# 6.5 FISSION PRODUCT REMOVAL AND CONTROL SYSTEMS

Fission Product Removal Systems are the Engineered Safety Feature (ESF) systems described under Subsections 6.5.1 and 6.5.2.

Fission product control systems control the release of fission products by operating in conjunction with fission product removal systems following a design basis accident. These systems are described under Subsection 6.5.3.

## 6.5.1 ENGINEERED SAFETY FEATURE (ESF) FILTER SYSTEMS

→(DRN 04-705, R14)

FSAR Chapter 15 documents the radiological consequences (off-site and control room doses) of various events. The following systems, located outside containment, contain ESF air filtration units to mitigate the consequences of postulated design basis accidents:

←(DRN 04-705, R14)

a) Control Room Air Conditioning System

b) Controlled Ventilation Area system (CVAS)

c) Shield Building Ventilation System (SBVS)

→(DRN 02-1751, R12-A)

d) Deleted

←(DRN 02-1751, R12-A)

### 6.5.1.1 Design Bases

The ESF air filtration systems are designed to accomplish the following:

a) (Control Room Air Conditioning System only)

→(DRN 04-705, R14)

Ensure that the radiation exposure to main control room personnel, throughout the duration of any one of the postulated accidents discussed in Chapter 15, does not exceed the limits of 1OCFR50, Appendix A, General Design Criterion 19 and 10CFR50.67.

←(DRN 04-705, R14)

b) (Control Room Air Conditioning system only)

The design bases employed for sizing the filters, fans, and associated ductwork are item "a" above, and appropriate design bases given in subsection 9.4.1.1.

c) (CVAS and SBVS only)

→(DRN 04-705, R14)

Provide high efficiency particulate filtration and iodine adsorption for air exhausted from the controlled ventilation area, the Post Accident sampling cabinets and the Reactor Building annulus following postulated design basis accidents such that the CVAS and SBVS, in conjunction with other ESF systems, limit the post accident radiological releases below the guidelines of 10CFR50.67.

←(DRN 04-705, R14)

d) (CVAS only)

→(DRN 04-705, R14)

Exhaust air from the controlled ventilation area following postulated design basis accidents at a rate required to create and maintain a negative pressure below 0.25 in. water gage (wg) relative to surrounding areas.

←(DRN 04-705, R14)

e) (CVAS only)

Perform its function assuming the maximum possible leakage in the controlled ventilation area from pump seals, or valve stems, etc. Refer to FSAR subsection 6.3.3.8 for a discussion of ECCS equipment leakage.

f) (SBVS only)

→(DRN 04-705, R14)

Provide mixing, dilution, holdup and filtration of airborne radioactive material that leaks from containment into the Shield Building annulus following postulated design basis accidents.

g) (SBVS only)

Exhaust air from the Shield Building annulus following postulated design basis accidents at a rate required to create and maintain a negative pressure below one in. wg relative to the outside atmosphere.

←(DRN 04-705, R14)

→(DRN 02-1751, R12-A)

h) Deleted

i) Deleted

j) Deleted

←(DRN 02-1751, R12-A)

The following design bases are applicable to all ESF air filtration systems:

k) The ESF air cleaning units are consistent with the recommendations of Regulatory Guide 1.52 (6/73), as shown in Table 6.5-1.

l) Perform its design functions assuming a single active component failure coincident with a loss of offsite power.

m) Perform continuously for at least 30 days following a design basis accident and be capable of retaining radioactive material after the system is taken out of service.

n) Perform its design function in the event of a safe shutdown earthquake.

o) Permit access for periodic inspection and testing to assure system integrity and functional capability.

p) The safety class of each system is given in Table 3.2-1.

q) Section 3.11 lists the environmental conditions for each system.

6.5.1.2 System Design

6.5.1.2.1 General System Description

6.5.1.2.1.1 Control Room Air Conditioning System

The Control Room Air Conditioning System is described in section 6.4 and Subsection 9.4.1. A system air flow diagram is shown in Figure 9.4-1.

6.5.1.2.1.2 Controlled Ventilation Area system

→
The CVAS is safety class 3 and seismic Category I. A system air flow diagram is shown in Figure 9.4-3 (for Figure 9.4-3, Sheet 5, refer to Drawing G853, Sheet 19).
←

The CVAS is designed to provide filtration of exhaust air from areas of the Reactor Auxiliary Building (RAB) which contain the following:

a) Low-pressure safety injection pumps

b) High-pressure safety injection pumps

c) Containment spray pumps

d) Shutdown heat exchangers

→
e) The containment penetration area and –35 Wing Area which contains recirculation SIS sump water lines.
←

f) The NNS Post Accident Sampling Exhaust System via the CVAS exhausted radioactive pipe chase.

Access doors into areas (a) through (e) are two door, airlock type with entry administratively controlled. Area (f) is sealed and has no access except through special block-out sections.

Under normal operation, the RAB Normal Ventilation System provides the necessary ventilation of the CVAS area. Upon receipt of a Safety Injection Actuation Signal (SIAS) the normal vent system is disabled, the exhaust fans E-23 (3A-SA) and E-23 (3B-SB) are energized and valves in the system ductwork are positioned to allow the fans to draw all exhaust air from the CVAS area through HEPA and charcoal filters before discharge to the atmosphere. Table 6.5-2 shows the operating and failure position of the CVAS valves.

→(DRN 04-705, R14)
The system flow rates and operating characteristics are based on the requirement to evacuate the controlled ventilation area to -0.25 in. wg within approximately 60 seconds (including diesel start and sequencer times) following an SIAS. The exhaust fans are capable of drawing 3000 cfm (nominal) through a loaded filter train.
←(DRN 04-705, R14)

Table 6.5-6 shows the events and associated delay times from the initiation of an SIAS up to the time that the controlled ventilation area has been depressurized by 0.25 in. wg.

