with a cooling coil, droplet separator, and recirculation fan) for the emergency feedwater pump room.
- One safety-related recirculation cooling unit (equipped with a cooling coil, droplet separator, and recirculation fan) for the CCWS components rooms.

9.4.6.2.2 Component Description

The major components of the SBVSE are described in the following paragraphs. Refer to Section 3.2 for the seismic and system quality group classification of these components.

Supply Air System – Safety-Related Train

The supply air units are located in divisions 1 and 4 at elevation +39 ft and in divisions 2 and 3 at elevation +69 ft (also elevation +96 ft for air intake components). The components are installed in a concrete chamber structure.

Each air conditioning train includes:

- Weather protection grilles, electrically heated to prevent ice formation.
- Dampers.
- Insect protection screens.
- Isolation damper, manually operated.
- Set of control dampers with electrical actuator.
- Prefilter.
- Roughing filter.
- Electric heater, with tubular elements, comprised of four heating stages.
- Air cooling coil of finned tube coil type, supplied with chilled water by the SCWS of the same division.
- Droplet separator, connected to the nuclear island drain and vent system (NIDVS).
- Silencer on fan suction side, splitter type.
- Supply air fan, free wheel radial type, direct driven.
- Non-return damper.
- Silencer on fan discharge side, splitter type.
- Two air humidifiers, electrically heated and connected to the potable and sanitary water system (PSWS), and NIDVS.

Recirculation-Exhaust Air – Safety-Related Train

The recirculation and exhaust air trains are located in divisions 1 and 4 at elevation +39 ft and in divisions 2 and 3 at elevation +69 ft.

Each train includes:

- Isolation dampers, manually operated.
- Recirculation and exhaust air fan, radial type, direct driven.

- Control damper with electrical actuator.
- Non-return damper.
- Isolation damper, manually operated.
- Dampers.
- Weather protection grilles.

Exhaust Air for Battery-Safety Chilled Water Room and Non-controlled Mechanical Area – Safety-Related Train

The exhaust air trains are located in divisions 1 and 4 at elevation +39 ft and in divisions 2 and 3 at elevation +69 ft.

Each train includes:

- Isolation damper, manually operated.
- Exhaust air fan, radial type, direct driven.
- Non-return damper.
- Isolation damper with electrical actuator.

Supply Air System – Maintenance Train

The maintenance train is non-safety-related. The supply air units are located in divisions 1 and 4 at elevation +39 ft. The components are installed in a concrete chamber structure.

Each air conditioning train includes:

- Insect protection screen.
- Isolation damper, manually operated.
- Set of control dampers with electrical actuator.
- Prefilter.
- Roughing filter.
- Electric heater, with tubular elements, comprised of four heating stages.
- Air cooling coil of finned tube coil type, supplied with chilled water by the operational chilled water system (OCWS).
- Droplet separator, connected to the NIDVS.

- Silencer on fan suction side, splitter type.
- Supply air fan, free wheel radial type, direct driven.
- Non-return damper.
- Silencer on fan discharge side, splitter type.
- Two air humidifiers, electrically heated and connected to the PSWS and the NIDVS.

Recirculation-Exhaust Air – Maintenance Train

The maintenance train is non-safety related. The recirculation-exhaust air trains are located in divisions 1 and 4 at elevation +39 ft.

Each train includes:

- Isolation dampers, manually operated.
- Recirculation and exhaust air fan, radial type, direct driven.
- Control damper with electrical actuator.
- Non-return damper.
- Isolation damper, manually operated.

Exhaust Air for Battery/Safety Chilled Water Room and Non-controlled Mechanical Area – Maintenance Train

The maintenance train is non-safety related. The exhaust air trains are located in divisions 1 and 4 at elevation +39 ft and in divisions 2 and 3 at elevation +69 ft.

Each train includes:

- An isolation damper, manually operated.
- Exhaust air fan, radial type, direct driven.
- Non-return damper.
- Isolation damper with electrical actuator.

Recirculation Cooling Units – Safety Related

One recirculation cooling unit provides cooling to the emergency feedwater pump room in the non-controlled mechanical area of each SB (1 through 4) at elevation -28 ft, 2 ½ in. Each of the four units consists of the following main components:

- Air cooling coil of finned tube coil type, supplied with chilled water by the SCWS.
- Droplet separator connected to the NIDVS.
- Recirculation fan, axial type, direct driven.

