9.4.2 Fuel Building Ventilation System

The fuel building ventilation system (FBVS) is designed to maintain acceptable ambient conditions in the Fuel Building (FB), to permit personnel access, and to control airborne radioactivity in the area during normal operation, anticipated occurrences, and following fuel handling accidents.

The conditioned air supply to the FB is provided by the nuclear auxiliary building ventilation system (NABVS) (refer to Section 9.4.3). The exhaust from the building is also processed by the NABVS through a filtration train, and the exhaust air is directed to the plant stack (refer to Section 9.4.3).

9.4.2.1 Design Bases

The following components are safety-related and designed to Seismic Category I requirements:

- Fuel handling hall isolation dampers.
- Isolation dampers for the fuel handling hall located in front of the equipment hatch.
- Isolation dampers for the room located in front of the emergency airlock.
- NABVS supply and exhaust isolation dampers to and from FBVS.
- FB isolation dampers to safeguard building ventilation system (SBVS).
- Electric heaters for heating of rooms which have safety-related systems, structures, or components containing borated fluid, and the rooms surrounding the extra borating system tanks.
- Recirculation cooling units in the extra borating system pump rooms, and fuel pool cooling system pump rooms.
- FBVS exhaust duct.

The FBVS air supply duct and other components of the FBVS are designated as Supplemental Grade (NS-AQ) safety class and Seismic Category II.

The FBVS components are located inside the FB structure, which is designed to withstand the effects of natural phenomena, such as earthquake, tornados, hurricanes, floods and external missiles (GDC-2).

The safety functions of the FB ventilation system can be performed assuming a single active component failure coincident with the loss of offsite power (LOOP).

The seismic design of the system components meets the guidance of RG 1.29 (Position C.1 for safety-related portion and Position C.2 for non-safety-related portion). The quality group classification and Seismic Category of system components meet the requirements of RG 1.26 and 1.29.

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

The release of radioactive material to the environment is controlled by meeting the guidance of RG 1.140, positions C.2 and C.3 (GDC-60). RG 1.52 is not applicable because the FBVS is not required to operate during post-accident engineered safety features (ESF) atmospheric cleanup. In case of radioactive contamination, the system will automatically direct the building exhaust through activated charcoal filtration beds located in the NABVS.

The FBVS provides appropriate ventilation and filtration to limit potential release of airborne radioactivity to the environment from the fuel storage facility under normal operation and in the event of a fuel handling accident in the fuel pool area. The design of the ventilation system meets the guidance of RG 1.13, Position C.4 (GDC-61).

The FBVS provides the following important non-safety-related functions:

- Controls and maintains a negative pressure during normal operation within the FB relative to the outside environment. Rooms identified as having possible radioactive contamination are designed to be at a negative pressure relative to the adjacent rooms to make sure air flows from areas of low radioactivity to areas of potentially higher radioactivity.
- Maintains these ambient conditions inside the FB during normal and fuel handling operation:

  A. Minimum temperature: 50°F.

  B. Maximum temperature: 113°F.

  C. Humidity: 25 to 70 percent.

  The following ambient conditions are maintained in the fuel pool area:

  D. Minimum temperature: 68°F.

  E. Maximum temperature: 104°F.

  F. Humidity: 30 to 70 percent.

- Provides heating, via electric heaters, in the boron rooms to prevent crystallization in the borating system piping. Electric heaters in the fuel pool rooms prevent condensation on the walls.

- Maintains the airborne radioactivity levels within the FB below the maximum permissible concentrations limits of 10CFR20 and consistent with the as low as reasonably achievable (ALARA) dose objectives of 10CFR50, Appendix I (refer also to Section 12.1 and Section 12.3.3).

9.4.2.2 System Description

A simplified diagram of the FBVS is shown in Figure 9.4.2-1—Fuel Building Ventilation System.

9.4.2.2.1 General Description

The FBVS provides air distribution for ventilation of the FB. The air supply to, and exhaust from, each room of the FB is provided by a network of supply and exhaust ducts which are connected to the NABVS. The conditioned air is supplied to all levels of the building through a duct 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. This maintains ambient conditions during normal operation within prescribed limits for operation of equipment and personnel safety and comfort.

The supply air is the conditioned outside air that is filtered, cooled or heated, humidified by the NABVS, and delivered to the FB rooms through the FBVS supply duct network.

The FBVS exhaust system is designed to limit spread of the airborne contaminants and to maintain a negative pressure in the FB with respect to the outside environment. The FBVS exhaust is processed through the filtration trains of the NABVS prior to discharge through the plant stack. The FBVS is divided into two subsystems referred to as Cell 4 and Cell 5. The cells separate the ventilation systems serving the redundant systems in the FB and each cell serves approximately half of the building. The supply and exhaust duct branches to each room are fed from the main supply and exhaust HVAC shafts in the building. These HVAC shafts are connected to the NABVS.