Proper operating ambient temperatures for the CVAS air cleaning units are maintained by air handling units AH-13 (3A-SA) and AH-13 (3B-SB) and by exhaust fans E-41 (3A-SA) and E-41 (3B-SB) which respectively supply and exhaust outside air for cooling.

Upon loss of normal ac power, the CVAS is automatically connected to the emergency diesel generators, as required.

The system is instrumented to signal, alarm, and record pertinent pressure drops and flow rates as described in Subsections 6.5.1.5 and 7.5.1. System control is discussed in Subsection 7.3.1.

Subsection 6.2.3 describes the SBVS and a system air flow diagram is shown in Figure 9.4-7.

FHB Ventilation System is described in subsection 9.4.2 and its air flow diagram is Figure 9.4-2.

The CVAS and SBVS air cleaning units include, in the direction of flow, demister, electric heating coil, prefilter, HEPA filter, charcoal adsorber, and HEPA filter followed by the fan. The FHB and Control Room filter trains include a similar arrangement to the CVAS and SBVS except that there is no demister.

With the exception of the Control Room Air Conditioning System, interconnecting ducts between redundant air filtration units are provided, to allow one unit to draw air flow through the second inactive Unit for decay heat removal in quantities as indicated on Figures 9.4-2, 3, and 7 (for Figure 9.4-3, Sheet 5, refer to Drawing G853, Sheet 19).

The preoperational tests conducted on the CVAS are discussed in FSAR Subsection 14.2.12.2.29.

6.5.1.2.2 Component Description

a) Filter Casing

The filter train casing is constructed of 0.25 in. carbon steel plate, ASTM A-36 with continuous gastight welds of all joints, seams and internal structural members. Caulking is not used for the repair of leaks at defective welds or in lieu of continuous welds. Bolting flanges are provided at the inlet and outlet of each train. The casing is designed and reinforced to withstand a negative pressure without permanent deformation or damage. Gasketing materials are ASTM D1056 Grade SCE-45 closed pore neoprene sponge. Gastight access doors are provided for each casing compartment as required to properly service and test system components.

b) Demisters

Demisters for the CVAS and SBVS filter trains meet qualification requirements of MSAR 71-45 and requirements of Underwriters' Laboratories (UL) Class 1. The demisters eliminate direct water spray, free droplets of water and mist which may be entrained in the incoming air stream. They effectively remove all particulates 10 microns or larger in diameter but do not lower the humidity of incoming air stream. The free water is collected and drained to the radioactive floor drain system.

c) Electric Heating Coils

The electric heating coils are used to reduce the relative humidity of the inlet air from 100 percent to 70 percent or below. The reduction in relative humidity enhances the adsorption efficiency of the downstream charcoal adsorber. The electric heating coil is located remote from the charcoal adsorber to prevent the heating coil from being a potential ignition source for the charcoal.

d) Filter Frames and Supports

Filter mounting frames are fabricated from stainless steel tubing, reinforced with bars and structural members as required to meet the structural criteria described below as well as system seismic requirements.

The frames are rigidly constructed with a maximum deflection of no more than 0.1 percent of their length under a loading of six in. wg. The frames are able to withstand a shock loading of at least two psi across the filter banks (or assemblies) without exceeding the elastic limit of the frame materials. A minimum face width of four in. is provided for both major and cross members of face sealed frames. All of the seating surfaces are flat and ground smooth, eliminating pits, weld splatter and all other surface defects. Filter units are clamped to the mounting frame with enough pressure to enable the gasket to maintain a leakproof seal under conditions of vibration, thermal expansion, frame flexure, shock, overpressure and varying temperature and humidity that can be expected in service. Uniform pressure is applied to the filter units and gaskets. Clamping devices are designed to permit any single filter unit to be removed from the mounting frame without affecting other units. Bolts and nuts used for clamping purposes are fabricated from stainless steel. Clamping bolts and sealing surfaces are designed so as not to bear the weight of HEPA filters. Support frames are installed to support the weight of HEPA filters and hold the filters in the proper location during the clamping process. Design of support frames are such that minimum obstruction are present around the filter seating surfaces to allow for maximum accessibility for visual inspection and manipulation of a test probe between filter units.

Structural design of mounting frames is in accordances with recommendations of USAEC report ORNL-NSIC-65 (January, 1970).

All filters and frames are of fire resistant construction in accordance with Underwriters Laboratories Standard for safety, UL-586, and are capable of withstanding a temperature of 250°F and 250 watts fission products decay heat for an indefinite period.

e) HEPA Filters

The high efficiency particulate air (HEPA) filters consist of 24 in. wide by 24 in. high by 12 in. deep extended media dry type units clamped to structurally rigid mounting frames. Each unit is rated at 1500 cfm. Filters are fabricated from a continuous sheet of asbestos or glass asbestos.

The HEPA filter media is glass sheet. It has a minimum tensile strength of 3.0 lb per in. width, retaining 50 percent of its tensile strength when folded flat upon itself. Elongation before rupture is at least one percent.

Each filter unit is provided with upstream and downstream faceguards consisting of galvanized hardware cloth.

The HEPA filters are designed to filter the air flow upstream and downstream of the charcoal adsorber section. The upstream HEPA filter removes particulates from the air stream and the downstream HEPA filter prevents any possible charcoal fines originating in the charcoal adsorber from exiting the filter train and being ejected to the atmosphere.

The HEPA filters meet military specifications MIL-F-51068D and MIL-F-51079A and are of fire and water resistant construction in accordance with UL-586, Class 1. They are individually factory tested and certified to have an efficiency not less then 99.97 percent when tested with 0.3 micron dioctylphthalate smoke in accordance with Military Standard MIL-STD-282 and USAEC Health and Safety Bulletin, Issue No. 120.

All HEPA filter gasket material retains its integrity and resilience when it is subjected to air stream temperatures up to 300°F.

f) High Efficiency Charcoal Adsorber Filters

High Efficiency Charcoal Adsorber filters furnished by the CVI Corporation are an integral part of the ESF filter trains installed in air cleaning systems.