One recirculation cooling unit is assigned to the rooms of the component cooling water system equipment in the non-controlled mechanical area of each SB (1 through 4) and is located at elevation -28 ft, 2 ½ in. Each of the four units is designed as a fan coil unit and consists of the following main components:

- Air cooling coil of finned tube coil type, supplied with chilled water by the SCWS.
- Droplet separator, connected to the NIDVS.
- Recirculation fan, radial type, direct driven.

Exhaust Air – Non-Safety Related

One exhaust fan is assigned to the toilet rooms located in divisions 1 and 4 at elevation +55 ft. The fans are located at elevation +81 ft with the following components:

- Exhaust fan, axial type, direct driven.
- Non-return damper.
- Isolation damper, manually operated.

9.4.6.2.3 System Operation

Normal Plant Operation

The SBVSE operates during normal plant operation and during outage conditions. The HVAC for each division (1 to 4) is provided by an air supply train and associated exhaust train (with the same safety classification). The normal operation for each division follows:

- The safety-related train is in service to provide filtration, heating, cooling and humidification. Outside makeup air is supplied to each train of the SBVSE through a separate air intake. This outside air mixes with the recirculated air upstream of the supply air filters. The amount of outside air admitted depends on the outside air temperature and is automatically adjusted by control dampers. If required, air heating is performed by the electric air heater. Air cooling is performed by the air cooling coil. The supply air fan supplies the air to the rooms of the SB division. If required, humidification is performed by the air humidifiers.
- The maintenance train (non-safety-related) for supply air and exhaust air is shut down.

- Air is supplied to the non-contaminable rooms of the SB plus the hot (controlled) mechanical area, which is exhausted by the SBVS.
- Air is exhausted from all rooms, except the controlled area exhausted by the SBVS.
- Air is released from the rooms representing the risk of accumulation of specific gas (i.e., hydrogen in battery rooms and refrigerant gas in SCWS room) and the rooms of the cold (i.e., non-controlled) mechanical area to the outside by a dedicated exhaust fan.
- Exhaust air is released from the toilet rooms of division 1 and 4 to the outside, also by a dedicated exhaust fan.
- The exhaust air of the remaining rooms is collected and directed to the recirculation-exhaust fan where a portion of the air can be recirculated or directly discharged to the outside. The amount of air to be recirculated depends on the outside air temperature and is automatically adjusted by the control damper.
- Ventilation tasks of the RSS, located in division 3, are provided by the SBVSE of the neighboring division 2.
- The recirculation cooling units are in automatic operation, and the fans are operated in ON-OFF mode depending on the room temperature.
- Electric heaters in supply air ducts, for example for battery rooms, are in automatic operation and are operated in ON-OFF mode depending on the room temperature.

In summer, the SBVSE operates in an open circuit (i.e., fresh air) or in recirculation mode with fresh air makeup depending on the outside temperature. In winter, the system operates in recirculation mode with fresh air makeup depending on the outside temperature.

In the event that maintenance needs to be performed in one division of the SB, the operator shuts down the safety-related train of the affected division and switches over to the maintenance train. The function is provided by the non-safety-related maintenance train common for two divisions. During maintenance, operation of the SBVSE is the same as in normal operation except for the position of some isolation dampers, depending on the division where the maintenance is being performed.

Functionally, operation of the maintenance air conditioning train and exhaust train is identical to the operation of the safety-related air conditioning train and exhaust train.

Switchover can only be performed manually because the two HVAC trains are not redundant. The chilled water for the maintenance air conditioning train is supplied by the OCWS.

The combination of divisions in maintenance will not include divisions 1 and 2 at the same time, or divisions 3 and 4 at the same time. For this reason, the operation of the SBVSE is the same during maintenance of one division.

During simultaneous operation of the safety and maintenance trains (i.e., both trains of division 1 or both trains of division 4), the maintenance trains operate in recirculation mode with fresh air makeup.

Abnormal Operating Conditions

Ventilation Failures

The failure of a SBVSE component could result in the loss of one SBVSE train. For this reason the SBVSE trains of the four divisions are redundant. Three other safety-related trains are available. Because the safety-related trains are not connected to each other, the failure of one train will not affect another division. The concept of SBVSE train redundancy follows the general design concept of the four redundant SBs and safety systems contained therein.

