9.4.3 Nuclear Auxiliary Building Ventilation System

The nuclear auxiliary building ventilation system (NABVS) provides conditioned air to the Nuclear Auxiliary Building (NAB) to maintain acceptable ambient conditions, to permit personnel access, and to control the concentration of airborne radioactive material during normal operations and anticipated occupational occurrences. The system also provides conditioned air to the Fuel Building (FB), Containment Building, and the annulus area between the Containment Building and the Shield Building.

The exhaust air from the NAB, FB, Safeguard Building (SB), Containment Building, and the annulus is processed through the NABVS filtration trains prior to release to the environment via the vent stack.

9.4.3.1 Design Basis

The NABVS provides a safety-related function to provide isolation between the vent stack and the NABVS exhaust. A safety-related Seismic Category I backdraft damper is located in the NABVS exhaust at the vent stack.

All remaining components of the NABVS are non-safety related and Non-Seismic, as specified in Section 3.2.

- The NABVS meets GDC-2 for all components as it relates to meeting the seismic design criteria based on the guidance of RG 1.29 Position C.2 (GDC-2).
- The NABVS has no shared systems or components with other nuclear power units (GDC-5).
- The NABVS meets GDC-60, as it relates to the ability of the system to limit release of gaseous radioactive effluents to the environment. The NABVS exhaust iodine filtration trains meet the guidance of RG 1.140 Positions C.2 and C.3. RG 1.52 is not applicable because the NABVS is not required to operate during post-accident engineered safety features (ESF) atmospheric cleanup. The air flow rate of a single cleanup filtration unit will not exceed 30,000 cfm.

The NABVS performs the following safety-related function:

- A safety-related backdraft damper is located in the NABVS exhaust at the vent stack. This backdraft damper isolates the NABVS as required from the other safety systems exhausting to the vent stack during accident operation.
- During accident conditions, the NABVS is shut down and the safety-related annulus ventilation system (AVS) and safeguard building (controlled area) ventilation system (SBVS) operate. Closure of the backdraft damper is initiated by a differential pressure between the plant vent stack and the NABVS duct.
- The remaining portions of the NABVS perform no safety-related functions and the system is not required to operate during a design basis accident.

The NABVS performs the following non-safety-related system functions:

- Controls and maintains a negative pressure within the NAB relative to the outside environment.
- Maintains the following temperature and humidity ranges for the areas serviced:
  - Minimum temperature 50°F.
  - Maximum temperature 113°F.
  - Humidity 15 to 70 percent.
- Laboratory
  - Minimum temperature 65°F.
  - Maximum temperature 79°F.
  - Humidity 30 to 70 percent.

9.4.3.2 System Description

9.4.3.2.1 General Description

The NABVS is divided into the following subsystems:

- Supply air.
- NAB air supply.
- Exhaust air.

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

Supply Air Subsystem

The outside-conditioned air is supplied through a set of redundant filter trains consisting of HEPA filters, heating coils, and cooling coils. See Figure 9.4.3-1—Nuclear Auxiliary Building Supply Air Filtration and A/C Trains. The conditioned supply air maintains ambient conditions in the areas served by this system within prescribed limits for operation of equipment, and personnel safety and comfort. The NABVS provides conditioned air to the following areas:

- NABVS air distribution supply air shafts and ductwork.
- Containment building ventilation system (refer to Section 9.4.7).
- Fuel building ventilation system (refer to Section 9.4.2).

- Annulus ventilation system (refer to Section 6.2.3).

The outside air is provided through intake mesh grills and louver dampers. The outside air intake openings are equipped with electrically heated and weather protected grills to prevent ice formation and ingress of insects and debris. The intakes are designed to provide adequate outside air to meet the distribution requirements of supply air under design conditions of the plant.

The air intake plenum supplies air through three filtration trains. Each train consists of a preheater, prefilter, cooling coil, heater, silencer, and air dampers. Four supply air fans take suction from the supply fan inlet plenum and supply air to the outlet air shaft for further distribution to the supply shafts of different buildings.