If high radiation is detected within the FB, the exhaust air is diverted to the iodine filtration trains of the NABVS prior to discharge through the plant stack (refer to Section 9.4.3).

Isolation dampers are provided to isolate the supply and exhaust ducts of the room in front of the equipment hatch, fuel pool area, and the room in front of the emergency airlock.

Isolation dampers are also provided to isolate the FB from NABVS supply and exhaust ducts.

Electric heaters are provided for heating of the boron rooms and the rooms surrounding the extra borating system tanks to avoid boron crystallization in borating system piping. Electric heaters are also provided for the fuel pool room to prevent condensation on the walls, and other selected rooms to maintain room ambient conditions.

Recirculation cooling units are provided in the fuel pool cooling pump rooms and extra-borating system pump rooms to limit the maximum room temperature, allowing proper operation of the equipment in these rooms.

9.4.2.2.2 Component Description

The major components of the FBVS are described as follows. Refer to Section 3.2 for the seismic and system quality group classification for these components. Individual codes and standards applicable to each component are also listed in the following paragraphs.

Ductwork and Accessories

The main supply and exhaust duct shafts for Cell 4 and Cell 5 in the FB are constructed of concrete with a painted surface. Ducting from the NABVS to the main supply and exhaust shafts is constructed of galvanized sheet steel.

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

Electrical Heaters

Unit heaters maintain the room ambient conditions. The heaters meet the requirements of Reference 1.

Fan Heaters

Fan heaters consist of a fan section and an electrical heater section. The casing unit is constructed of heavy gauge steel. The fan is vane-axial design with electrical motor driver.

Recirculation Cooling Units

The recirculation cooling units consist of a fan section and a water cooling section. The casing unit is constructed of heavy gauge steel. The fan is electric motor driven. The condensate from the units is directed to the drain system. The cooling coils are designed in accordance with Reference 1.

Dampers

Manual dampers are adjusted during initial plant startup testing to establish accurate air flow balance between rooms. The motorized dampers will fail to "close" or "open" position in case of loss of power, depending on the safety function of the damper. The performance and testing requirements of the dampers will be per Reference 1.

Fire Dampers

Fire dampers are installed where ductwork penetrates a fire barrier. Fire damper design meets the requirements of UL 555 (Reference 2) and the damper fire rating is commensurate with the fire rating of the barrier penetrated.

9.4.2.2.3 System Operation

Normal Plant Operation

During normal plant operation, fresh conditioned air is supplied to the FB rooms by the FBVS supply duct network. The supply air to the FB is provided by the NABVS. The room air conditioning is provided by the supply and exhaust air flows based on the minimum required 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.

During normal operation, isolation dampers are open to provide ventilation of the FB. These isolation dampers also can be controlled by the NABVS.

During normal operation, system fire dampers are in the open position.

A negative pressure is maintained in the FB relative to the outside environment by regulating the FBVS supply and exhaust flows. A negative pressure is also maintained for rooms having the potential for radioactive contamination (principally due to iodine) relative to the adjacent rooms to provide air flows from areas of low radioactivity to areas of potentially higher radioactivity.

Electrical heaters operation is controlled by temperature sensors in the boron rooms and the fuel pool rooms. Non-safety-related electrical heaters are operated as needed, depending on the room temperatures.

Recirculation cooling units are used for fuel pool cooling system pump rooms, and extra-borating system pump rooms to make sure that acceptable temperatures are maintained within the rooms for proper operation of the components and safe personnel access. The recirculation cooling units for the fuel pool cooling system pump rooms operate when the pumps are in operation. The recirculation cooling units for the extra-borating system pump rooms operate based on room temperature to provide recycled cool air.

During plant outages, the supply and exhaust ducts of the room in front of the equipment hatch are isolated so that the air flow is from the FB to the Reactor Building (RB). When the equipment hatch is opened, this room is considered as part of the RB and is therefore ventilated by the RB ventilation system.

In the event radioactive contamination is detected in the FB during normal operation, or a potential airborne radioactive hazard exists during maintenance of equipment or systems, the exhaust air is diverted to iodine filtration trains of the NABVS prior to discharge through the plant stack. Iodine activity is detected separately in each cell.

Abnormal Operating Conditions

Failure of Supply and Exhaust Air

The FBVS supply and exhaust air systems are non-safety related. Failure of supply and exhaust air systems in the NABVS will lead to the loss of supply and exhaust functions of FBVS. In this case, negative pressure with respect to the outside atmosphere and room temperatures of the FB cannot be maintained; however, the recirculation cooling units and heaters will maintain acceptable temperatures in the fuel pool cooling and extra borating system pump rooms.