→(DRN 02-1751, R12-A; 04-705, R14)

The charcoal adsorbers consist of four in. thick charcoal beds separated by an airspace. The Control Room filter train include three (3)-1500 cfm capacity charcoal adsorber beds in each train. The CVAS filter train has two (2)-1500 cfm capacity charcoal adsorber beds, and the SBVS filter train has five (5)-2000 cfm capacity charcoal adsorber beds.

←(DRN 02-1751, R12-A; 04-705, R14)

The charcoal adsorbers are of stainless steel construction with gasketless feature and design to prevent air from bypassing the charcoal beds.

Adsorber media is activated coconut shell charcoal impregnated with potassium trioxide and packed in a GRAV-A-PAC fill hopper to fill the four in. deep adsorber beds. The hopper is designed to provide a uniform maximum packing density which enhances the charcoal filter efficiency for removal of radioiodines from the air stream.

Representative samples of charcoal furnished have the same qualification and batch test characteristics as the system adsorbent. Samples were tested in a laboratory under the same service conditions of the adsorber to demonstrate the High Efficiency Charcoal Adsorber filter capability of removing 99 percent of iodines in the form of methyliodide.

The beds of the SBVS, FHB, CVAS and Control Room adsorbers have a maximum design loading that is less than 2.5 mg of iodine per gm of activated charcoal and are designed for a residence time of at least 0.25 second for each two inches of bed depth.

→(DRN 01-571, R11-A)

The adsorber, when fully charged with activated charcoal passes the amount of air specified with a plus or minus tolerance of 0.15 in. wg on the stated air resistance. The laboratory tests, performed at a relative humidity of 70 percent for a methyl iodide penetration of less than 0.5 percent, conform to ASTM D3803-1989.

←(DRN 01-571, R11-A)

### 6.5.1.3 Design Evaluation

→(DRN 02-1751, R12-A; 04-705, R14)

Two 100 percent capacity ESF air filtration trains are provided, either of which is capable of fulfilling the objectives given in the design bases. The trains are located within the Reactor Auxiliary Building which protects them from the effects of natural phenomena (other than earthquakes) and missiles. All systems are seismic Category I. All components are qualified to meet the applicable enviromental conditions specified in Section 3.11.

←(DRN 02-1751, R12-A; 04-705, R14)

Instrumentation, controls and power to the redundant filter trains are electrically separated and powered from separate onsite power sources. The filter trains are actuated by their respective safety related channels. Manual switches are provided in the main control room for all fans, motorized valves, and dampers.

→(DRN 02-219, R11-A)

Failure modes and effects analyses for the Control Room Air Conditioning System, the CVAS, the SBVS, and the Fuel Handling Building Ventilation System are provided in Tables 9.4-3, 6.5-3, 6.2-31 and 9.4-5, respectively. These tables show that providing fully redundant filter trains assures that the systems can

←(DRN 02-219, R11-A)

→(DRN 02-219, R11-A)
withstand a single active failure without impairing their functional capability.
←(DRN 02-219, R11-A)

In claiming credit for the post accident fission product removal, each air cleaning unit is designed to be tested in place to verify that the unit meets the particulate filtration, iodine adsorption and leak tightness requirements. The test programs are discussed in Subsection 6.5.1.4.

Temperature sensors located adjacent to and downstream of charcoal adsorbers are provided to monitor temperature of the adsorbers at all times. Except for the Control Room Air Conditioning System emergency filter trains, cross connecting ducts are provided allowing one exhaust fan to draw enough air through the second idle air cleaning unit to remove radioactive decay and oxidation heat. The heat load in the Control Room Air Conditioning System emergency filters is negligible.

Charcoal adsorbers are designed and filled with activated charcoal that has been demonstrated to remove more than 99 percent of elemental and organic iodines. Mass of activated charcoal in each air cleaning unit exceeds the basis of a loading of 2.5 mg of iodines per gram of activated charcoal.

ESF air filtration systems are designed and constructed to the recomendations of Regulatory Guide 1.52 with the exceptions delineated in Table 6.5-1.

An analysis to provide delay times up to the depressurization of the controlled ventilation areas by the exhaust fan E-23 following an SIAS shows that depressurization to -0.25 in. wg is achieved as shown on Table 6.5-6.

All components of the ESF air filtration systems are designed as seismic Category I. Procurement specifications require and vendors have substantiated through tests, calculations and/or operational date that components will remain operable under safe shutdown earthquake loads.

→(DRN 04-705, R14)
Dose analyses of postulated accidents are discussed in Chapter 15. Offsite and main control room doses resulting from these accidents are shown to be within the guideline values of 10CFR50.67 and GDC-19, respectively.
←(DRN 04-705, R14)

6.5.1.4 Tests and Inspection

Testing and maintenance are considered as primary factors in assuring the reliability and the post accident fission product removal capability of the ESF filter systems. Preoperational and periodic tests will be conducted on all ESF air filtration systems. The preoperational and periodic tests on the HEPA filters and charcoal adsorbers are as required by the plant technical specifications. The preoperational in-place leak testing of duct-work and housings in accordance with the criteria of ANSI N509-1980 and ANSI N510-1980. Each air cleaning unit is equipped with all necessary sampling and injection ports, instruments and instrument taps to permit the required testing.

