9.4.5 Safeguard Building Controlled-Area Ventilation System

Each of the four safeguard divisions is separated into two functional areas:

- Hot mechanical area serviced by the safeguard building controlled-area ventilation system (SBVS).
- Electrical, instrumentation and control (I&C) and heating, ventilation and air conditioning (HVAC) area serviced by the electrical division of the safeguard building ventilation system (SBVSE). Refer to Section 9.4.6.

The SBVS provides a suitable and controlled environment, in the mechanical areas of the Safeguard Buildings (SB) where engineered safety feature components are located, for personnel access and to allow safe operation of the equipment during normal plant operation, outages, under anticipated operational occurrences, and postulated accidental events.

The SBVS, through its interconnections to the SBVSE and the nuclear auxiliary building ventilation system (NABVS), provides conditioned air for ventilation to the mechanical part of the SBs. The conditioned air supply to all four divisions of SB is provided independently for each division by the SBVSE (refer to Section 9.4.6). The exhaust air (normal exhaust) from the four divisions of the SB is processed by the NABVS (refer to Section 9.4.3).

9.4.5.1 Design Bases

The SBVS is safety-related and designed to Seismic Category I requirements, except the following:

- Electric air heating convectors (unit heaters) which are non-safety related and Non-Seismic. The heaters are located in stairwell and service access areas and are used for personnel comfort only.

The safety-related components of the SBVS are located inside the SB that is designed to withstand the effect of natural phenomena, such as earthquake, tornados, hurricanes, floods and external missiles (GDC 2). The SBVS vents and louvers are supplied by the SBVSE for supply and the NABVS for exhaust air.

The safety-related components of the SBVS are appropriately protected against dynamic effects and designed to accommodate the effects of, and to be compatible with, the environmental conditions associated with normal operation, maintenance, testing and postulated accidents. The safety-related components of the SBVS remain functional and perform their intended safety function after anticipated operational occurrences and design basis accidents, such as a fire, internal missiles, or pipe break (GDC 4). Refer to Section 3.5.1.1, Section 3.5.1.4, Section 3.5.2, and Section 3.6.1 for

information on compliance with GDC 4 as it relates to protection from missiles and postulated piping failures.

The safety-related components and systems of the SBVS are not shared among nuclear power units (GDC 5).

The essential onsite electrical power systems meet the guidance of NUREG-CR/0660 (subsection A–item 2, and subsection C-item 1) (Reference 1) for protection of essential electrical components (such as contactors, relays, circuit breakers) from failure due to the accumulation of dust and particulate materials (GDC 17). This is accomplished by the roughing prefilters and filters of the supply air units of the SBVSE as described in Section 9.4.6.

The release of radioactive materials to the environment is controlled by meeting the guidance of RG 1.52 (position C.3) (GDC 60). Upon receipt of a high radiation alarm in the mechanical areas of the SBs, the SBVS will direct the exhaust air (accident exhaust) through activated charcoal filtration beds located in the Fuel Building (FB) prior to release through the plant stack. As a backup, the contaminated air also can be processed through activated charcoal filtration beds of the NABVS.

Filtration during normal operation is provided by the NABVS by meeting the guidance of RG 1.140 (positions C.2 and C.3). Refer to Section 9.4.3.

Capability for withstanding or coping with a station blackout (SBO) event is provided to comply with the requirements of 10 CFR 50.63. Acceptance is based on meeting the applicable guidance of RG 1.155, including position C.3.2.4. Refer to Section 8.4 for a description of the design features to cope with the SBO event.

The SBVS provides isolation and confinement of the hot mechanical areas of the SBs. The system also provides reduction of a possible radioactive release into the environment.

In case of fuel handling accident in the FB, or fuel handling accident in the Reactor Building (RB), the exhaust air (accident air) from these buildings is directed through the SBVS activated charcoal filtration beds located in the FB prior to release through the plant stack.

