## 6.2.3 Secondary Containment Functional Design

The Reactor Shield Building (RSB) completely encloses the Reactor Containment Building (RCB) and provides a second containment barrier to the release of airborne radioactive material. The space between the RSB and RCB forms an annulus, which is maintained at a subatmospheric pressure and is filtered by the annulus ventilation system (AVS).

### 6.2.3.1 Design Bases

The RSB functions as a secondary containment to prevent the uncontrolled release of radioactivity to the environment following a postulated accident.

The RSB and AVS provide the secondary containment function under the environmental conditions of normal operation, maintenance, testing, and postulated accidents, including protection against dynamic effects resulting from equipment failures (GDC 4).

The AVS maintains the annulus at a subatmospheric pressure during normal operations and following postulated accidents, establishing a barrier against uncontrolled release of radioactivity to the environment (GDC 16).

The AVS filters leakage from the primary containment following a postulated accident before releasing it to the environment.

The AVS maintains the ambient air temperature in the annulus to avoid significant boron precipitation in piping that traverses the annulus.

The AVS is designed to permit periodic inspection and functional testing to confirm barrier integrity and the operability of the secondary containment ventilation system (GDC 43). RSB inspection is addressed in Section 3.8.4. Containment leakage testing in accordance with 10 CFR 50, Appendix J is described in Section 6.2.6.

### 6.2.3.2 System Description

#### 6.2.3.2.1 General Description

The RSB is a reinforced concrete shell structure consisting of an upright cylinder capped with a spherical dome. The RSB is concentric with, and completely encloses the RCB, creating an annular region approximately six feet in width. The RSB is surrounded by the Safeguard Buildings and the Fuel Building. Section 3.8.1 contains plan and elevation views of the Reactor Building.

The primary function of the RSB is to protect the RCB from damage due to external events. The RSB also functions as a secondary containment to prevent the uncontrolled release of radioactivity to the environment. The design description and performance criteria of the RSB are presented in Section 3.8.4.

The annulus ventilation system collects and filters airborne radioactive material that may leak from the primary containment by maintaining a subatmospheric pressure in the annulus.

#### 6.2.3.2.2 Annulus Ventilation System

The AVS is designed to contain leakage from the primary containment by maintaining a subatmospheric pressure in the annulus. The AVS consists of three trains: one train is used during normal plant operation; two trains are used to mitigate potential accidents. AVS design and performance parameters are presented in Table 6.2.3-1.

Refer to Section 3.2 for the seismic and system quality group classification of the AVS.

##### 6.2.3.2.2.1 AVS Normal Operation Train

The normal operation filtration train is shown in Figure 6.2.3-1. The full capacity normal operation filtration train is designed to maintain a subatmospheric pressure in the annulus, to maintain the annulus temperature above 45°F to prevent boron precipitation in the extra borating system piping, and to provide conditioned air in the annulus for personnel accessibility.

During normal operation, the conditioned air is drawn from the Nuclear Auxiliary Building ventilation supply shaft (See Section 9.4.3) through a fire damper, a motor-operated control damper, and two motor-operated isolation dampers. The supply air is distributed in the bottom of the annulus to four different locations. A subatmospheric pressure of less than or equal to -0.8 inches water gauge is maintained in the annulus during normal operation by regulating the control damper with two redundant pressure sensors located in the annulus.

The exhaust air is drawn from the top of annulus by the Nuclear Auxiliary Building ventilation system exhaust fans through two motor-operated isolation dampers and a fire damper. The exhaust air is filtered by the Nuclear Auxiliary Building filtration trains and discharged through the vent stack.

The normal operation filtration train is in service during normal plant operation and plant shutdown conditions. The two accident trains are available as backup if the normal operation train is not able to maintain the subatmospheric pressure in the annulus.

The motor-operated air-tight dampers—located on the normal operation filtration train supply and exhaust ducts—isolate the secondary containment in case of a postulated accident. The redundant dampers in the supply and exhaust trains are powered by different electrical divisions backed by separate emergency diesel generators. The dampers can be operated automatically or manually from the main control room (MCR). In the event of a station blackout (SBO), these dampers are automatically closed by batteries.

The fire dampers on both supply and exhaust trains are located at the wall penetration between the Fuel Building and the annulus. These dampers are equipped with thermal sensors for automatic closing, and can be closed or re-opened remotely if not released by the thermal sensor.