→
Test canisters containing representative samples of charcoal are located on the adsorber. The samples will be used for the periodic laboratory testing of the adsorber as required by Technical Specifications. When all test canisters are depleted and past sample data indicates the charcoal is still efficient, a slotted-tube sampler will be used to obtain a representative sample directly from the charcoal adsorber bed and refill the test canisters for future laboratory testing.
←

### 6.5.1.5 Instrumentation Requirements

Instrumentation for controlling and monitoring the ESF air filtration systems meets the applicable requirements of standard IEEE-279-1971 and Regulatory Guide 1.52. Each filter train is provided with instrumentation to indicate and alarm pressure drop at the main control room. An arrangement diagram of instrumentation and testing nozzles is provided on Figure 6.5-1. This arrangement is typical for all units except that the main control room and Fuel Handling Building ESF filter trains do not require the demister and its differential pressure taps.

a) Monitoring Instrumentation

Instrumentation provided for sensing and transmitting abnormally high temperatures at the charcoal adsorbers are as follows:

The temperature of air leaving each adsorber assembly within the unit is monitored by a continuous thermistor sensing loop. Air temperatures leaving each assembly reaching the high and high-high set points are annunciated in the main control room for appropriate operator action.

The pressure drops across the prefilter, and HEPA filters, are indicated locally. The pressure drop across filter trains are indicated locally and recorded in the main control room.

Upon initiation of air flow, as determined by the pressure differential across the filter train, the electric heating coils are energized and remain energized as long as differential pressure is maintained across the filter train.

b) Actuating Instrumentation

The Control Room Emergency Filter Trains are automatically started by SIAS or a high radiation signal. One of the two emergency filtration fans can be manually deenergized and placed on standby.

Under accident conditions, the CVAS filter exhaust system is actuated by a SIAS. The CVAS area is isolated and all air is exhausted through the CVAS filter train for filtering through charcoal adsorbers prior to release to atmosphere.

The FHB emergency filter units are actuated by the receipt of a high radiation signal following a fuel handling accident, from monitoring instruments located inside the building.

The SBVS is automatically actuated upon receipt of a SIAS. One fan can be manually shutdown and placed in the standby mode. The standby system is automatically restarted if the operating unit should fail. Actuation logic is discussed in section 7.3 and monitoring instrumentation is discussed in section 7.5.

6.5.1.6 Materials

Materials of construction of ESF filter trains are painted carbon steel and stainless steel. Demisters are constructed from stainless steel. Electric heating coils for SBVS have stainless steel finned tubes with terminals for wiring hermetically sealed in an external terminal box. Electric heating coils for all other ESF air cleaning units have copper coated steel fins.

Prefilters and mounting frames are made of fire resistant construction in accordance with UL-900, Class 1, with filter cells constructed of materials capable of withstanding a temperature of 2500°F and 250 watts fission products decay heat for an indefinite period.

→(EC-5000081434, R301)

HEPA filters are fabricated by pleating a continuous glass microfiber sheet. Mounting frames are fabricated from 3/16 in. stainless steel, ASTM A 240. HEPA filter gasket material is flat close celled type neoprene, ASTM D1056 Grade SCE-43, which retains its integrity and resilience when subjected to gas flow of 300°F with radiation exposure as high as $5x10^7$ rads. Gasket material used to seal inspection and access doors of the marine bulkhead type is neoprene, ASTM-D-156 Grade SCE-45, with similar properties to that used on HEPA filters.

The High Efficiency Charcoal Adsorber filters are charcoal contained in an all welded stainless steel assembly. The radiation stability of coconut shell charcoal adsorbents has been demonstrated by tests. For example, coconut shell impregnated with potassium triiodide ($KI_3$) is reported in Table IV of a report by A.G. Evans entitled "Effect of Intense Gamma Radiation on Radioiodine Retention by Activated Carbon", proceedings of the 12th AEC Air Cleaning Conference. (8/72)

←(EC-5000081434, R301)

The ESF air filtration systems are located outside the containment. The systems operate at relatively low temperatures, therefore radiolytic or pyrolytic decomposition of system materials does not pose any problem.

6.5.2 CONTAINMENT SPRAY AS FISSION PRODUCT CLEANUP SYSTEM

6.5.2.1 Design Bases

The design bases for the Containment Spray System (CSS) as a fission product cleanup system are as follows:

→(DRN 04-705, R14)

a) Provide adequate capability for the fission product scrubbing of the containment atmosphere following a LOCA so that offsite doses and doses to operators in the main control room are within the guidelines of 10CFR50.67 and GDC-19 respectively. The radioactive material release assumptions of Regulatory Guide 1.183 and simultaneous operation of other fission product removal systems are used in determining system capability.

←(DRN 04-705, R14)

→(DRN 04-705, R14)

b) Maintain the boron concentration in the containment spray solution to reduce containment concentrations of iodine isotopes. The extent to which credit is taken for this fission product removal in the offsite dose analysis is discussed in Chapter 15.

←(DRN 04-705, R14)

c) System materials are chosen for compatability with boric acid solution.

d) Perform its function following a LOCA assuming a failure of any single active component.

e) System is designed to seismic Category I requirements and in accordance with ASME Section III, safety class 2. The system is designed to function under post accident environment conditions. (See Section 3.11.)

f) System is designed to facilitate testing and inspection to the extent practicable as required by General Design Criteria 42 and 43.

Subsection 6.2.2 describes additional design bases including sizing of the system and its components.

### 6.5.2.2 System Design

A piping and instrumentation diagram of the Containment Spray System is given in Drawing G163. The system consists of two independent and redundant loops each consisting of a spray pump, shutdown heat exchanger, piping, valves, spray headers and nozzles. Subsection 6.2.2 describes design details of all components of CSS. The arrangement of spray headers and nozzles is shown in Figures 6.2-41 and 6.2-42. The spray patterns for both loops are shown in Figures 6.2-43 and 6.2-44. The headers are located as high as practicable in order to provide maximum fall height and residence time to the containment spray. Each header conforms to the shape of the containment dome. Nozzles on these headers are at equal distance from each other. This arrangement provides uniform distribution of sprayed water.

→(DRN 04-705, R14)

It is conservatively assumed, based on calculation, that one containment spray loop covers at least 80% of the containment free air volume.

