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 vent 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 pool floor 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 fan heaters for heating of rooms that 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). Upon receipt of a containment isolation signal, the FBVS supply and exhaust is isolated from the NABVS. Potential bypass leakage from primary containment is captured and filtered by the SBVS iodine filtration trains before being released into the environment.

The seismic design of the system components meets the guidance of RG 1.29 (Position C.1 for the safety-related portion and Position C.2 for the non-safety-related portion). Table 3.2.2-1 provides the seismic design and other design classifications for components in the FBVS.

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 high radiation alarm in the FB (refer to Table 11.5-1, Monitors R-17 and R-18), 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).

Air conditioning and heating loads for the FB Rooms are calculated using methodology identified in ASHRAE Handbook (Reference 3).

- 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 cooling supply units are designed to provide cooling as required to prevent the FB room temperatures from exceeding their maximum design temperature.
- Winter heating loads will be 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 FBVS provides the following 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:
  - Minimum temperature: 50°F.
  - Maximum temperature: 113°F.
  - Humidity: 25 to 70 percent.

  The following ambient conditions are maintained in the fuel pool area:
  - Minimum temperature: 68°F.
  - Maximum temperature: 104°F.
  - Humidity: 25 to 70 percent.

  The following ambient conditions are maintained in the boric acid rooms:
  - Minimum temperature: 68°F.
  - Maximum temperature: 113°F.
  - Humidity: 25 to 70 percent.
- Provides heating via air supply duct heaters and fan heaters to maintain minimum ambient room temperature. Electric heaters in the fuel pool rooms prevent condensation on the walls. For non-safety-related equipment located in the same rooms with safety-related equipment, the seismic classification for the non-safety-related equipment is described in Section 3.7.3.8 for interaction of Seismic Category I subsystems.
- 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 Sections 12.1 and 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.

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

9.4.2.2.1 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 vent 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 (Monitors R-17 and R-18, Table 11.5-1), the exhaust air is diverted to the iodine filtration trains of the NABVS prior to discharge through the vent stack (refer to Section 9.4.3, Section 11.5.3.1.7, and Table 11.5-1, Monitors R-17 and R-18).

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. Table 3.2.2-1 provides the seismic design and other design classifications for components in the FBVS.

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 (Reference 1).

Electric Heaters

Unit heaters maintain the room ambient conditions. The heaters meet the requirements of ASME AG-1 (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 ASME AG-1 (Reference 1).

Dampers

Manual dampers are adjusted during initial plant startup testing to establish accurate air flow balance between rooms. The motor-operated isolation dampers will fail as-is in case of loss of power. The performance and testing requirements of the dampers will be per ASME AG-1 (Reference 1).

Fire Dampers

Fire dampers are installed where ductwork penetrates a fire barrier. Fire damper design meets the requirements of NFPA 80 (Reference 2) and NFPA 90A (Reference 12) and the damper fire rating is commensurate with the fire rating of the barrier penetrated. Fire dampers are equipped with fusible links for automatic closure when the temperature reaches a predetermined setpoint.

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 (refer to Table 11.5-1, Monitors R-17 and R-18) 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 vent stack (refer to Section 11.5.3.1.7 and Table 11.5-1, Monitors R-17 and R-18). 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, two 100 percent capacity heaters are provided to fulfill the single failure criteria of the heaters. For heaters serving a safety-related function, 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, Section 11.5.3.1.7, and Table 11.5-1, Monitor R-19). However, no credit is taken for iodine filtration in the fuel handling accident dose consequence analysis described in Section 15.0.3.10.2. 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)

Upon receipt of a containment isolation signal, the following functions are initiated automatically:

- Closes FBVS exhaust air isolation dampers to NABVS.
- Closes FBVS supply air isolation dampers from NABVS.
- Opens FBVS exhaust air isolation dampers to exhaust air from the entire Fuel Building to the SBVS.
- Opens isolation dampers for the SBVS Accident Exhaust Iodine Filtration Trains.
- Starts SBVS iodine filtration train fans to pull air through SBVS Accident Exhaust Iodine Filtration Trains and to direct exhaust air to the vent stack. The SBVS maintains negative pressure in the Fuel Building.