On receipt of containment isolation signal or high radiation signal in the RB, the volume of the FB is isolated to limit leakage out of the FB. The SBVS maintains negative pressure in the FB and air from the FB is directed to the SBVS iodine filtration trains (refer to Section 9.4.2).

The SBVS can be used for containment building ventilation system (CBVS) low flow containment purge in an emergency for redundancy to the CBVS iodine filtration trains (refer to Section 9.4.7).

The seismic design of the system meets the guidance of RG 1.29 (position C.1 for the safety-related portions and position C.2 for the non-safety-related portions).

Air conditioning and heating loads for the SBVS rooms are calculated using methodology identified in ASHRAE Handbook (Reference 11).

- Summer air conditioning loads will be calculated with a maximum outside air design temperature 0 percent exceedance value, using U.S. EPR Site Design Envelope Temperature (See Table 2.1-1). The analysis will be completed for both a normal and accident plant alignment configuration.
- The recirculation cooling units are designed to provide cooling as required to prevent the SBVS room temperatures from exceeding their maximum design temperature.
- Winter heating loads are calculated with the plant operating in an outage alignment configuration. Winter heat loads will be calculated with a minimum outside air design temperature 0 percent exceedance value, using U.S. EPR Site Design Envelope Temperature (See Table 2.1-1).

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

- With outside air ambient design temperature conditions of -40°F to 115°F, the SBVS maintains the following temperature and humidity ranges for the areas serviced.
  - Minimum temperature 50°F.
  - Maximum temperature 104°F.
  - Humidity 25 to 70 percent.
- Controls and maintain a negative pressure within the hot mechanical areas of Safeguard Buildings relative to the outside environment.

The SBVS performs the following safety-related system functions:

- Maintains acceptable ambient conditions for the safety-related components in the hot mechanical 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.

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

- Maintains acceptable ambient conditions (temperature and humidity) in the SB hot mechanical rooms for equipment operation and personnel comfort during normal plant operation and plant maintenance.
- Ventilates the hot mechanical rooms in the SB to maintain a good working environment for personnel in these areas during normal plant operation and plant maintenance.
- Provides personnel comfort heating for the service access areas and the stairwell areas during normal plant operation and plant maintenance.

9.4.5.2 System Description

9.4.5.2.1 General Description

The SBVS is composed of following subsystems:

- SB controlled-area air supply subsystem (see Figure 9.4.5-1).
- SB controlled-area exhaust air subsystem, (see Figure 9.4.5-2).

The SBVS provides ventilation to the four divisions of the SBs. The SB divisions one and four are located on opposite sides of the RB, while SB divisions two and three are housed together and located next to the RB.

The SBVS supplies conditioned air for ventilation to the mechanical area of the SB, divisions one, two, three and four. During normal operation the conditioned air supply to SB divisions is provided independently for each division by the SBVSE (refer to Section 9.4.6). The supply duct of each SB division is equipped with two isolation dampers and one volume control damper. The conditioned air is supplied to the cold and hot mechanical areas at all levels of the four SBs via a ductwork distribution network. The flow rate to each room is calculated based on the minimum air renewal rate, equipment heat loads and heat balance between the rooms to make sure that ambient conditions are maintained within prescribed limits for operation of equipment and the safety and comfort of personnel.

The SBVS air supply and exhaust flows are designed to prevent the spread of airborne contamination and to maintain a negative pressure in the SBs with respect to the outside environment.

The SBVS has two separate modes of exhaust:

- Operational Air Exhaust Mode–The exhaust air (normal exhaust) from all four divisions of the SBs (hot mechanical areas) connects to a single concrete duct in the annulus, which then runs via the FB and connects to the exhaust duct of the NABVS. The exhaust duct of each SB division is equipped with two isolation dampers and one volume control damper. The exhaust air is processed by the

NABVS through a filtration train prior to release through the plant stack (refer to Section 9.4.3).

