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Subject: **Transmittal of ESBWR DCD Tier 2, Chapter 6 Markups Related to GEH Internal Corrective Action**

The purpose of this letter is to submit markups to the ESBWR DCD, Tier 2, Chapter 6 which are the result of GEH internal review. These markups will be incorporated into the DCD, Revision 8. The markup pages are contained in Enclosure 1. Changes associated with this corrective action clarify that the dedicated instruments which provide power permissives to the deluge system squib initiators are temperature switches, not thermocouples.

If you have any questions or require additional information, please contact me.

Sincerely,

Richard E. Kingston

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Vice President, ESBWR Licensing

Enclosure:

1. Transmittal of ESBWR DCD Tier 2, Chapter 6 Markups Related to GEH Internal Corrective Action – DCD Markups

cc:	AE Cubbage	USNRC (with enclosure)
	JG Head	GEH/Wilmington (with enclosure)
	DH Hinds	GEH/Wilmington (with enclosure)
	TL Enfinger	GEH/Wilmington (with enclosure)
	eDRF Section	0000-0124-1502

Enclosure 1

MFN 10-303

Transmittal of ESBWR DCD Tier 2, Chapter 6 Markups Related to GEH Internal Corrective Action

DCD Markups

each of the injection lines leading from the GDCS pools to the RPV, thus making GDCS flow possible. The actual GDCS flow delivered to the RPV is a function of the differential pressure between the reactor and the GDCS injection nozzles, as well as the loss of head due to inventory drained from the GDCS pools. The timer delay allows the RPV to be substantially depressurized prior to squib valve actuation.

After a longer equalization valve time delay and when the RPV coolant level decreases to 1.00 m (3.28 ft.) above the top of the active fuel (TAF), squib valves are actuated in each of four GDCS equalizing lines. The open equalizing lines leading from the suppression pool to the RPV make long-term coolant makeup possible. The longer equalization valve delay ensures that the GDCS pools have had time to drain to the RPV and that the initial RPV level collapse as a result of the blowdown does not open the equalizing line. The long-term flow requirements for the GDCS equalizing lines are as follows: with the suppression pool water at saturation temperature, with vessel water level below equalizing line nozzles, the flow delivered inside the RPV through the GDCS equalizing lines is as shown in Table 6.3-2. This flow is required assuming a double-ended-guillotine-break in one GDCS equalizing line, and the worst single failure in a second equalizing line.

In the event of a core melt accident in which molten fuel reaches the lower DW, the flow through the deluge lines is required to flood the lower DW region with a required deluge network flow rate as shown in Table 6.3-2. The system design is such that a single active failure in one of the deluge valves does not prevent any of the pools from draining into the DW.

All piping connected with the RPV is classified as safety-related, Seismic Category I. The electrical design of the GDCS is classified as safety-related. The GDCS piping and components are protected against damage from:

- Movement;
- Thermal stresses;
- Effects of the LOCA; and
- Effects of the safe shutdown earthquake.

The GDCS is protected against the effects of pipe whip, which might result from piping failures up to and including the design basis event LOCA. This protection is provided by separation, pipe wipe restraints, energy-absorbing materials (if required) or by providing structural barriers.

The GDCS is mechanically separated into four identical divisions. Each GDCS division takes inventory from the GDCS pools (one division each from two pools and two divisions from the third pool) and the suppression pool. The equipment in each division is separated from that of the other three divisions.

6.3.2.7.2 System Description

Summary Description

The GDCS provides short-term post-LOCA water makeup to the annulus region of the reactor through eight injection line nozzles, by gravity-driven flow from three separate water pools located within the DW at an elevation above the active core region. The system provides long-term post-LOCA water makeup to the annulus region of the reactor through four equalization nozzles and lines connecting the suppression pool to the RPV. During severe accidents the GDCS floods the lower DW region directly via four GDCS injection drain lines (one each from two pools and two from the third pool) through the deluge system, if the core melts through the RPV.

Detailed System Description

The GDCS is composed of four divisions designated as Divisions A, B, C, and D. Electrical separation and mechanical train separation between the divisions are provided. The mechanical trains A and D draw water from independent pools designated as A and D and trains B and C draw water from a common pool designated as B/C. Physical separation is ensured between divisions by locating each train in a different area of the reactor containment. A single division of the GDCS consists of three independent subsystems: a short-term cooling (injection) system, a long-term cooling (equalizing) system, and a deluge line. The short-term and long-term systems provide cooling water under force of gravity to replace RPV water inventory lost during a LOCA and subsequent decay heat boil-off. The deluge line connects the GDCS pool to the lower DW. GDCS typical process flows are shown in Figure 6.3-1a.

Table 6.3-2 provides the design basis parameters for the GDCS, and includes:

- For GDCS pools, the minimum total drainable inventory;
- The minimum surface elevation of the GDCS pools above the RPV nozzle elevation;
- The minimum suppression pool available water inventory 1.00 meter (3.28 ft) above TAF; and
- The minimum GDCS equalizing line driving head, which is determined by the elevation differential between the top inside diameter of the first Suppression Pool horizontal vent and the centerline of the GDCS equalizing line RPV nozzle.

