6.2.2 Containment Heat Removal Systems

The containment design includes integrated systems to limit the containment pressure and temperature increase and maintain them at acceptably low levels following the accident. These systems include the CONVECT system, recirculation and heat removal features built into the in-containment refueling water storage tank (IRWST), and re-alignment of the safety injection system (SIS) to the hot legs.

The CONVECT system is further described in Section 6.2.5, while the IRWST and the SIS are further described in Section 6.3.

6.2.2.1 Design Bases

The containment heat removal systems include the CONVECT system, the IRWST, and the SIS. The design bases of the CONVECT system is described in Section 6.2.5.1, while the design bases of the IRWST and the SIS are described in Section 6.3.1

6.2.2.2 System Design

In the event of an accident, communication is established between the accessible space and the equipment area by opening mixing dampers and a combination of rupture and convection foils, thereby transforming the divided containment volume into a single convective volume. This transformation to a single convective volume is performed by the CONVECT system. This enables equalization of pressure between the containment compartments and promotes efficient mixing of the atmosphere by establishing a global convective loop within the containment. The resulting atmospheric mixing increases convective cooling to walls and structures.

The CONVECT system of convection foils, rupture foils, and mixing dampers is part of the combustible gas control system (CGCS). The CONVECT system is designed to provide adequate mixing for both large and small breaks inside and outside of equipment rooms. Following a large-break LOCA, the pressure differential between rooms increases rapidly and the rupture foils open in either direction. For a small break, the pressure differential might not be sufficient at all locations, so only the rupture foils near the break open. However, as the equipment area temperature rises, the convection foils open to provide adequate vent area between the accessible space and the equipment rooms. Table 3.2.2-1 provides the seismic and other design classifications of the CONVECT system components.

Following blowdown, the vapor in the atmosphere condenses on the passive containment heat sinks located throughout the containment. The saturated water drains along the intermediate floors, grates, stairwells, and walls to the IRWST. Condensation-induced circulation zones provide additional mixing of the containment atmosphere during and after blowdown. Saturated water drains from the heat sinks in the equipment area, pools on the heavy floor, and mixes with the liquid break effluent.

Curbed grates in the heavy floor direct the condensate and spilled reactor coolant back to the IRWST.

For the U.S. EPR design, a manual realignment of at least 75 percent of the low head safety injection (LHSI) system from the cold leg to the hot leg injection location takes place during the final LBLOCA phase (about 60 minutes after the initiating event). Hot leg injection serves both as a mechanism for removing core decay heat, leading to the complete cessation of steaming, and for maintaining core boron concentrations below the threshold concentration for precipitation.

Water from the IRWST, which serves as the long term water source for the SIS, is recirculated by the LHSI pumps through the LHSI heat exchangers, where it is cooled by the component cooling water system (CCWS). Then it is pumped into the RCS to cool the core before it returns to the IRWST through the break.

The SIS provides cooling of the IRWST in the event of a LOCA and provides long-term core cooling. The SIS consists of four independent trains, providing sufficient capacity, diversity, and independence to perform its required safety functions following design basis transients or accidents assuming a single failure in one train while a second train is out-of-service for preventive maintenance. Section 3.2 identifies component classifications for the IRWST and SIS. Section 6.3.2.2.2 includes a discussion of the design features for avoidance of the potential loss of long-term cooling capability due to sump screen blockage in the IRWST and presents the performance evaluation of the design, a summary of component testing, and a comparison to the regulatory positions of RG 1.82.

The debris interceptor structures, including trash racks, retention baskets and ECCS strainers, are designed and analyzed per the provisions of ANSI/AISC N690-1994, "Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities," including Supplement 2 (S2). The term "debris interceptor structures" incorporates those items that combine to function as complete assemblies, including structural framing members, filtering panels and their frames, baseplate assemblies that attach the devices to the floors and walls, tightness devices that close the gaps between the framing members and the wall of the IRWST, and connections between these items. The structural qualification of the debris interceptors includes an evaluation of the structural integrity of the supports and anchorages as it relates to the abilities of the trash rack, retention baskets, and ECCS strainers to perform their intended function.

The following industry codes and standards are used for the structural qualification of the debris interceptors.:

1. Design Properties of Materials: ASME Boiler & Pressure Vessel Code, Section II, Part D, 2004 edition.

2. Steel Analysis: ANSI/AISC N690-1994, "Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities," including Supplement No. 2.

3. Concrete Anchorages: ACI 349-01/349R-01, "Code Requirements for Nuclear Safety Related Concrete Structures and Commentary."

4. Damping Values: NRC Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," Revision 1, March 2007.

The debris interceptor components such as IRWST retaining baskets, trash racks, TSP baskets and sump strainers are categorized as Seismic Category I mechanical equipment in U.S. EPR FSAR, Tier 1, Table 2.2.2-1. The seismic qualification of this equipment is covered by ITAAC Item 3.3 in U.S. EPR FSAR, Tier 1, Table 2.2.2-3.

6.2.2.3 Design Evaluation

The design basis containment analysis for loss of coolant accidents and main steam line breaks, and the containment pressure and temperature responses for these events, is discussed in Section 6.2.1. As shown in Figure 6.2.1-12, Figure 6.2.1-16, and Figure 6.2.1-20, containment pressure decreases to half its peak in less than twenty-four hours after a LOCA. Analysis of heat removal capacity of the LHSI heat exchanger in support of containment heat removal is discussed in Section 6.2.1.1.3.

The evaluation of NPSH availability of the SIS pumps is discussed inSection 6.3.3.3.

The failure modes and effects analyses of the CONVECT System are described in Section 6.2.5. The failure modes and effects analyses of the SIS are listed in Table 6.3-6. The common mode failure is addressed by the qualification program and periodic testing.

6.2.2.4 Tests and Inspections

Tests and inspections of the CONVECT system are described in Section 6.2.5.4, while the tests and inspections of the IRWST and the SIS are described in Section 6.3.4.

6.2.2.5 Instrumentation Requirements

Instrumentation requirements of the CONVECT system are described in Section 6.2.5.5, while the instrumentation requirements of the IRWST and the SIS are described in Section 6.3.5.

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