- Accident Air Exhaust Mode–If airborne contamination is detected in any of the four hot mechanical areas of the SBs or there is a containment isolation signal, the SBVS will automatically direct the exhaust air (accident exhaust) via four separate exhaust air ducts and isolation dampers to one common concrete duct in the annulus. This exhaust duct connects to two accident iodine exhaust filtration trains located in the FB. The exhaust air is processed through one of two redundant and independent iodine filtration trains prior to release through the plant stack. Each iodine filtration train includes inlet and outlet dampers, moisture separator, electric heater, inlet and outlet high efficiency particulate air (HEPA) filters, carbon adsorber, exhaust fan, and backdraft damper. The fans direct the exhaust air to the plant stack.

As a backup, during the accident mode, the contaminated air also can be processed through the iodine filtration units of NABVS (refer to Section 9.4.3).

In case of a fuel handling accident in the FB, or a fuel handling accident in the RB, the accident exhaust air from these buildings is directed and filtered through the SBVS iodine exhaust filtration trains located in the FB, and released through the plant stack.

In case of containment isolation signal or high radiation signal in the RB, the SBVS maintains a negative pressure in the FB and filters all areas of the FB in addition to performing the SBVS accident air exhaust filtration function.

The supply and exhaust duct network of the hot mechanical area in the SBs is equipped with isolation dampers to isolate the following areas from the other rooms:

- Rooms where safety injection and residual heat removal system components in divisions one and four are installed.
- Rooms where severe accident heat removal system components in division four are installed.
- Personnel air lock area in division two.

Recirculation cooling units are provided for the following rooms where high heat load equipment is located:

- Rooms in the SB, divisions one through four, where safety injection and residual heat removal system components are installed.
- Valve rooms in the SB, divisions one through four, where component cooling water system and emergency feedwater system components are installed.
- Rooms where hydrogen and containment atmosphere monitoring system (divisions one and four), and severe accident sampling system (division four) components are installed.

Electric air heating convectors are provided in the service corridors, interconnecting passageway, and stairways to maintain the minimum allowable temperatures in these areas.

The SBVS is designed to circulate sufficient air to prevent accumulation of flammable or explosive gas or fuel-vapor mixture from components such as storage batteries and stored fuel.

Refer to Section 12.3.6.5.6 for ventilation system design features which demonstrate compliance with the requirements of 10 CFR 20.1406.

9.4.5.2.2 Component Description

The major components of the SBVS are listed below, along with the applicable code and standards. Refer to Section 3.2 for the seismic and system quality group classification of these components.

Ductwork and Accessories

The main supply and exhaust air shafts are constructed of concrete with painted surfaces. The air supply and exhaust duct branches for each area are fed from the main supply and exhaust air shafts. These ducts are constructed of steel and structurally designed for fan shutoff pressures. The ductwork meets the design, testing and construction requirements per ASME AG-1-2003 (Reference 2).

Electric Air Heating Convectors (Area Heaters)

The electrical air heating convectors are installed to maintain room ambient conditions. The convectors are controlled by local room temperature sensors and control circuits.

Moisture Separator

The moisture separator is a combination of moisture separator and prefilter. The moisture separator must meet the requirements of RG 1.52 (Reference 10), ASME N509 (Reference 9), and ASME AG-1 (Reference 2). The moisture separator is located upstream of the filter air heater and the HEPA prefilter. The moisture separator shall be a design that has been qualified by testing in accordance with the procedures described in Reference 9.

Filter Air Heaters

Filter air heaters are located upstream of iodine filtration units to prevent excessive moisture accumulation in the charcoal filter beds. The heaters meet the requirements of Reference 2.

Prefilters

The prefilters are located upstream of the HEPA filters and collect large particles to increase the useful life of the high efficiency filters. The prefilters meet the requirements of ANSI/ASHRAE Standard 52.2-1999 (Reference 3).