The GDCS deluge lines provide a means of flooding the lower DW region with GDCS pool water in the event of a core melt sequence which causes failure of the lower vessel head and allows the molten fuel to reach the lower DW floor.

The core melt sequence results from a common mode failure of the short-term and long-term systems, which prevents them from performing their intended function. Deluge line flow is initiated by thermocouples, which sense high lower DW region basemat temperature indicative of molten fuel on the lower DW floor. Logic circuits actuate squib-type valves in the deluge lines upon detection of basemat temperatures exceeding setpoint values, provided another set of dedicated ~~thermocouples~~temperature switches also sense the DW temperature to be higher than a preset value. The deluge lines do not require the actuation of squib-actuated valves on the injection lines of the GDCS piping to perform their function.

Each division of the GDCS injection system consists of one 200 mm (8 inch) pipe (with a temporary strainer[1] and a block valve) exiting from the GDCS pool. Just after the 200 mm (8 inch) block valve, a 100 mm (4 inch) deluge line branches off and is terminated with three 50 mm (2 inch) squib valves and deluge line tailpipe to flood the lower DW. The 200 mm (8 inch) injection line continues after the 100 mm (4 inch) deluge line connection from the upper

[1] Temporary strainer is removed after initial flushing of GDCS injection lines.

DW region through the DW annulus where the 200 mm (8 inch) line branches into two 150 mm (6 inch) branch lines each containing a check valve, squib valve, and block valve. Each division of the long-term system consists of one 150 mm (6 inch) equalizing line with two block valves, a check valve and a squib valve. All piping is stainless steel and rated for reactor pressure and temperature. Figure 6.3-1 illustrates the arrangement of GDCS piping.

The RPV injection line nozzles and the equalizing line nozzles all contain integral flow limiters with a venturi shape for pressure recovery. The maximum throat diameter of the nozzles in the short-term system is 76.2 mm (3 in) and the maximum throat diameter of the nozzles in the long-term system is 50.8 mm (2 in). The short-term and long-term flow limiters have nominal reactor side outlet ratio of length to diameter (L/D) values of 4.41 and 6.59, respectively. Each injection line and equalizing line contains a locked open, manually-operated maintenance valve located near the vessel nozzle and another such valve located near the water source.

In the injection lines and the equalizing lines, there exists a check valve located upstream of the squib-actuated valve. Downstream of the squib-actuated injection valve is a test line, which can be used to back-flush. This operation is conducted during refueling and maintenance outages for the region of piping between the reactor and the squib valve.

The GDCS squib valves are gas propellant type shear valves that are normally closed and which open when a pyrotechnic booster charge is ignited. The squib valve is designed to withstand the DW LOCA environment sufficiently long enough to perform its intended function. During normal reactor operation, the squib valve is designed to provide zero leakage. Once the squib valve is actuated it provides a permanent open flow path to the vessel.

The check valves close upon reverse impulse caused by spurious GDCS squib valve operation to protect the lower pressure piping and minimize the loss of RPV inventory after the squib valves are actuated and the vessel pressure is still higher than the GDCS pool pressure plus its gravity head. Once the vessel has depressurized below GDCS pool surface pressure plus its gravity head, the differential pressure opens the check valve and allows water to begin flowing into the vessel.

The deluge valve is a squib-actuated valve that is initiated by a high temperature in the lower DW region. This temperature is sensed by thermocouples located on the basemat protective layer. The deluge valve is designed to survive the severe accident environment of a core melt and still perform its intended function. The pyrotechnic material of the squib charge used in the deluge valve is different than what is used in the other GDCS squib valves to prevent common mode failure. The deluge valve is designed to withstand the water hammer expected as a result of an inadvertent GDCS squib valve opening while the reactor is at normal operating pressure and temperature. Once the deluge valve is actuated it provides a permanent open flow path from the GDCS pools to the lower DW region. Flow then drains to the lower DW via permanently open DW lines.

The GDCS check valves remain fully open when zero differential pressure exists across the valve. A test connection line downstream of the check valve allows the check valve to be tested during refueling outages. This provides a means for testing the operation of the check valve.

All system block valves are normally locked open and are used for maintenance during a plant refueling or maintenance outage.

Suppression pool equalization lines have an intake screen to prevent the entry of debris material into the system that might be carried into the pool during a large break LOCA.

The GDCS pool airspace opening to the DW is covered by a perforated steel plate to prevent debris from entering the pool and potentially blocking the coolant flow through the fuel. Protection against the dynamic effects associated with postulated pipe ruptures is described in Section 3.6. The maximum hole diameters in the perforated steel plate are 38 mm (1.5 inch). A splash guard is provided at the opening to minimize any sloshing of GDCS pool water into the DW following a dynamic event.