Each SBVSE train is located in a separate enclosure and is independently powered to limit common mode active failures of multiple trains. Common mode failures of the SBVSE are minimized due to the diversity of fans of the safety-related trains (i.e., divisions 1 and 4 as opposed to divisions 2 and 3) and because of the diversity of the cooling and the heat sinks for the associated SCWS.

Failure of a SBVSE component will not adversely affect the operation of the interfacing systems SCWS, OCWS, or PSWS.

If the SBVSE in one division fails, switchover from the safety-related train to the maintenance train of either division 1 or 2 or division 3 or 4 is possible. Therefore, ventilation of electrical and I&C equipment in all divisions is provided even in case of failure of one of the four divisions.

Additionally, the SCWS has the same configuration as the SBVSE. If the SCWS in one division fails, switchover from the safety-related train to the maintenance train in either division 1 and 2 or division 3 and 4 is possible.

If a failure of a safety-related train of the SB is postulated during maintenance of a SB HVAC system, two SB trains remain available.

Loss of Offsite Power (LOOP)

In case of LOOP, fans and actuators of each safety-related train of the SBVSE (division 1 to division 4) are backed up by the corresponding emergency diesel generator, with the exception of the humidifiers. Humidifiers are not required for safety function.

Loss of Ultimate Heat Sink (LUHS)

For the SBVSE, the chilled water to the safety trains is provided by the SCWS, with the following key features:

- Two water-cooled chillers, cooled by the CCWS, in divisions 2 and 3.
- Two air-cooled chillers at elevation +39 ft in divisions 1 and 4.

In case of loss of ultimate heat sink (LUHS), the SCWS provides the cooling function of the SBVSE of the two divisions 1 and 4. Because the water-cooled chillers of divisions 2 and 3 are lost in case of LUHS, the cooling function of divisions 2 and 3 is not available.

9.4.6.3 Safety Evaluation

- The safety-related portion of the SBVSE is located in the associated SB. The SB is a Seismic Category I structure that is designed to withstand the effects of earthquakes, tornadoes, hurricanes, floods, external missiles, and other appropriate natural phenomena. Section 3.3, Section 3.4, Section 3.5, Section 3.7, and Section 3.8 provide the bases for the adequacy of the structural design of this building.
- The safety-related portion of the SBVSE is designed to remain functional after a safe shutdown earthquake (SSE). Section 3.7 and Section 3.9 provide the design loading conditions. Section 3.5, Section 3.6 and Section 9.5.1 provide the hazards analyses to demonstrate that a safe shutdown, as outlined in Section 7.4, can be achieved and maintained.
- Structures, systems and components important to safety in the SBVSE are not shared with any other nuclear reactor units.
- The design of the SBVSE provides for complete redundancy with four independent divisions; therefore, a single failure in any portion of the SBVSE will not compromise the ability of the system to perform its safety function. Vital power can be supplied from either onsite or offsite power systems, as described in Section 8.2 and Section 8.3. Initial testing and periodic inservice functional testing are carried out in accordance with Section 9.4.6.5.
- Section 3.2 delineates the quality group classification and seismic category applicable to the safety-related portion of this system and supporting systems. The power supplies and control functions necessary for safe function of the SBVSE are Class IE, as described in Section 7.1 and Section 8.3.
- Section 9.4.6.3 describes provisions made to identify and isolate leakage or malfunction and to provide isolation of the non-safety-related portions of the system.

9.4.6.4 Inspection and Testing Requirements

Refer to Section 14.2 (test abstracts #078 and #203) for initial plant startup test program. Initial inplace acceptance testing of SBVSE components will be performed in accordance with ASME AG-1-2003 (Reference 2).

The safety-related portions of the SBVSE are designed and located to permit required periodic testing.

9.4.6.5 Instrumentation Requirements

Indication of the operational status of the equipment, position of dampers, instrument indications and alarms are provided in the MCR. Fans, motor-operated dampers, heaters and cooling units are operable from the MCR. Local instruments are provided to measure differential pressure across filters, flow, temperature and pressure. The fire detection and sensors information is delivered to the fire detection system.

9.4.6.6 References

1. NUREG-CR/0660, Boner, G.L. and Hanners, H.W., "Enhancement of Onsite Emergency Diesel Generator Reliability," University of Dayton Research Institute UDR-TR-79-07 for U.S. Nuclear Regulatory Commission, January 1979.
2. ASME AG-1-2003, "Code on Nuclear Air and Gas Treatment," The American Society of Mechanical Engineers, 2003 [including the AG-1a, 2004 Addenda].