←(DRN 04-705, R14)

→(DRN 05-1138, R14)

During the initial injection mode the containment spray pumps take suction from the Refueling Water Storage Pool (RWSP) and spray borated water into the containment. The operation is initiated by Containment Spray Actuation Signal (CSAS). When the predetermined water level is reached in RWSP, Recirculation Actuation Signal (RAS) is generated which shifts suction of the Containment spray pumps to the Safety Injection System (SIS) sump.

←(DRN 05-1138, R14)

→(DRN 05-1138, R14)

The sprays produced by the CSS are the primary mechanism for removal of iodine from the containment atmosphere. The sprays reach the containment atmosphere in less than a minute following LOCA.

←(DRN 05-1138, R14)

The sequence of events and associated time delays for starting and bringing CSS to full operation with and without preferred (offsite) power is given in Tables 6.2-23 and 6.2-24.

→(DRN 05-1138, R14)

←(DRN 05-1138, R14)

→(DRN 04-705, R14)

Water from safety injection tanks will be mixed with water from RWSP and the primary system in the SIS sump, which will raise the overall boron concentration.

←(DRN 04-705, R14)

The pH control of water that is circulated within the containment following a LOCA is provided. Stainless steel baskets containing Trisodium Phosphate Dodecahydrate (TSP) are located near the SIS sump pump intake. TSP is dissolved by the containment spray water and other water draining toward the SIS sump and thus raises pH of the recirculated water. The CSS is designed to operate continuously. The system design is further described in Subsection 6.2.2.

### 6.5.2.3 Design Evaluation

→(DRN 04-705, R14)

An analysis is performed assuming both CSS loops are in operation. This is the worst case during injection mode of operation because injection time is minimized. A calculation of the iodine removal effectiveness of the system is performed to establish the degree of iodine dose mitigation by the containment spray following the postulated accident. The mathematical model used for this calculation is based upon WASH-1329, June 1974, report. The iodine released to the containment is considered to be released instantaneously and uniformly distributed in the containment net free volume. The containment free volume

←(DRN 04-705, R14)

is made up of two defined regions, sprayed and unsprayed. The sprayed region exists primarily above the operating floor. Credit (70 percent) is taken for floor grating which essentially provides uninterrupted passage for spray drops. The whole sprayed volume is treated as one uniformly sprayed region. The containment fan coolers provide mixing between sprayed and unsprayed regions.

The performance of the CSS as a fission product cleanup system is evaluated at peak values of containment pressure and temperature after LOCA.

→(DRN 04-705, R14)

The principle system parameters influencing fission product removal performance are a minimum spray flow of 1750 gal./min, a minimum boron concentration of 1700 ppm, an average fall drop height of 150 ft., and a sprayed region volume of 80 percent of the net free containment volume.

Containment spray removal coefficients consistent with NUREG-0800, Section 6.5.2 are assumed. One train of Containment Spray is assumed to operate following a LOCA, with a minimum flow rate of 1750 GPM. The removal coefficient for particulate/aerosol iodine is assumed, consistent with NUREG-0800, to decrease by a factor of ten when the airborne inventory has dropped to 2% of the total particulate iodine released to the containment (a PF of 50). This is assumed to occur after 1.8 hours. The removal of elemental iodine from containment sprays is conservatively neglected for off-site and control room inhalation/submersion dose calculations. For control room doses from filter (CVAS/SBVS/control room), containment, and external shine the containment spray removal constants were determined in accordance with SRP guidance.

Reduction of airborne activity by natural deposition within the containment is for LOCA dose analyses. The Powers 10% Aerosol Deposition is specified for natural deposition of aerosols/particulates. This model is described in NUREG/CR-6604. The lower bound of this deposition model ($10^{th}$ percentile) is specified. The guidance of NUREG-0800, Section 6.5.2 is applied for natural deposition of elemental iodine.

←(DRN 04-705, R14)

TSP baskets are so located that all sprayed water dissolving TSP will drain to the SIS sump.

A single failure analysis is performed on all active components of the CSS to show that a failure of any active component will not degrade the system capability. The single failure analysis is presented in Table 6.2-27.

Evaluation of spray nozzle design and droplet size is discussed in Subsection 6.2.2.

6.5.2.4 Tests and Inspection

All components are hydrostatically tested either at manufacturer's plant or after installation in the field. Preoperational tests were performed before the start-up of the plant as discussed in Chapter 14.

Operating personnel will perform periodic inspection and testing of the equipment. This will be done in accordance with ASME Section XI with active pumps and valves tested to the requirements of Subsection IWP and IWV respectively (refer to Subsection 3.9.6 and the Technical Specifications). A recirculation line from pump discharge back to RWSP permits verification of pump performance. The actual boric acid solution water is recirculated.

The testing of the containment spray nozzles is described in Subsection 6.2.2.

Water samples from RWSP are periodically analyzed to check the boron concentration and also to check that no precipitates have formed.

### 6.5.2.5 Instrumentation Requirements

The CSS is automatically actuated by a Containment Spray Actuation Signal (CSAS) as described in Subsection 7.3.1.1.3. Instruments are provided for monitoring the status and performance of the CSS. Indicators, alarms, controls and actuation logic are further described in Section 7.3.

### 6.5.2.6 Materials

The materials used in the CSS are compatible with boric acid spray solution and the containment environment following LOCA. The CSS materials which could be in contact with the spray solution are either austenitic stainless steel Type 316, 304 or an acceptable alternative material. None of the materials used are subject to decomposition by radiation or thermal environment (refer to Subsection 6.1.1).

→(DRN 04-705, R14)

As no additives are used other than TSP, no corrosion concern exists. As discussed in Subsection 6.1.3, the pH of SIS sump water will be maintained over seven by the use of TSP to minimize the potential for corrosion of paint, stainless steel and other materials used and to prevent the re-evolution of iodine into gaseous form.

←(DRN 04-705, R14)

## 6.5.3 FISSION PRODUCT CONTROL SYSTEMS

The fission product control systems provided for Waterford 3 are the containment vessel and the Shield Building. By definition, the fission product control systems do not include the Containment Isolation System, the fission product removal systems, or the Combustible Gas Control System. However, the fission product control systems operate post accident in conjunction with the above ESF systems.

