High Pressure Coolant Injection System Reliability Study

1 HPCI SYSTEM DESCRIPTION

The HPCI system is a single-train system that provides a reliable source of high-pressure coolant for cases where there is a loss of normal core coolant inventory. Figure 1 provides a simplified schematic diagram of the system.

The HPCI system consists of a steam turbine-driven pump, valves and valve operators, and associated piping, including that from the normal and alternate pump suction sources and the pump discharge up to the penetration of the main feedwater line. For this study, the part of the main feedwater line from the check valve upstream of the HPCI connection to the reactor vessel, including the check valve, was considered part of the HPCI system. The steam turbine-driven pump includes all steam piping from the main steam line penetration to the turbine, and turbine exhaust piping to the suppression pool, valves and valve operators, gland sealing steam, and the turbine auxiliary oil system.

Additional components that were considered to be part of the HPCI system were the circuit breakers at the motor control centers (MCCs) (but not the MCCs themselves), the dedicated DC power system that supplies HPCI system power and the associated inverters, and the initiation and isolation logic circuits with their associated detectors. Heating, ventilating, and air conditioning (HVAC) systems and room cooling associated with the HPCI system were included. However, only a specific loss of service water to individual HPCI room coolers was included, and not the loss of the entire service water system.

Support system failures were considered for possible inclusion in this HPCI study. However, examination of the operational data found no cases when support system failures clearly caused HPCI failure. In addition, the support system failure contribution to the overall HPCI system failure probabilities in the PRAs was found to be small. Therefore, support systems were treated as outside the scope of this study.

The HPCI system is actuated by either a low reactor water level or a high drywell pressure. Initially the system operates in an open loop mode, taking suction from the condensate storage tank (CST) and injecting water into the reactor pressure vessel (RPV) via one of the main feedwater lines. When the level in the CST reaches a low-level setpoint, the HPCI pump suction is aligned to the suppression pool. To maintain RPV level after the initial recovery, the HPCI system is placed in manual control, which may involve controlling turbine speed, diverting flow through minimum-flow or test lines, cycling the injection motor-operated valve (MOV), or complete stop-start cycles.

The HPCI system is also manually used to help control RPV pressure following a transient. Although this is not part of the ECCS design function, it is depended on, in approximately 90% of the PRA/IPEs. However, only approximately 10% of the PRA/IPEs that depend on this function model the pressure control operation. In this mode, the turbine-driven pump is operated manually with the injection valve closed and the full-flow test-line MOV open. Turbine operation with the injection line isolated and the test line open allows the turbine to draw steam from the RPV, thereby reducing RPV pressure. Operation of the system in the pressure control mode may also occur with intermittent injection of coolant to the RPV. As steam is being

drawn off the RPV, the RPV water inventory is reduced, resulting in the need for level restoration. When level restoration is required, the injection valve is opened and the test-line MOV is closed. Upon restoration of RPV water inventory, the system is returned to the pressure control line-up. This cycling between injection and pressure control can be repeated as necessary.

Table 1. Plants with HPCI systems.

Plant	Docket	Plant	Docket
Browns Ferry 2	260	Limerick 1	352
Brunswick 1	325	Limerick 2	353
Brunswick 2	324	Monticello	263
Cooper	298	Peach Bottom 2	277
Dresden 2	237	Peach Bottom 3	278
Dresden 3	249	Pilgrim	293
Duane Arnold	331	Quad Cities 1	254
Fermi 2	341	Quad Cities 2	265
Fitzpatrick	333	Susquehanna 1	387
Hatch 1	321	Susquehanna 2	388
Hatch 2	366	Vermont Yankee	271
Hope Creek	354		

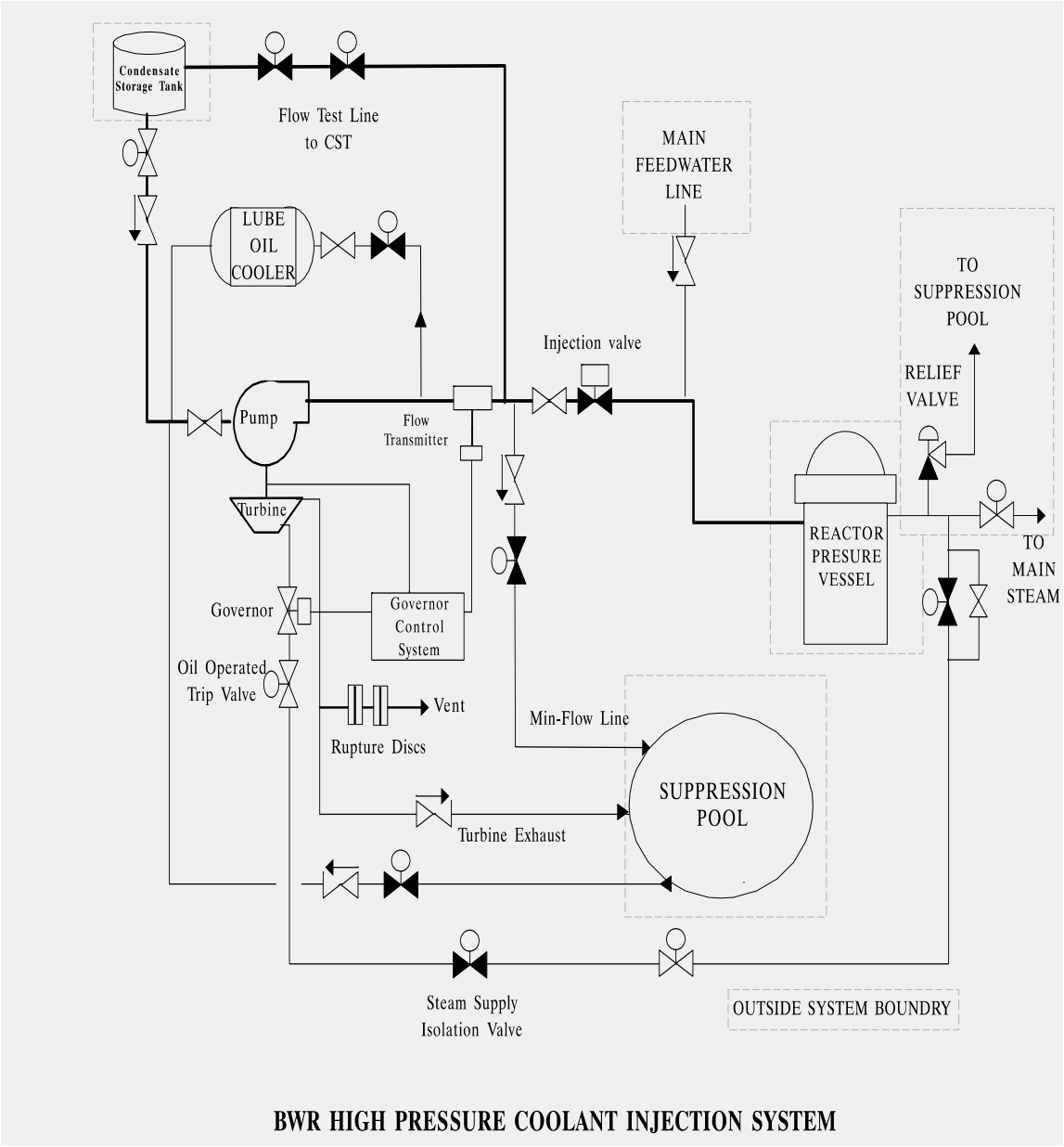

Figure 1. HPCI system diagram.