Failure of Heaters and Recirculation Cooling Units

In each room provided with safety-related heaters, a sufficient number of heaters are provided to fulfill the single failure criteria of the heaters. Redundant heaters, two 100 percent capacity units, are provided in small rooms. Three 50 percent or four 33 percent capacity heaters are provided for larger rooms. For heaters serving the boron and fuel pool areas, the required power has been calculated based on failure of an electrical division. Thus, failure of one electrical division will not prevent other divisions from supplying power and fulfilling their functions.

Failure of one recirculation cooling unit will lead to the loss of cooling in the corresponding room. As a result, the extra borating and fuel pool cooling system pumps located in that room may not operate properly. Redundant extra borating and fuel pool cooling system pumps located in a separate room and served from a separate train will, however, still be operational.

Failure of Isolation Dampers

For safety-related isolation functions, automatic isolation is provided in the design by placing two dampers in series, with power for each damper supplied by a different electrical division. Failure of one electrical division thus does not hinder the isolation function of the system.

Fuel Handling Accident in the Fuel Building

In the event of a fuel handling accident in the FB, the air exhaust and supply of the space above the fuel pools are isolated by closing the isolation dampers serving this room. This occurs automatically by the sampling activity monitoring system signal. Alternatively, this isolation also can be performed via local push buttons located in the fuel pool room.

To prevent spread of airborne contamination, the iodine filtration trains of the safeguard building ventilation are used to process the exhaust air and to maintain the required pressure in the FB fuel pool hall (refer to Section 9.4.5). The remainder of the FB is ventilated by the NABVS.

Fuel Handling Accident in the Containment Building

In the event of a fuel handling accident in the Containment Building, to preclude uncontrolled migration of contamination, the FB areas in front of the emergency airlock and in front of the equipment hatch are isolated by closing the air exhaust and supply dampers dedicated to these areas.

Prior to opening the emergency airlock during an outage, the air exhaust in front of the emergency airlock is isolated by closing the dampers dedicated to this area.

Prior to opening the equipment hatch during an outage, the air supply and exhaust for the equipment area in front of the hatch are isolated by closing the dampers dedicated to this area.

Loss of Coolant Accident (LOCA)

In the event of 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.

Loss of Offsite Power (LOOP)

Upon loss of offsite power, all motorized dampers will fail to the “close” position, limiting pathways for potentially contaminated air to leak out to the environment.

The following equipment will remain operational during LOOP:

- Electric heaters in the boron system rooms.
- Recirculation cooling units in the fuel pool cooling system pump rooms, and extra borating system pump rooms.
- Dampers for isolating the fuel pool room and FB.

The power for the equipment listed above is supplied from the corresponding emergency diesel generators.

Station Blackout (SBO)

In the event of SBO, the following equipment will remain operational:

- Electric heaters in the extra borating system pump rooms.
- Isolation dampers for the fuel pool room so that the dampers can be closed in the event of high temperature in the fuel pool.

The power for the equipment listed above is supplied from the SBO emergency diesel generators (SBODG).

9.4.2.3 Safety Evaluation

The FBVS provides the following safety-related functions:

- Automatic isolation of the supply and exhaust air to the fuel handling hall in order to mitigate the consequences of a fuel handling accident in the hall.
- Manual isolation from the main control room (MCR) of the supply and exhaust airflow to the hall in front of the equipment hatch prior to opening of the hatch. This isolation mitigates the consequences of a fuel handling accident in the RB with the hatch opened.
- Automatic isolation of the supply airflow to the room in front of the emergency airlock in order to mitigate the consequences of a fuel handling accident in the RB. The isolation of the exhaust airflow from the room in front of the emergency airlock is performed manually from the MCR prior to opening of the emergency airlock.
- Automatic isolation of the FB from NABVS supply and exhaust ducts in the event of containment isolation signal or high radiation signal in the RB. The SBVS maintains negative pressure in the FB and filters the FB atmosphere through SBVS iodine filtration trains.
- Maintains ambient conditions for boron rooms during normal operation, abnormal operation, and postulated accident events.
- Maintains ambient conditions in the extra borating system pump rooms and the fuel pool cooling system pump rooms during normal, abnormal, and postulated accident events.
- Safety-related components can function as required with failure of a single active component. The safety-related redundant components are powered from different electrical divisions so that the system can remain operable in case of failure of one of the electrical divisions.

9.4.2.4 Inspection and Testing Requirements

Refer to Section 14.2 (test abstracts #081and #203) for initial plant startup test program. Initial in-place acceptance testing of FBVS components will be performed in accordance with Reference 1.

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

9.4.2.6 References

1. ASME AG-1-2003, "Code on Nuclear Air and Gas Treatment," The American Society of Mechanical Engineers, 2003 (including the AG-1a, 2004 Addenda).

2. UL 555, "Standard for Fire Dampers," Underwriter's Laboratories, Sixth Edition, June 1999.

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