### 6.5.3.1 Primary Containment

The primary containment structure consists of a cylindrical steel pressure vessel with hemispherical dome forming a continuous leak tight free standing steel shell. It is completely enclosed by the reinforced concrete Shield Building having a cylindrical shape with shallow dome roof. An annular space is provided between the primary containment vessel and the Shield Building and clearance is also provided between the containment vessel and the Shield Building dome.

Details of the containment vessel are discussed in Section 3.8.

→(DRN 04-705, R14)

The containment steel shell, mechanical penetrations, isolation valves, hatches, and locks function to limit release of radioactive materials, subsequent to postulated accidents, such that the resulting offsite doses are less than the guideline values of 10CFR50.67. Containment parameters affecting fission product release accident analyses are given in Table 6.5-4.

←(DRN 04-705, R14)

Long and short-term containment response to the design basis accident is discussed in Subsection 6.2.1. The operation of the Containment Spray System (CSS) to reduce iodine concentrations and containment atmosphere temperature and pressure is discussed in Subsections 6.5.2 and 6.2.2.

Redundant, safety-related hydrogen recombiners are provided in the containment as the primary means of controlling post accident hydrogen concentrations.

The Containment Atmosphere Release System (CARS) is provided to purge containment at low containment atmosphere pressure. Although use of the CARS is not required for post accident hydrogen control because of the hydrogen recombiners, its operation following a design basis accident allows fission products to be released to the Shield Building annulus for fission product removal by the Shield Building Ventilation System.

Layout drawings of the containment and the Containment Atmosphere Release System are shown on Figures 6.2-36 and 6.2-37.

The Containment Atmosphere Purge System will not be used following a design basis accident. This system is described in Section 9.4.

The Containment Vacuum Relief System is used to prevent excess external pressure on the primary containment steel shell. This system is described in Subsection 3.8.2.3.

### 6.5.3.2 Secondary Containment

Additional fission product control is achieved following a design basis accident by the maintenance of a negative pressure inside the Shield Building annulus by the Shield Building Ventilation System. A partial vacuum inside the annulus prevents outleakage through the concrete structure and thus provides control over the release of fission products to the outside environment.

The cleanup of fission products in the annulus is accomplished by the Shield Building Ventilation System which is described in Subsections 6.2.3 and 6.5.1.

The time sequence of events for the annulus transient and for performing the dose estimates are described in Subsection 6.2.3 and Appendix 15B.

A summary of Shield Building Ventilation System operation following a design basis accident is provided in Table 6.5-5. Secondary containment volume and the ductwork are shown in Figures 6.2-36, 6.2-37, 6.2-39, and 6.5-4.

→(EC-5000081471, R301)

Fission product control is also provided by the Control Ventilation Area System (CVAS). The CVAS maintains a portion of the Reactor Auxiliary Building at a negative pressure following a design basis accident and provides filtration. The CVAS is discussed in Subsection 6.5.1.

←(EC-5000081471, R301)

During normal operation the annulus will be maintained at negative pressure by the Annulus Negative Pressure System which is discussed in Section 9.4.

## 6.5.4 ICE CONDENSER AS A FISSION PRODUCT CLEANUP SYSTEM

This subsection is not applicable to Waterford 3.

TABLE 6.5-1 (Sheet 1 of 5) Revision 14 (12/05)

COMPARISON OF ESF AIR FILTRATION
SYSTEMS WITH REGULATORY POSITIONS
OF REGULATORY GUIDE 1.52 (6/73)

| Regulatory Position Item | System Design Feature |
|---|---|
| 1a | All systems have been designed to applicable temperature, relative humidity radiation dose rate, seismic, and pressure considerations in accordance with the regulatory guide and postulated DBA conditions. Check and butterfly valves can perform their function in the radiation environment described in Regulatory Guide 1.52. |
| →(DRN 04-705, R14) | |
| 1b | Accident condition dose rates have been indicated for check and butterfly valves and is in excess of the 30 day integrated dose. Dose rates were not indicated for sheet metal work and casings. All cable for the ESF air filtration systems can withstand the 30 day post-LOCA integrated dose from the air filtration units. |
| ←(DRN 04-705, R14) | |
| 1c,d,e | All systems comply with these regulatory positions. |
| 2a | All systems include 100 percent redundant units and comply with regulatory position. |
| 2b | Physical separation is provided between redundant active components of ESF air filtration system so that damage to one system does not also cause damage to the second system. |
| 2c | All systems are designed as seismic Category I. |
| →(DRN 02-1751, R12-A) | |
| 2d | All systems are located outside primary containment. The SBVS, CVAS, and control room ventilation systems comply with regulatory position. |
| ←(DRN 02-1751, R12-A) | |
| 2e | On all system HEPA filters, charcoal adsorber filters, filter casings, sheet metal work, and filter racks have been specified to specific radiation dose and have been specified in accordance with the material type and thickness of ORNL-NSIC-65, MIL-F-51068FD and MIL-F-51079A. Other materials (e.g., gaskets and insulation) have been specified, for use only if their behavior in radiation environments is established as acceptable for the materials intended post-accident environment. |
| 2f | All systems will comply with regulatory position. |