The design supply air flow to serve the NAB, FB, annulus ventilation system, and Containment Building would require all three trains to be in operation. However, during normal operation, a reduced air flow rate can be used that requires only one supply train to be in operation.

Nuclear Auxiliary Building Air Supply Subsystem

This subsystem supplies air to the NAB to maintain ambient conditions within the prescribed limits for equipment operation and personnel access. See Figure 9.4.3-2—Nuclear Auxiliary Building Air Supply and Exhaust Subsystem.

The conditioned air is supplied to all levels of the building through air shaft cells and a duct distribution network. The flow rate to each room is calculated based on the room volume and equipment heat loads to maintain ambient conditions. The normal operation of the system is to maintain a negative pressure in the building with respect to the outside atmosphere to prevent leakage of potentially contaminated air to the environment. The air flow paths within the NAB are designed so that if radiation is detected, migration of contaminated air from areas of potentially high radioactivity to areas of potentially low radioactivity is limited.

The recirculation cooling units are provided for the rooms with high heat loads. Cooling coil units with fans provide recycled cooled air to the rooms where vapor compressors, electrical switchgear, and transformers are located.

Exhaust Air Subsystem

This subsystem processes exhaust air through filtration trains and charcoal filtration trains to limit airborne radioactivity released through the vent stack. See Figure 9.4.3-3—Nuclear Auxiliary Building Exhaust Filtration Trains Subsystem.

The system processes air exhaust from the following areas:

- FB Cell 5 exhaust (refer to Section 9.4.2).

- FB Cell 4 exhaust (refer to Section 9.4.2).
- NAB Cell 3 exhaust, including annulus exhaust.
- NAB Cell 2 exhaust.
- NAB Cell 1 exhaust.
- SB Cell 6 exhaust (refer to Section 9.4.5).
- Containment Building full flow purge exhaust (refer to Section 9.4.7).

The filtration trains to process exhaust air from the above areas are located inside the NAB. Each filter train consists of a prefilter and a HEPA filter. Under normal operating conditions, these flow paths open into a common exhaust plenum. Four exhaust fans take suction from this plenum and discharge into another exhaust plenum which directs the exhaust air to the vent stack for an elevated release.

If high radiation is detected in any of the rooms within the NAB (refer to Table 11.5-1, Monitors R-11, R-12, and R-13), FB (refer to Table 11.5-1, Monitors R-17 and R-18), or SBs (refer to Table 11.5-1, Monitor R-25), the NABVS exhaust is diverted to an iodine filtration plenum. It is then directed to one of the iodine filtration trains. Each iodine filtration train includes fire dampers, preheater, iodine adsorber using activated carbon, post filter, dampers, and a booster fan. The exhaust air from the booster fan is directed to the exhaust plenum for discharge through the vent stack. See Figure 9.4.3-4—Nuclear Auxiliary Building Exhaust Iodine Filtration Train Subsystem.

The NABVS also has two iodine filtration train units and fans to serve the laboratory exhaust air. Each laboratory iodine filtration train unit includes preheater, prefilter, HEPA filter, iodine adsorber, post filter, motor-operated dampers, and booster fan. The exhaust air from the booster fan is directed to the exhaust plenum for discharge through the vent stack. See Figure 9.4.3-5—Nuclear Auxiliary Building Laboratory Iodine Exhaust Filtration Train.

Non-condensibles from the turbine gland steam condenser and the condenser evacuation system exhaust into the NABVS exhaust plenum. Air is pulled from the exhaust plenum by the NABVS exhaust fans and discharged at the vent stack.

9.4.3.2.2 Component Description

The major components of the NABVS are listed below, along with the applicable code and standards. Table 3.2.2-1 provides the seismic design and other design classifications for components in the NABVS.

Ductwork and Accessories

The supply and exhaust air 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).

Heaters

Supply air trains have hot water heaters. The heater design is based on the minimum outside air design temperature and supply air temperature requirements. The coils are constructed and tested in accordance with ASME AG-1 (Reference 1). Electric heaters are located upstream of iodine filters to prevent excessive moisture accumulation in the charcoal beds.