The GDCS is designed to operate from safety-related power. The system instrumentation and the GDCS squibs are powered by divisionally separated safety-related power. The deluge valve initiation circuitry is powered by nonsafety-related power.

System Operation

During normal plant operation, GDCS is in a standby condition. It can be actuated simply by transmitting a firing signal to the squib valves. The firing signal can be initiated automatically or manually from switches in the main control room. The design basis for the system during normal plant operation is to maintain RPV backflow leak-tight. Each GDCS injection line positively prevents unnecessary heating of the GDCS pools and transport of radioactive contamination to the GDCS pools or suppression pool.

When the reactor is shutdown, the GDCS is normally in a standby condition. Deactivating and isolating GDCS divisions are governed by plant Technical Specifications.

During a LOCA, GDCS injection lines are initiated following a sustained RPV Level 1 signal or a sustained Drywell Pressure High signal, and the GDCS equalizing lines are initiated following a sustained RPV Level 1 signal (Table 7.3-4). The signals start two sets of timers in each division; injection valve timer for initiation of the short-term water injection lines and a longer equalization timer which creates a permissive signal (in combination with RPV water level below Level 0.5 or 1.00 m (3.28 ft.) above TAF) for initiation of the long-term injection lines. After the injection valve timer expires, the short-term injection squib valves open to allow water to flow from the GDCS pools to the RPV. Once the reactor becomes adequately depressurized the water flow refills the RPV thereby ensuring core coverage and decay heat removal.

The long-term portion of GDCS can begin operation following a longer equalization valve time delay initiated by a sustained RPV Level 1 signal and when RPV level reaches Level 0.5, which is 1.00 m (3.28 ft.) above the TAF. Flow is initiated with the opening of the squib valve on each GDCS equalizing line. The GDCS equalizing lines perform the RPV inventory control function in the long-term and makeup for the following inventory losses:

- For any LOCA above the core the equalizing lines provide for coolant boil-off losses to the DW (most coolant boil-off is returned to the RPV as condensate from the isolation condensers or the Passive Containment Cooling System heat exchangers).
- For a vessel bottom line break, the equalizing line provides inventory for coolant boil-off losses to the DW and break flow losses in the mid-term. In the long-term the equalizing lines provide for evaporation losses to the DW.

The GDCS is designed to mitigate the consequences of a hypothetical severe accident with molten core material on the lower DW floor. The lower DW basemat is divided into 30 cells, with two thermocouples (channels A and B) installed in each cell, to sense the presence of molten fuel on the lower DW floor. A temperature greater than the setpoint sensed by channel A thermocouples in any two adjacent cells, coincident with channel B thermocouples also sensing a temperature greater than the setpoint in any two adjacent cells, initiates deluge line flow. Inadvertent actuation is prevented by the presence of an inhibit signal if another set of dedicated safety-related ~~thermocouples~~temperature switches monitoring the lower DW temperature do not sense the temperature to be greater than a preset value. The initiation signal opens the deluge valve on each separate deluge line to allow GDCS pool water to drain to the lower DW. This water aids in cooling the molten core.

GDCS Injection and Equalizing Line Sloping

The GDCS injection lines downstream of the GDCS pools have a minimum downward slope of 1:48 (one unit of rise per 48 units of run) to each GDCS injection line squib valve. Downstream of each GDCS injection line squib valve, the lines have a minimum upward slope of 1:48 to each RPV injection line nozzle.

The GDCS equalizing lines downstream of the suppression pool have a minimum downward slope of 1:48 to each GDCS equalizing line squib valve. Downstream of each GDCS equalizing line squib valve, the lines have a minimum upward slope of 1:48 to each RPV equalizing line nozzle.

Equipment and Component Description

The following describes the GDCS squib valve, deluge valve and biased-open check valve, which are unique system components that are not used in previous BWR designs.

Squib Valve

The function of the squib valve is to open upon an externally applied signal and to remain in its full open position without any continuing external power source in order to admit reactor coolant makeup into the reactor pressure vessel in the event of a LOCA. The valves also function in the closed position to maintain RPV backflow leaktight and maintain reactor coolant pressure boundary during normal plant operation. The GDCS squib valves have a flow coefficient, C_v, that permits development of full GDCS flow. The valve is a horizontally mounted, straight through, long duration submersible, pyrotechnic actuated, non-reclosing valve with metal diaphragm seals and flanged ends. The valve design is such that no leakage is possible across the diaphragm seals throughout the 60 year life of the valve. The squib valve is classified as Quality Group A, Seismic Category I, and ASME Section III Class 1. The valve diaphragm forms part of the reactor pressure boundary and as such is designed for RPV service level conditions.

Valve actuation occurs via squib valve initiators, in which a pyrotechnic booster charge is ignited and hot gases are produced. The logic for initiation is described in Subsection 7.3.1.2.2. To minimize the probability of common mode failure, the injection line squib valve pyrotechnic booster charge is from a different batch than from the batch used in equalizing line squib valves.