9.4.7 Containment Building Ventilation System

The containment building ventilation system (CBVS) is designed to maintain acceptable ambient conditions inside the Containment Building for proper operation of equipment and instrumentation during normal plant operation and normal shutdown (i.e., outages). The CBVS also provides acceptable ambient conditions for personnel access to the service compartment during normal plant operation, and equipment compartment during outage for conducting inspections, tests and maintenance during normal plant operation.

9.4.7.1 Design Bases

The containment penetration isolation valves and low-flow purge filtration system are safety related and designed to Seismic Category I requirements. The reactor pit cooling fans and internal filtration system components are non-safety related but designed to Seismic Category I requirements. All other components of the CBVS are non-safety related and Non-Seismic.

The CBVS components are located inside buildings that are designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, and external missiles (GDC 2).

Containment atmospheric cleanup is performed by internal filtration for the equipment compartment. The containment purge subsystems remove radioactive materials via iodine filtration trains prior to release to the atmosphere (GDC 41). The filtration systems are designed to allow periodic inspection (GDC 42).

The containment isolation valves are automatically closed within five seconds upon receipt of a containment isolation signal, in accordance with BTP 6-4 (Reference 8), to maintain the integrity of the containment boundary and to limit the potential release of radioactive material.

The reactor pit area temperature is maintained less than 150°F under postulated accident conditions to prevent concrete degradation.

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

- Controls and maintains a negative pressure in the Containment Building when the CBVS purge subsystem is operating.
- Maintains the following ambient conditions in the service compartments for personnel accessibility and equipment operability during refueling and shutdown:
  - A minimum temperature of 59°F.
  - A maximum temperature of 86°F.

– 30 percent to 70 percent humidity.

- Maintains the following ambient conditions in the equipment compartments for protection and safe operation of the equipment:

  – A minimum temperature of 59°F.

  – A maximum temperature of 131°F.

9.4.7.2 System Description

9.4.7.2.1 General Description

The supply air for the containment building ventilation system is conditioned outside air that is filtered, cooled or heated, and humidified by the nuclear auxiliary building ventilation system (NABVS) as described in Section 9.4.3. The supply air is delivered to the Containment Building through the Fuel Building plenum. The supply air is then distributed through the CBVS supply duct network if the containment purge subsystem is operating.

The CBVS is composed of the following separate subsystems:

- Containment purge subsystem.
- Internal filtration subsystem.
- Containment Building cooling subsystem.
- Service and equipment compartment cooling subsystem.

The containment isolation system is addressed in Section 6.2.4.

Containment Purge Subsystem

The containment purge subsystem includes low-flow and full-flow purge supply and exhaust systems. See Figure 9.4.7-1—Containment Building Low Flow and Full Flow Purge Supply Subsystem and Figure 9.4.7-2—Containment Building Low Flow and Full Flow Purge Exhaust Subsystem.

The containment low-flow purge subsystem is normally not in operation during the plant normal operation. However, the low-flow purge subsystem can be used during normal operation and outage conditions. The containment full-flow purge subsystem is used during plant outages. The supply side ducts receive air from NABVS (refer to Section 9.4.3) through the Fuel Building (FB) concrete plenum. The supply air is then directed through the containment annulus penetration ducts into the containment plenum which discharges air into the service compartments of the Containment Building. The service compartments include technical rooms, instrument rooms, staircases, tank rooms, annular space at the operating floor, and annular space at the lower level. With the purge subsystem in operation, the air from the service compartments flows into equipment compartments as a result of pressure differential.

The low-flow purge exhaust subsystem contains two redundant filtration trains located in the FB. The filtration trains receive air from the exhaust duct of the low-flow purge exhaust subsystems. The full-flow purge exhaust is directed to the NABVS. The CBVS low flow purge exhaust can also be directed to the safeguard building controlled-area ventilation system (SBVS) iodine filtration trains in an emergency for redundancy (refer to Section 9.4.5). Each filtration train consists of an electric heater, prefilter, upstream HEPA filters, carbon adsorber, downstream HEPA filters, and exhaust fan. The exhaust air from the filtration trains is directed to the plant vent stack. The full-flow purge exhaust subsystem directs the containment exhaust air through the NABVS exhaust filtration train (refer to Section 9.4.3).

The dampers downstream of the supply plenum regulate pressure inside the Containment Building. The equipment compartment exhaust dampers regulate differential pressure between the service and equipment compartments when the low-flow purge subsystem is operating.

The containment purge subsystems provide automatic isolation of containment atmosphere by quick closure of containment isolation valves and closure of the air supply in front of the hatch.

The containment purge subsystem is designed in accordance with ASME AG-1-2003 (Reference 1) and RG 1.52 for atmospheric cleanup.