HEPA Filters

HEPA filters are constructed, qualified and tested in accordance with Reference 2. The periodic inplace testing of HEPA filters to determine the leak tightness is performed per ASME N510-1989 (Reference 4).

Adsorbers

Carbon adsorbers are used to remove radioactive iodine from the exhaust air. The efficiency for removal of methyl iodine is based on the decontamination efficiency assigned during the laboratory tests. The periodic inplace testing of adsorbers to determine the leak-tightness is performed per Reference 4.

Fans

The supply and exhaust fans are centrifugal or vane-axial design with electrical motor drivers. Fan performance is rated in accordance with ANSI/AMCA-210-99 (Reference 5), ANSI/AMCA-211-1987 (Reference 6), and ANSI/AMCA-300-1985 (Reference 7).

Isolation Dampers

Manual dampers are adjusted during initial plant startup testing to establish accurate air flow balance between the rooms. The motor-operated isolation dampers will fail in position in case of power loss. The performance and testing requirements of the dampers are per Reference 2.

Fire Dampers

Fire dampers are installed where ductwork penetrates a fire barrier. Fire damper design meets the requirements of UL 555 (Reference 8) and the damper fire rating is commensurate with the fire rating of the barrier penetrated.

Recirculation Cooling Units

The recirculation cooling units consist of a fan section, a water cooling section, and a moisture separator. The fan is driven by an electric motor. The cooling coils are finned coil type and are connected to the safety chilled water system (SCWS). The cooling coils are designed in accordance with Reference 2. The moisture separator collects condensate which is directed to drain system.

9.4.5.2.3 System Operation

Normal Plant Operation

During normal plant operation, the fresh conditioned air is supplied to four divisions of the SBs independently for each division by the SBVSE (refer to Section 9.4.6). The isolation dampers on each supply duct are in the open position and the volume control dampers on each supply duct are set to a flow rate in order to maintain a negative pressure in the controlled areas compared to the atmospheric pressure.

The room air conditioning is obtained by the supply and exhaust air flows based on the minimum air renewal rate, equipment heat load, and heat balance between the rooms. The air is heated or cooled to maintain the required ambient conditions of the rooms.

The operational air exhaust from the four divisions of the SBs (hot area) is processed by the NABVS. The isolation dampers on each exhaust duct are in open position, and the volume control dampers on each exhaust duct are set to a flow rate in order to maintain negative pressure in the controlled areas.

The accident air exhaust isolation dampers are in open position, and the iodine filtration trains located in the FB are in a standby mode.

Isolation dampers for switching the fuel handling accident exhaust from both FB and Containment Building are in the closed position.

The associated dampers for the following areas are in the open position:

- Supply air flow to the rooms where safety injection and residual heat removal system equipment is located in divisions 1 and 4.
- Supply and exhaust air flow to the rooms where severe accident heat removal system components are located in division 4.
- Supply and exhaust air flow to and from the personnel air lock area in division 2.

A negative pressure is maintained in the SBs relative to the outside environment by regulating the SBVS supply and exhaust flows. A negative pressure is also maintained for the iodine risk rooms (safety injection, residual heat removal, and severe accident heat removal systems equipment rooms) relative to adjacent rooms.

The electrical air heating convectors are used in the service corridors, interconnecting passageway, and stairways to maintain comfortable temperatures in these areas. The operation of convectors is automatically controlled by the temperature sensors located in these areas.

The recirculation cooling units provide recycled cool air to the rooms where high heat load equipment is located. The operation of recirculation cooling units is automatically controlled by the temperature sensors located in these rooms.

Plant Outage Condition

During the plant outage condition, the system configuration will remain the same as during normal plant operation except the following:

- Air supply and exhaust of the rooms where the safety injection and residual heat removal systems equipment are located in SB divisions 1 and 4 are isolated by closing the associated dampers.
- If the personnel air lock is open, the air supply and exhaust air flow to and from the personnel air lock area is placed in service by manually closing or opening the associated dampers.
- If maintenance is performed on the equipment or systems which pose delayed iodine release hazard, the exhaust air from these areas is diverted to the iodine filtration plenum of the NABVS prior to discharge through the plant stack (refer to Section 9.4.3).