Loss of Offsite Power (LOOP)

The following equipment will remain operational during LOOP:

- Electric heaters in the extra borating pump rooms and pipe chase.
- 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 and pipe chase.
- 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 FB from NABVS supply and exhaust ducts in the event of containment isolation signal. The SBVS maintains negative pressure in the FB and filters the FB atmosphere through SBVS iodine filtration trains.
- Maintains ambient conditions in the extra borating system pump rooms and pipe chase 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

The FBVS major components, such as dampers, cooling units, heaters, and ducts are located to provide access for initial and periodic testing to verify their integrity.

Test and analysis will be completed during normal operation with the system operating in an accident alignment. Analysis will use as-built information from equipment to extrapolate the performance of the air-conditioning system. Analysis will show that the equipment performance is adequate to maintain design conditions during plant operating conditions.

Initial in-place acceptance testing of the FBVS is performed as described in Section 14.2 (test abstracts #081 and #203), Initial Plant Test Program, to verify the system is build in accordance with applicable programs and specifications.

The FBVS is designed with adequate instrumentation and temperature indicating devices to enable testing and verification of equipment function and heat transfer capability.

During normal plant operation, periodic testing of FBVS is performed to demonstrate system and component operability and integrity.

Isolation dampers are periodically inspected and damper seats replaced as required.

Recirculation cooling units are tested by manufacturer in accordance with Air Movement and Control Association (AMCA) standards (References 4, 5, and 6). Cooling coils are hydrostatically tested in accordance with ASME AG-1 (Reference 1) and their performance is rated in accordance with the Air Conditioning and Refrigeration Institute (ARI) standards (Reference 7).

Ductwork is leak-tested in accordance with the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) technical manual “HVAC Air Duct Leakage Test Manual” (Reference 8), American Society of Mechanical Engineers, ANSI/ASME N510 (Reference 9), ASME AG-1 (Reference 1), and RG 1.52 (Reference 11).

Fan heaters are tested in accordance with ASME AG-1, Section CA (Reference 1).

Periodic testing and inspections identify systems and components requiring corrective maintenance, and plant maintenance programs correct deficiencies.

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 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 vent stack are addressed in Section 11.5.3.1.7 and Table 11.5-1, Monitors R-17, R-18, and R-19.

9.4.2.6 References

1. ASME AG-1, “Code on Nuclear Air and Gas Treatment,” The American Society of Mechanical Engineers, 1997 (including the AG-1a-2000 “Housings” Addenda).

2. NFPA 80, “Standard for Fire Doors and Other Opening Protectives,” National Fire Protection Association Standards, 2007.

3. “ASHRAE Handbook Fundamentals,” American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc., 2005.

4. ANSI/AMCA Standard 210-99, “Laboratory Methods of Testing Fans for Aerodynamic Performance Rating,” American National Standards Institute/Air Movement and Control Association International, 1999.

5. AMCA Publication 211-87, “Certified Ratings Program – Air Performance,” Air Movement and Control Association International, 1987.

6. ANSI/AMCA Standard 300-85, "Reverberant Room Method of Testing Fans for Rating Purposes," American National Standards Institute/Air Movement and Control Association International, 1985.

7. ANSI/ARI Standard 410-2001, "Forced-Circulation Air-Cooling and Air-Heating Coils," Air Conditioning and Refrigeration Institute, 2001.

8. "HVAC Air Duct Leakage Test Manual," Sheet Metal and Air Conditioning Contractors' National Association, 1985.

9. ANSI/ASME N510-1989, "Testing of Nuclear Air-Treatment Systems," American National Standards Institute/The American Society of Mechanical Engineers, 1989.

10. Deleted.

11. NRC Regulatory Guide 1.52, Rev. 3, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Post Accident Engineered Safety Feature Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," 2001.

12. NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilation Systems," National Fire Protection Association Standards, 2002.

Next File