##### 6.2.3.2.2.2 AVS Accident Trains

The AVS accident filtration trains are shown on Figure 6.2.3-2. The filtration trains are engineered safety feature (ESF) filters and are used during postulated accidents to contain leakage from the primary containment by maintaining a subatmospheric pressure in the annulus. The exhaust air from the annulus is filtered before release to the environment via the vent stack.

There are two full capacity ESF trains, each consists of an air-tight motor-controlled damper, an electrical heater, a pre-filter, an upstream HEPA filter, an iodine absorber, a downstream HEPA filter, an air-tight motor controlled damper, a fan, and a back-draft damper. The filter system components are designed in accordance with Regulatory Guide 1.52, and are described in Section 6.5.1.

During a postulated accident, the ESF filtration trains collect the containment leakage from the annulus, remove airborne radioactivity through the filtration train, and release the filtered air to the vent stack. The AVS accident trains reduce the pressure in the annulus to at least -0.25 inches water gauge or less and maintain the lower subatmospheric pressure. The system is capable of maintaining a uniform negative pressure throughout the secondary containment structure following the design basis loss of coolant accident (LOCA).

The exhaust air is monitored for radiation levels before release to the vent stack, as described in Section 12.3.4.

The two ESF trains are physically separated by being installed in separate rooms of the Fuel Building, which are also in separate fire areas. The two ESF trains are powered by different electrical divisions backed by separate emergency diesel generators.

##### 6.2.3.2.2.3 System Operation

The normal operation filtration train is in service during normal plant operation, including cold shutdown and outages. During normal operation, the isolation dampers are in the open position and the annulus is continuously vented. The subatmospheric pressure inside the annulus is maintained by regulating the control damper located on the supply side of the normal operation filtration train. The supply air from the AVS maintains the annulus temperature between 45°F and 113°F.

A failure of the normal operation filtration train leads to the loss of supply and exhaust air to the annulus. In this case, one of the accident filtration trains is started, and the two isolation dampers on the supply and exhaust side of the normal filtration train are closed to isolate the normal operation filtration train and maintain the leak tightness of the annulus.

In case of a postulated accident, a containment isolation signal causes the normal filtration train to automatically stop. The normal filtration train supply air isolation dampers close immediately and the exhaust isolation dampers close with a delay, to maintain the annulus negative pressure during the switchover to the accident filtration trains. Both accident filtration trains start on receipt of a containment isolation signal and an alarm is issued in the MCR.

#### 6.2.3.2.3 Bypass Leakage

Certain containment penetrations introduce the potential for primary containment leakage to bypass the filtered annulus and escape directly to the environment. Potential bypass leakage paths exist through the double seals of the equipment hatch, personnel airlocks, fuel transfer tube, and containment ventilation system isolation valves.

The leak-off system provides a means to capture bypass leakage and route it to the annulus to be processed. The leak-off system has no components with an active safety function. The subatmospheric pressure in the annulus provides the driving force to route the bypass leakage to the annulus. The leak-off system is functional during normal plant operation and during postulated accidents. Leak-off system component classifications are presented in Section 3.2.

Containment penetrations that are paths for potential bypass leakage terminate in areas of the surrounding buildings that are filtered during a postulated accident. Section 6.2.6.5 addresses the treatment of bypass leakage for containment leakage rate testing.

### 6.2.3.3 Safety Evaluation

The AVS system components are located inside the Fuel Building, which is a Seismic Category I structure. The two AVS accident filtration trains are designed to withstand the safe shutdown earthquake and are classified as Seismic Category I.

The safety-related components of the AVS system remain functional and perform their intended function following a postulated internal hazard (e,g., fire, flood, internal missiles, pipe breaks). The two accident filtration trains are physically separated from each other to prevent common mode failures. Since the accident filtration trains are completely redundant and are both full capacity, one train alone can collect and process radioactive material that may leak from the primary containment following an accident. The supply and exhaust trains of the normal filtration train can be isolated with two redundant dampers in series.

Guard pipes surround high energy lines passing through the annulus to protect against pipe failures that could compromise the integrity of the secondary containment. Design criteria for guard pipes are presented in Section 3.6.2.2. Containment penetrations are listed in Section 6.2.4. Doors and hatches leading to the annulus are maintained under administrative control.

