6.2.2 Containment Heat Removal Systems

Containment heat removal systems reduce containment pressure and temperature following any LOCA and maintain them at acceptably low levels. For the U.S. EPR, the containment heat removal function is accomplished by cooling the IRWST inventory into which the spilled and condensing reactor coolant flows following RCS blowdown, via the LHSI cooling function of the SIS.

Following blowdown, the reactor coolant vapor produced from the RCS leak condenses on the containment heat sinks. The saturated water drains along the intermediate floors, grates, stairwells, and walls to the heavy floor of the containment building. The effects of condensation induce circulation zones that provide a mixing of the containment atmosphere during and after blowdown. The saturated water draining from the heat sinks pools and forms a large condensation surface on the heavy floor. In the case of a LOCA, saturated reactor coolant spills out of the break, splashes on the heavy floor, and induces waves in the pooled water, which provides constant circulation that further promotes condensation on the pool surface. Curbed grates in the heavy floor drains direct the condensed reactor coolant back to the IRWST. The water in the IRWST is recirculated by the LHSI pumps through the heat exchangers, where it is cooled by the component cooling water system (CCWS), and pumped into the RCS to cool the core. The condensation of the reactor coolant vapor by the heat sinks and the subcooled liquid flowing across the heavy floor, and rejection of the heat to the environs via the LHSI heat exchanger cooling chain, results in long-term cooling and depressurization of the containment.

Long-term hydrogen mixing experiments were conducted in the Battelle Model Containment (BMC) facility to verify hydrogen mixing by natural convection after a LBLOCA in the Biblis containment. The geometry of the BMC facility is similar to that of the U.S. EPR; no fan coolers or sprays were available for active cooling during these tests.

The U.S. EPR does not credit active cooling by fan coolers or sprays inside containment during a postulated LBLOCA. The similar geometry and the minimum active containment cooling systems used in the BMC facility tests make the findings directly applicable to the LBLOCA for the U.S. EPR containment analysis.

As described in the June 1999 NEA/CSNI report on containment thermal-hydraulics and hydrogen distribution (Reference 6), these tests provide direct experimental evidence that sump flashing or evaporation resulting from sump liquid superheat generate effective natural convection currents throughout containment. The condition of sump liquid superheat also occurs in the IRWST in the long term as a result of LBLOCA. These tests show that sump evaporation that occurs in the absence of active containment cooling establishes effective natural convection currents throughout the U.S. EPR containment.

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 Figures 6.2.1-12, 6.2.1-16, and 6.2.1-20, the LHSI heat exchangers are sufficient to reduce the containment pressure to half its peak in less than eight hours after a LOCA.

The SIS provides cooling of the IRWST in the event of a LOCA and provides long-term cooling and pressure suppression of the containment volume. 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 6.3 discusses the SIS, including design bases, instrumentation, and inspection and testing requirements. Section 6.3 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.