TABLE 6.5-1 (Sheet 2 of 5)

| Regulatory Position Item | System Design Feature |
|---|---|
| 2g | Local indication of pressure drop and flow is provided on all filters. High differential pressure and low flow is alarmed in the main control room. |
| 2h | All systems comply with IEEE-308 and 279 (1971). IEEE-323 and 344 (1971) have been considered in the design of electrical equipment supplied with filter trains where applicable. IEEE-336 and 338 (1971) are complied with to the extend applicable. Conformance to IEEE-338 is predicated on redundancy to provided practical test capability. |
| 2i | All systems comply with regulatory position. No filter bypasses are provided. |
| 2j | Because of the length of the filter trains in these systems (31-40 ft) some disassembly will be needed for maintenance and replacement. Generally two or three sub-assemblies are provided depending on the capacity of each filter train. |
| 2k | All systems comply with regulatory position. |
| 2l | Primary systems not applicable. Secondary systems comply with regulatory position. |
| 2m | Failure of the ARRS (cleanup system) will not deleteriously affect the operation of ESF systems. |
| 3a | All systems comply with regulatory position. |
| 3b | All systems comply with regulatory position. |
| 3c-d | All systems comply with regulatory position. |
| 3e | All systems comply with regulatory position. |
| 3f | All systems comply with regulatory position and with the following exceptions or clarifications:<br><br>Bolted on removable panels are used for electric heating coil removal. Doors are provided for all other access, which include filter replacement. Door height is less than that shown in ORNL-NSIC-65 Subsection 4.5.7. |

| Regulatory Position Item | System Design Feature |
|---|---|
| 3f (Cont'd) | One light on each side of filter may be used where the width of the unit is five ft. or less. Lights can be replaced from inside the housing. Grouted shims are used for leveling. |
| 3g | All systems comply with regulatory position. |
| 3h | All painted carbon steel surfaces are either blasted clean in accordance with Steel Structure Painting Council (SSPC) surface preparation specification No. SP-3, or in accordance with SSPC specification No. SP-5-63. If the steel is blasted, the shop coat is applied within four hours of blast cleaning. The shop coat is one coat three mil dry film thickness, applied in accordance with the manufacturer's specification No. B471.9911. Aluminum and Zinc are not to be used. |
| 3i | All systems will comply with regulatory positions except for the following clarifications or corrections:<br>1) Average residence time is based on superficial gas velocity and is a function of packing density.<br>2) The degree of activation of the carbon will be determined by $CC1_4$ activity as determined in accordance with test procedure given in RDT-M16-1T, October 1973.<br>3) Adsorber media will be new activated coconut shell charcoal. The radiation stability of the media has been demonstrated by tests conducted as reported in Table IV of the following reference: Evans, A.G., Effect of Intense Gamma Radiation Retention by Activated Carbon, Proceedings of the 12th AEC Air Cleaning Conference. |
| →(DRN 01-571) | 4) Radioiodine removal efficiencies for elemental iodine and methyl iodide will be determined from test methods as described in ASTM D3803-1989. |
| ←(DRN 01-571)<br>3 | 1) Testing shows that the CVI method of filling the adsorber cells produces a maximum uniform packing density and that vibrating or shaking the packed bed does not produce settling. Based on these results and the nature of the design which precludes formation of any voids, the prototype test is not considered necessary.<br>2) Uniform packing density is achieved by use of hopper to match ASTM D2854-70 specification "Test for Apparent density of Activated Carbon". |

| Regulatory Position Item | System Design Feature |
|---|---|
| →(DRN 02-1751, R12-A) | |
| 3j | CRACS designs do not include water sprays. |
| ←(DRN 02-1751, R12-A) | |
| | SBVS and CVAS design includes deluge system and provisions for preventing adsorber fires by ensuring continued cooling of adsorbers by air flow even in the event of a single failure. This is accomplished by providing cross connections between redundant fans and filter trains. |
| 3k | All systems comply with regulatory position except for the Control Room Air Conditioning System which is sized to provided a positive pressure inside the envelope. |
| 3l,m | All fans and ductwork systems comply with regulatory positions. |
| 3n | All systems comply with regulatory position. |
| 4a,b | All systems comply with regulatory position. |
| 4c | Vacuum breakers are not provided as operating personnel are not expected to enter while the unit is in operation. |
| 4d | Space availability limits compliance with this regulatory position. However, there is always space available for maintenance if not always the amount in this position. |
| 4e,f | All systems comply with regulatory position. |
| 4g | Hoists are provided instead of elevators. |
| 4h | Permanent test connections (normally capped) are provided for testing. |
| 4i | All systems comply with this regulatory position. |
| 4j | All systems comply with this regulatory position. |
| 4k | All systems comply with this regulatory position. |
| 4l | All systems comply with this regulatory position. |
| 4m | All systems comply with this regulatory position. |
| 5a | All systems comply with regulatory position. |

TABLE 6.5-1 (Sheet 5 of 5)

| Regulatory Position Item | System Design Feature |
|---|---|
| 5b | All systems comply with regulatory position except that the in-place HEPA DOP test conforms to ANSI N510-1975 which exceeds the requirements of ANSI N101-1972, and periodic testing is in accordance with the Technical Specifications.<br><br>There will be no adsorber bypass during DOP testing since the DOP will be removed from the adsorbers when the fans are operated. |
| 5c | All systems comply with regulatory position. Activated carbon adsorber sections will be tested in accordance with ANSI N510-1975, and periodic testing is in accordance with the Technical Specifications. |
| 5d | All systems will be leak tested in accordance with Section 12 of ANSI N510-1975. |
| 6a,b | Complete test reports and test results will be furnished by CVI Corp. |

TABLE 6.5-2

CVAS OPERATING VALVE SCHEDULE

| Valve Designation | Type of Operator | Area or Unit Served | Fail Position | Normal Operation Position | CVAS Operation Position |
|---|---|---|---|---|---|
| 3HV-B226 A | P | CVAS Area Normal Supply | FC | 0 | C |
| 3HV-B227 B | P | | FC | 0 | C |
| 3HV-B218 A | P | CVAS Area Normal Exhaust | FC | 0 | C |
| 3HV-B217 B | P | | FC | 0 | C |
| 3HV-B210 A | P | CVAS Train A | FO | C | O |
| 3HV-B208 A | M | | As is | C | 0 |
| 3HV-B206 A | M | | As is | C | O |
| 3HV-B225 B | P | CVAS Train B | FO | C | O |
| 3HV-B209 B | M | | As is | C | O |
| 3HV-B207 B | M | | As is | C | O |
| 3HV-B205 | Manual | CVAS Train A & B Bypass | | Locked open | Locked open |
| 3HV-B224 A | P | Pipe Pen Area Normal Supply | FC | O | C |
| 3HV-B223 B | P | | FC | O | C |
| 3HV-B216 A | P | Pipe Pen Area Normal Exhaust | FC | O | C |
| 3HV-B215 B | P | | FC | O | C |