Prefilters

The prefilters are located upstream of HEPA filters and collect large particles to increase the useful life of the HEPA filters. The prefilters will meet the requirements of ANSI/ASHRAE Standard 52.2 (Reference 2).

HEPA Filters

HEPA filters are constructed, qualified and tested in accordance with ASME AG-1 (Reference 1). The periodic in-place testing of HEPA filters to determine the leak-tightness is performed per ANSI/ASME N510 (Reference 3).

Adsorbers

Carbon filters 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 in-place testing of the adsorbers to determine the leak-tightness is performed per ANSI/ASME N510 (Reference 3). The activated carbon total bed depth requirement will be 2 inches with a maximum assigned activated carbon decontamination efficiency of 95 percent.

Post Filters

The post filter is located downstream of the carbon adsorber. During operation of the carbon filtration exhaust, the air flow rate will be low through the carbon adsorber to prevent spread of the carbon dust. However, the post filter ensures that carbon dust or carbon fines are removed prior to the air being distributed further. The post filter meets the requirements of ASME AG-1 (Reference 1), and has an average atmospheric dust efficiency of 95% in accordance with ANSI/ASHRAE Standard 52.2 (Reference 2). The post filter is equipped with differential pressure measurement which indicates the degree of particulate loading and the need for filter change.

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 (Reference 4), AMCA 211 (Reference 5) and ANSI/AMCA 300 (Reference 6).

Isolation Dampers

The isolation dampers are located upstream and downstream of each filtration train. The motor-operated dampers will fail as-is in case of loss of power. Backdraft dampers prevent air flow to non-operating air supply and exhaust trains. The performance and testing requirements of the dampers are 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 7) and NFPA 90A (Reference 13) 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 set point.

Recirculation Units

The recirculation units are comprised of chilled water cooling coils and fans, which are designed to process and supply cool air for the compressor, switchgear and transformer rooms.

9.4.3.2.3 System Operation

Normal Plant Operation

Under normal plant operation, the NABVS continuously draws, conditions, and supplies outside air to maintain the required ambient conditions in various rooms of the NAB, FB, and annulus. Two of the four supply fans are able to provide the required air flow during normal plant operation.

The NABVS exhausts sufficient air to maintain a negative pressure inside the NAB relative to the outside environment. The exhaust air from the NAB, FB, SB, and Containment Building is processed through a dedicated filtration train to a common exhaust plenum, and subsequently directed by two of the four exhaust fans to the vent stack.

The laboratory exhaust is processed through one of the two iodine filtration trains, with one of two exhaust fans operating, prior to its discharge through the vent stack.

All system fire dampers are in the open position.

When the plant is in cold shutdown, the NABVS operates in combination with the containment building ventilation system to purge the containment service compartments. The exhaust is processed through a specific NABVS exhaust train.

Abnormal Operating Conditions

Failure of Iodine Adsorber Train

Failure of a fan in an operating iodine adsorber train initiates the operation of another iodine train; thus, the single failure has no effect on the functioning of the system. For the laboratory exhaust system, two filter trains are provided; in the event of a failure in one of the trains, the other train will start automatically.

Iodine Activity Detection

In the event iodine is detected in the NAB, FB, or SB, the affected exhaust flow paths are redirected through the iodine filtration train prior to discharge through the vent stack. Iodine activity is detected separately in each cell.

Fuel Handling Accident in the Fuel Building

In the event of a fuel handling accident in the FB, the FB exhaust and supply are isolated by closing the appropriate dampers (refer to Section 9.4.2). To prevent spread of airborne contamination, the iodine filtration trains of the SB ventilation system process the exhaust air to maintain the required pressure in the FB pool hall (refer to Section 9.4.5). The remainder of the FB is ventilated by the NABVS. During and after the fuel handling accident, proper NABVS supply and exhaust flow rates are maintained by adjusting the control dampers.

Fuel Handling Accident in the Containment Building

In the event of a fuel handling accident in the Containment Building, the CBVS full and low flow purge supply and the full flow purge exhaust containment isolation valves are closed and low flow purge exhaust is filtered through the low flow purge exhaust subsystem filtration trains (refer to Section 9.4.7). Excess air supply from the NABVS is redirected by adjusting the supply air control dampers.