If a fire is detected in the annulus during normal operation, the continuous ventilation of the annulus is stopped manually from the MCR by closing the fire dampers located at the wall penetration between the Fuel Building and Nuclear Auxiliary Building ventilation supply and exhaust shafts to reduce the possibility for fire propagation.

Analyses have demonstrated the ability of the AVS to depressurize and maintain a subatmospheric pressure in the annulus during normal operation and following a design basis LOCA. The LOCA is assumed to occur concurrent with a loss of off-site power, and a loss of one of the accident trains. The total thermal and pressure expansion of the primary containment structure is assumed to occur prior to the start of the remaining accident train, resulting in a starting pressure of 14.712 psia. The drawdown of the annulus is started 60 seconds after the start of the postulated accident. Analytical results indicate that the pressure in the annulus reaches a subatmospheric pressure sufficient for the AVS to perform its safety function with substantial margin. Analytical specifications and results are presented in Table 6.2.3-2.

### 6.2.3.4 Inspection and Testing Requirements

Refer to Section 14.2 (Test Abstract #077) for initial plant testing of the AVS. Refer to the technical specifications (Chapter 16) Section 3.6.6 and Section 3.6.7 for surveillance requirements. Inspections and testing of the ESF filter system components are described in Section 6.5.1.

The following AVS component functions are tested for operability:

- Temperature sensor measurement validation.
- Damper closing and opening.
- Fire damper closing and opening.
- Emergency button operability.
- Efficiency of HEPA and carbon filters.

- In-place leakage testing of the filters.

The functionality of the AVS is verified by testing alarms and indications and by confirming the availability of selectors in the MCR and by manual operation of heaters and dampers. A periodic switchover of system fans is performed during operation to check the functioning of each fan.

The AVS system is designed to permit access and periodic inspection of the system components. The operating equipment is accessible for visual inspection during all plant operating modes. Lighting inside filter banks between the rows of filters and inspection portholes in the filter housing doors allow for viewing while in operation.

### 6.2.3.5 Instrumentation Requirements

Indication of the operational status of the AVS 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.

### Table 6.2.3-1—Design and Performance of Annulus Ventilation System

| Design Feature | Value |
|---|---|
| Maximum annulus pressure during normal operation [2] | ≤ -0.8 inches water gauge |
| Maximum annulus pressure during postulated accidents [2] | ≤ -2.5 inches water gauge |
| Minimum annulus temperature (all modes) | 45°F |
| Maximum relative humidity at iodine filters (postulated accident) | 70% |
| Design pressure | 2.77 inches water gauge |
| Design temperature | 212°F |
| Electrical heater power (each train) | 6 kW |
| Minimum rated efficiency – Pre-filter | 55-65% |
| Minimum rated efficiency – HEPA filters | 99.95% |
| Minimum rated efficiency – Iodine adsorbers [1] | 99% |
| Fan design air flow | 60 – 1177 cfm |

**Note:**

1. Laboratory test results for both elemental iodine and organic iodine, based on four (4) inch deep bed of carbon.

2. The subatmospheric pressure in the annulus will be equal to or lower than the value listed.

**Table 6.2.3-2—Secondary Containment Response Analysis**

| Design Feature [3] | Value | |
|---|---|---|
| Annulus temperature | Initial | 86.6°F |
| | After 24 hours | < 92°F |
| Annulus pressure | Start of drawdown | 0.44 inches water gauge |
| | At 305 seconds | -0.25 inches water gauge |
| | After 565 seconds | ≥ -2.5 inches water gauge |
| Annulus volume | Initial | 706,299 $ft^3$ |
| | After compression and at start of drawdown analysis | 704,737 $ft^3$ |
| Heat transfer coefficients [1, 2] | N/A [4] | |
| Conductive heat transfer [1] | N/A [4] | |
| Radiant heat transfer [1] | N/A [4] | |
| Compressive effect of primary containment [1] | Volume reduction of 1556 $ft^3$ | |
| Secondary containment in-leakage assumed [1] | 0.25% of containment free volume per day | |
| Secondary containment out-leakage assumed [1] | Zero leakage out of the secondary containment | |
| Heat loads generated within annulus [1] | Negligible | |

**Notes:**

1. During postulated accident in primary containment.
2. Heat transfer calculated by methods provided in BTP 6-2.
3. Secondary containment response analysis based on worst single failure.
4. An infinite heat transfer coefficient was assumed such that the surface temperature in contact with primary containment is at the design maximum value from time zero.

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