Internal Filtration Subsystem

The internal filtration subsystem (See Figure 9.4.7-3—Containment Building Internal Filtration Subsystem) limits the release of radioactive material by reducing radioactive iodine contamination inside the equipment compartment with air circulation and filtration during normal plant operation. The internal filtration subsystem contains one filtration train which consists of an electric heater, prefilter, upstream HEPA filter, carbon adsorbers, and a downstream HEPA filter; with two redundant fans downstream of the filtration train. The air is drawn from the equipment compartments, filtered, and returned to the equipment compartments.

The system is designed in accordance with Reference 1 and RG 1.140.

Containment Building Cooling Subsystem

The containment building cooling subsystem (See Figure 9.4.7-4—Containment Building Cooling Subsystem) provides cool air into a concrete circular header located above the residual heat removal-safety injection room, and into the reactor pit cooling fan plenum. The containment building cooling subsystem provides cool air to the reactor coolant pumps, steam generators, chemical volume control system (CVCS), control rod drive mechanism system (CRDMS), and vent and drain system. There are two trains of two main fans and four cooling coils located in the equipment compartments. The cooling coils receive cold water from the operational chilled water system (OCWS).

Two trains of two reactor pit cooling fans located in the equipment compartments supply cool air to the reactor pit area. These fans are used to ventilate the reactor pit during normal and station blackout (SBO) conditions. The reactor pit is cooled by air from a plenum between the main fans and the reactor pit cooling fans. The supply air subsystem to the reactor pit is composed of a 16 duct layout around the main coolant piping.

The exhaust from these areas is recycled through the cooling coils located in the equipment compartments.

Service Compartments Cooling Subsystem

The service compartment cooling subsystem (See Figure 9.4.7-5—Containment Building Service Compartments Cooling Subsystem) contains 12 recirculating cooling units. Each air cooling unit is equipped with a cooling coil connected to the OCWS. The recirculation cooling units provide ventilation and cooling for the service compartments. The service compartments include safety injection system valve rooms, steam generator blowdown system tank and heat exchanger rooms, instrument measuring cabinets and table rooms, and containment dome and annular space.

9.4.7.2.2 Component Description

The major components of the CBVS are listed in the following paragraphs, 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 supply and exhaust air ducts are structurally designed for fan shutoff pressures. The ductwork is designed, tested and constructed in accordance with Reference 1.

Electric Heater

The electric heaters are located upstream of iodine filters to prevent excessive moisture accumulation in the carbon adsorbers. The heaters are constructed and tested in accordance with Reference 1.

Prefilters

The prefilters are located upstream of HEPA filters and collect large particles to increase the useful life of the high efficiency filters. The prefilters are designed in accordance with ANSI/ASHRAE Standard 52.2-1999 (Reference 2).

HEPA Filters

HEPA filters are constructed, qualified, and tested in accordance with Reference 1. The periodic inplace testing of HEPA filters to determine the leak-tightness is performed per ASME N510-1989 (Reference 3).

Adsorbers

Carbon adsorbers are used to remove radioactive iodine from the exhaust air. The efficiency for removing methyl iodine is based on the decontamination efficiency assigned during the laboratory tests. The periodic in-place testing of adsorbers to determine the leak-tightness is performed per Reference 3.

Fans

The supply and exhaust fans are centrifugal or vane-axial designed with electric motor drivers. Fan performance is rated in accordance with ANSI/AMCA-210-99 (Reference 4), ANSI/AMCA-211-1987 (Reference 5), and ANSI/AMCA-300-1985 (Reference 6).

Isolation Dampers

Manual dampers are adjusted during initial plant startup testing to establish accurate air flow balance between rooms. The motor-operated dampers will fail to the “close” or “open” position in case of power loss, depending on the safety function of the dampers. The performance and testing requirements of the dampers will be conducted in accordance with Reference 1.

Fire Dampers

Fire dampers are installed where ductwork penetrates a fire barrier. Fire damper design meets the requirements of UL 555 (Reference 7) 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 housing is constructed of heavy gauge steel. The fan is driven by an electric motor. The cooling coils are finned coil type and are connected to the operational chilled water system. The cooling coils are designed in accordance with

Reference 1. The moisture separator collects condensate which is directed to drain system.

9.4.7.2.3 System Operation

Normal Plant Operation

The containment low-flow purge subsystem can operate during normal operation. The containment building negative pressure is maintained by controlling the supply air flow through the motorized dampers. The internal filtration subsystem equipment compartment is isolated unless airborne radioactivity contamination is detected and personnel access is required in the service compartment. When the low-flow purge subsystem is in operation, a negative pressure is maintained between the equipment and service compartments.

When the reactor is in cold shutdown, ventilation in the Containment Building is provided by both low-flow and full-flow purge subsystems. The negative pressure in containment is regulated by the supply air flow of both low-flow and full-flow purge subsystems.

The internal filtration subsystem is in operation during plant operation to detect activity level in the building, and air flow purges the equipment compartment in a recirculation mode. This system is not required during outages since there are no fission products being produced.