Legend

P - Pneumatic
M - Electric Motor
FC - Fail Closed
FO - Fail Open
O - Open

TABLE 6.5-3

CONTROLLED VENTILATION AREA SYSTEM FAILURE MODES & EFFECTS ANALYSIS

| Component Identification and Quantity | Failure Mode | Effect on System | Method of Detection | Monitor | Remarks |
|---|---|---|---|---|---|
| CVAS Areas isolation valves<br>3HV-B226A, 3HV-B227B<br>3HV-B218A, 3HV-B217B<br>3HV-B224A, 3HV-B223B<br>3HV-B216A, 3HV-B215B | Fails to close | None | Class 1E valve position indicating lights | CRI | Redundant valve in series will close |
| Filter train isolation valves<br>3HV B210A<br>3HV B225B<br>Filter train Inlet & Discharge Valves<br>3HV-B208A, 3HV-209B<br>3HV-B206A, 3HV-B207B | Fails to open | Fan will not start | Class 1E differential pressure alarm across filter train | CRI | 100 percent capacity redundant filtration unit will start automatically |
| Filter train Demister (2) | Clogs | Reduced air flow through filter train | Class 1E differential pressure alarm across filter train | CRI | 100 percent capacity redundant filtration unit will start automatically |
| Filtration Unit filters (4):<br>Medium Efficiency Filter<br>HEPA Prefilter<br>HEPA Afterfilter | Filter Clogs | Reduced air flow through filter train | Class 1E differential pressure alarm across filter train | CRI | 100 percent redundant filter train remains operable |
| Electric Heating Coils (2):<br>EHC-48 (3A-SA) | Does not go on | Filter train fan will stop | Class 1E temperature sensors | CRI | 100 percent capacity redundant system will automatically start. |
| EHC-48 (3B-SB) | Class 1E primary overtempera-ture protection thermal cut-outs fail to deenergize coils | Hazard of electrical fire | Class 1E temperature sensors | CRI | Class 1E secondary overtemperature protection thermal cutouts are provided to deenergize coil and coil in redundant system remains operational |
| | Class 1E primary overtempera-ture protection thermal cut-outs remain in open position or coil fails to operate for other reasons | Decrease in supply air temperature | Class 1E temperature sensors | CRI | Coil in redundant system remains operational |
| Filtration Unit Fan (2):<br>E - 23 (3A-SA)<br>E - 23 (3B-SB) | Fails to start | No air flow through filter train | Class 1E differential pressure transmitter across filter train | CRI | 100 percent capacity redundant system will automatically start |
| Decay cooling valve in filter trains discharge interconnecting pipe (1)<br>3HV-B205 | Closed and cannot be re-opened | Loss of decay heat cooling air | Class 1E charcoal tempera-ture alarm. Valve position switch alarm | CRI | Valve locked open except for filter train testing or maintenance. Closure during accident not possible. |

TABLE 6.5-4 

➔(DRN 04-705, R14)

THIS TABLE HAS BEEN DELETED

←(DRN 04-705, R14)

TABLE 6.5-5 Revision 14 (12/05)

SECONDARY CONTAINMENT OPERATION
FOLLOWING A DESIGN BASIS ACCIDENT

General

| | |
|---|---|
| Type of Structure: | Concrete Shield Building Cylinder with Dome |
| Annulus Free Volume: | 550,000 $ft^3$ |
| Annulus Width: | 4 ft. average |
| Location of Fission Product Removal Systems: | Reactor Auxiliary Building Equipment Room at EL. +46 ft. MSL |

Time Dependent Parameters

→(DRN 04-705, R14)

| | |
|---|---|
| Leak Rate to Annulus: | 0.5 weight percent for the first day and 0.25 percent per day thereafter |
| Total Recirculation Flow; Max. | 10.000 cfm |
| Exhaust Flow; Max. | 10,000 cfm |
| Pressure; Max. | < -0.25 in. |
| SBVS adsorber efficiency, % | 99.0 percent |

←(DRN 04-705, R14)

→

TABLE 6.5-6 Revision 10 (10/99)

←

CONTROLLED VENTILATION AREAS SYSTEM DESIGN BASIS DELAY TIMES
(LOSS OF OFFSITE POWER)

| System | Time (Seconds) | Event Description | Event No. |
|---|---|---|---|
| CVAS | 0.0 | Containment pressure reaches 5 psig. Safety injection actuation signal (SIAS) conditions met. and SIAS starts the diesel generator(s). | 1 |
| CVAS | 10.0 | Diesel generator output breaker closes. | 2 |
| CVAS | 17.0 | CVAS isolation valves begin to open (according to diesel load sequencing). Filter train inlet and outlet valves begin to open. | 3 |
| CVAS | 18.0 | CVAS Exhaust Fan E-23 starts when Filter train valves are more than 5 percent open. | 4 |
| CVAS | 23.0 | CVAS Exhaust Fan E-23 reaches full speed (assumed steady state) with 3,000 CFM capacity. | 5 |
| CVAS | 35.0 | Controlled Ventilation Areas space pressure is reduced to 0.25 in. water gauge. | 6 |

→ ←

References

1) For Event No. 3, Refer to FSAR Table 8.3-1.

2) For Event No. 6, Time is 23 seconds plus 12 seconds calculated. (Refer to NRC Q 022.13)

3) For Event No. 4, total valve opening time is 5 seconds. It is assumed butterfly valves reach 5 percent open in one second.