Abnormal Operating Conditions

Loss of Recirculation Cooling or Area Ventilation

Failure of recirculation cooling or area ventilation in one SB division has no effect on safety function of SBVS since other three unaffected SB divisions are capable of performing the necessary safety function.

Two supply and exhaust dampers are provided for isolation of the hot mechanical area of each SB division. If one damper fails, the other damper can perform the safety function.

Loss of an Accident Iodine Exhaust Filtration Train

The SBVS provides two accident exhaust iodine filtration trains. Failure of one filtration train has no effect since the unaffected train can perform the necessary filtration function.

Redundant switching dampers are arranged in parallel configuration. As such failure of one damper has no consequence since the unaffected damper can perform the necessary function.

If both SBVS exhaust iodine filtration trains fail, the negative pressure and filtering function of SB hot mechanical area, and fuel handling accident exhaust in the FB can be provided by the exhaust filtration trains of NABVS (See Section 9.4.3). The fuel

handling accident exhaust in the RB can be provided by the exhaust filtration trains of CBVS (refer to Section 9.4.7).

Loss of Offsite Power

The following equipment will remain operational during loss of offsite power (LOOP). The power supply for this equipment is supplied from the corresponding emergency diesel generators.

- Dampers in all divisions of SB.
- Iodine exhaust filtration trains located in the FB.
- Dampers to the zones that need to be isolated and confined.

Station Blackout

Station black out (SBO) does not lead to release of radioactivity inside the SB, FB and RB. The system filtering function is therefore not required during SBO. However, the following components are supplied from the SBO diesel generators alternate AC (AAC) power:

- Supply air control dampers to the controlled areas in divisions one and four, to isolate air supply when exhaust is not in operation due to SBO.
- Recirculation cooling units in the SB divisions one and four, where the EFW valves are located.

Loss of Ultimate Heat Sink

During loss of ultimate heat sink (LUHS), the air flow of the recirculation cooling units is cooled by the chilled water provided by the SCWS. Two water-cooled chillers are located in divisions two and three, and two air-cooled chillers are located in divisions one and four. In case of LUHS, the water-cooled chillers are not available. With the safety chilled water divisions 1/2 and 3/4 interconnect, the safety chilled water is then supplied by air-cooled chillers which provide the cooling function for the recirculation cooling units located in divisions one, two, three and four.

Loss of Coolant Accident

In the event of a loss of coolant accident (LOCA), the air supply from the SBVSE and the exhaust to the NABVS are closed automatically. Exhaust air is then diverted by opening or closing the associated dampers to process the exhaust air through the SBVS iodine exhaust filtration trains located in the FB.

In the event of a LOCA, the containment isolation signal or high radiation signal in the RB initiates isolation of the FB from NABVS supply and exhaust duct to limit leakage

into the FB. The SBVS maintains negative pressure in the FB and exhaust air from the FB is directed to the SBVS iodine filtration trains (refer to Section 9.4.2).

Iodine Presence in the SB Rooms

In the event of a failed fuel element and residual heat removal pump seal leakage, high iodine is expected to be present in only one of the four divisions at a time, and it is necessary to purify the air in this division for personnel access. The air supply and exhaust flow for the affected division is increased to purge the possibly contaminated areas, while air supply and exhaust for the other three divisions is decreased. This is achieved by opening or closing the isolation dampers and partially opening the control dampers in order to maintain an acceptable total exhaust air flow to the NABVS iodine filtration train.

Fuel Handling Accident in the FB

In the event of a fuel handling accident in the FB, the exhaust air from the FB is processed through the SBVS iodine filtration trains located in the FB. The damper configuration is as follows:

- Associated dampers in the ducts from the FB are in the open position.
- Associated dampers in the ducts from the RB are in the closed position.
- Associated dampers for the SBVS accident air exhaust are in the closed position.
- One (or both) SBVS iodine filtration trains are in service.