The containment building cooling subsystem operates during normal and shutdown conditions to remove heat generated in the equipment compartments. This system operates continuously to maintain ambient conditions in the equipment compartments. If the supply air temperature downstream of fans is 82°F or higher, the cooling coils provide cool air.

The service compartment cooling subsystem also operates during normal and shutdown conditions to maintain acceptable room temperatures in the service compartments.

Abnormal Operating Conditions

The containment isolation valves located on the low-flow and full-flow purge supply and exhaust ducts automatically close when a containment isolation signal is initiated. In the event of loss of the internal filtration subsystem, the exhaust air can be filtered through the containment low-flow purge exhaust subsystem prior to release to the plant stack.

In the event of loss of the chilled water system, the component cooling water system (CCWS) provides a water supply to the cooling coils.

In the event of failure of the containment building cooling subsystem fans, the fresh air to the annular space and the operating floor and equipment compartment can be supplied by the full-flow purge subsystem in conjunction with a reconfiguration of the dampers.

Loss of Ultimate Heat Sink

In case of loss of ultimate heat sink (LUHS) or the loss of CCWS, the cooling fans in the Containment Building are kept in operation to avoid localized areas of high temperature.

Loss of Offsite Power

Upon loss of offsite power (LOOP), the containment penetration isolation valves fail to the closed position. The dampers on the internal filtration subsystem and containment building cooling subsystem fail to the “as-is” position. The power supply to main fans and reactor pit cooling fans is supplied from corresponding emergency diesel generators. Air cooling unit fans stop in the service compartment cooling subsystem.

Fuel Handling Accident in the Containment Building

In the event of a fuel handling accident in the Containment Building, the containment isolation valves on the containment purge subsystem can be manually closed by pushing the emergency push button located in the fuel handling area inside the Containment Building. The dampers are closed when the hatch is opened. The low-flow purge exhaust subsystem is used to avoid the spread of contamination by keeping a negative pressure in the Containment Building. To achieve this safety function, the low-flow purge subsystem exhaust is switched over to the iodine filtration trains of the safeguard building controlled-area ventilation system (refer to Section 9.4.5).

High Pressure Level or Safety Injection Signal

In case of high-pressure level or a safety injection signal, the containment penetration valves on the containment purge subsystem are closed and air flow in the Containment Building is stopped.

Station Blackout

In the event of a SBO, the reactor pit area is air cooled to prevent degradation of the concrete structure. The reactor pit cooling fans take air from the supply air shaft. The air is supplied to the bottom of the pit and transferred through openings in the pit wall around the main coolant piping to maintain a temperature less than 150°F. The power supply to the reactor pit cooling fans is provided by the alternate AC (AAC) diesel generators.

Small-Break Loss-of-Coolant Accident and Loss-of-Coolant Accident

In the event of a small-break loss-of-coolant accident (SBLOCA) or loss-of-coolant accident (LOCA), containment isolation valves automatically close after receipt of the containment isolation signal. These valves are designed to perform their isolation function under LOCA conditions and will close within five seconds after receipt of a containment isolation signal.

9.4.7.3 Safety Evaluation

The CBVS maintains proper temperatures in the Containment Building during normal operations and shutdown conditions. Sufficient redundancy is included for proper operation of the system when one active component is out of service. The CBVS is not an engineered safety feature and has no safety-related function except the containment isolation and low-flow purge.

The containment purge subsystem supply and exhaust penetrations through the containment annulus are equipped with two normally open isolation valves, each connected to separate control trains. A failure in one train will not prevent the remaining isolation valve from providing the required capability. The valves automatically close within five seconds after receipt of a containment isolation signal. The isolation valves and containment penetrations are the only portions of the CBVS that are safety related.

9.4.7.4 Inspection and Testing Requirements

9.4.7.4.1 Preoperational Tests

Refer to Section 14.2 (test abstracts #073, #075, #076, and #203) for initial plant startup test program. Initial in-place acceptance testing of CBVS components will be performed in accordance with Reference 1 and Reference 3.

9.4.7.5 Instrumentation Requirements

Indication of the operational status of the equipment, position of dampers, instrument indications and alarms are provided in the main control room (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.

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

3. ASME N510-1989 (R1995), “Testing of Nuclear Air-Treatment Systems,” The American Society of Mechanical Engineers, 1989.

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

5. ANSI/AMCA-211-1987, “Certified Ratings Program–Air Performance,” American National Standards Institute/Air Movement and Control Association International, 1987.

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

7. UL 555, “Standard for Fire Dampers,” Underwriter’s Laboratories, Sixth Edition, June 1999.

8. NUREG-0800, BTP 6-4, Revision 3, “Containment Purging During Normal Plant Operations,” U.S. Nuclear Regulatory Commission, March 2007.

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