Operation of Safety Injection System during LOCA

In the event of a loss of coolant accident (LOCA), leakages in the safety injection system (SIS) can lead to iodine activity levels that are above the limits of the NABVS iodine filtration trains. In such a case, the SB exhaust is routed through the SB ventilation system (refer to Section 9.4.5). Excess air supply from NABVS is redirected by adjusting the supply air control damper. The NABVS supply and exhaust to the FB are isolated (refer to Section 9.4.2).

Loss of Offsite Power (LOOP)

A LOOP results in a loss of power to the NABVS electrical components, such as fans, dampers, cooling units, and heaters. The NABVS system is not provided with emergency power.

Station Blackout (SBO)

In the event of SBO, there will be no power to any of the electrical components of the NABVS. Isolation dampers with spring return will fail to the closed position. Other isolation dampers will fail “as-is”.

9.4.3.3 Safety Evaluation

The backdraft damper located in the NABVS exhaust at the vent stack is the only component in the NAVBVS that performs a nuclear safety-related function. None of the other NABVS components are required to operate during a design basis accident (DBA). In case of a DBA, the NABVS is isolated from the HVAC systems of other buildings by isolation dampers. The backdraft damper prevents exhaust air flow from the AVS and SBVS from discharging into the NABVS.

The NABVS provides adequate capacity and redundant trains to maintain proper temperature levels in the NAB, FB, Containment Building, and annulus.

9.4.3.4 Inspection and Testing Requirements

The NABVS major components, such as dampers, motors, fans, filters, coils, heaters, and ducts are located to provide access for initial and periodic testing to verify their integrity.

Initial in-place acceptance testing of the NABVS is performed as described in Section 14.2 (test abstracts #079 and #203), Initial Plant Test Program, to verify the system is built in accordance with applicable programs and specifications.

The NABVS is designed with adequate instrumentation for differential pressure, temperature, and flow indicating devices to enable testing and verification of equipment function, heat transfer capability and air flow monitoring.

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

During normal operation, equipment rotation is utilized to reduce and equalize wear on redundant equipment during normal operation.

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

Fans and air handling units are tested by manufacturer in accordance with Air Movement and Control Association (AMCA) standards (References 4, 5, and 6). Air filters are tested in accordance with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards (Reference 2). Cooling coils are hydrostatically tested and their performance is rated in accordance with the Air Conditioning and Refrigeration Institute (ARI) standards (Reference 8).

Housings and ductwork are leak-tested in accordance with the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) technical manual "HVAC Air Duct Leakage Test Manual" (Reference 9), American Society of Mechanical Engineers, ANSI/ASME N510 (Reference 3), ASME AG-1 (Reference 1), and RG 1.140 (Reference 10).

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

Carbon filtration units are tested by manufacturer for housing leakage, filter bypass leakage and airflow performance. Periodically and subsequent to each filter or adsorber material replacement, the unit is inspected and tested in-place in accordance with the requirements of RG 1.140 (Reference 10), ANSI/ASME N510 (Reference 3) and ASME AG-1 (Reference 1). The charcoal adsorber samples are tested for efficiency in a laboratory in accordance with RG 1.140 (Reference 10) and ASTM D3803 (Reference 11). Air filtration and adsorption unit 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.

9.4.3.5 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.

All instrumentation provided with the filtration units is as required by RG 1.140.

The radiation instrumentation requirements for controlling airborne radioactivity releases via the vent stack are addressed in Section 11.5.3.1.6 and Table 11.5-1.

9.4.3.6 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. ANSI/ASHRAE Standard 52.2-1999, “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size,” American National Standards Institute/American Society of Heating, Refrigerating and Air Conditioning Engineers, 1999.

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

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

8. ANSI/ARI Standard 410-2001, “Forced-Circulation Air-Cooling and Air-Heating Coils,” Air Conditioning and Refrigeration Institute, 2001.

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

10. NRC Regulatory Guide 1.140, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," 2001.

11. ASTM D3803-89, “Standard Test Method for Nuclear Grade Activated Carbon,” 1989.

12. Deleted.

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

Next File