Fuel Handling Accident in the RB

In the event of a fuel handling accident in the RB, the exhaust air from the RB is processed through the SBVS iodine filtration trains located in the FB. The damper configuration is as follows:

- Associated dampers in the ducts from the RB are in the open position.
- Associated dampers in the ducts from the FB are in the closed position.
- Associated dampers for the SBVS accident air exhaust from the SB are in the closed position.
- One (or both) SBVS iodine filtration trains are in service.

Residual Heat Removal System Break outside Containment

The rooms inside SB divisions one and four containing the residual heat removal (RHR) equipment and piping are equipped with isolation dampers in the supply and

exhaust air ducts. These dampers are manually closed during RHR operation to prevent the spread of steam and airborne contamination due to a pipe failure.

Operation of Containment Heat Removal System in Severe Accidents

The rooms inside SB division four containing the severe accident heat removal system equipment are isolated from the other rooms by closing the associated dampers located in the supply air ducts for each room.

9.4.5.3 Safety Evaluation

The SBVS is designed to maintain ambient conditions in areas of the SB divisions one through four where engineered safety equipment is located. This permits personnel access and allows safe operation of the equipment during normal plant operation, outages, and under all anticipated occupational occurrences, including postulated accident events.

The SBVS provides isolation and confinement of the hot mechanical areas of the SBs. Two isolation dampers and one volume control damper are provided in the supply and exhaust ducts to make sure that hot mechanical areas can be purged or isolated without any leakage. The hot mechanical areas are maintained at negative pressure with respect to the outside atmospheric air pressure. The system also provides reduction of radioactive release into the environment.

Each recirculation cooling unit for SB divisions one through four operates independently of the recirculation cooling unit in the other divisions. In case of a recirculation cooling unit failure inside one division, the recirculation cooling units for the other three divisions are unaffected.

Upon receipt of a high radiation alarm in the hot mechanical areas of the SBs, the SBVS directs the exhaust through the SBVS activated charcoal filtration beds located in the FB prior to release through the plant stack. As a backup, the contaminated air also can be processed through the activated charcoal filtration beds of NABVS. Sufficient redundancy is provided to provide reasonable assurance of proper system operation with one active component out of service.

Confinement of the four SB hot mechanical areas and startup of the SBVS accident iodine filtration trains is initiated by the safety automation system (SAS) signal.

Isolation dampers in the supply and exhaust ducts are provided for the SB division one through four rooms where safety injection and residual heat removal system equipment is located. These dampers close during RHR operation to prevent the spread of steam and airborne contamination due to a RHR system pipe failure.

Redundant components are powered from different electrical divisions to remain available in case of failure of one division. As a backup, power is supplied to the engineered safety equipment by the emergency diesel generators (EDG).

Capability for withstanding or coping with an SBO event is met by the design of the AAC power source satisfying the ten minute criteria; (i.e., the AAC power source can be started from the main control room (MCR) within ten minutes of the onset of an SBO event). The SBO diesel generators are designed to operate for a minimum of twenty-four hours with available onsite fuel supplies.

9.4.5.4 Inspection and Testing Requirements

Refer to Section 14.2 (test abstracts #083 and #203) for initial plant startup test program. Initial inplace acceptance testing of SBVS components is performed in accordance with Reference 2, and Reference 4.

Refer to Section 16 (SR 3.7.12) for surveillance requirements.

9.4.5.5 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. The radiation instrumentation requirements for controlling airborne radioactivity releases via the plant stack are addressed in Section 11.5.

The minimum instrumentation, indication and alarms for ESF filter systems are provided in Table 9.4.1-1.

9.4.5.6 References

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8. UL 555, "Standard for Fire Dampers," Underwriters Laboratories, Sixth Edition, June 1999.

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