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Subject: Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-6 S01

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the subject NRC RAI originally transmitted via the Reference 1 letter and supplemented by an NRC request for clarification in Reference 2. DCD Markups related to this response are provided in Enclosure 2.

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

Sincerely,

James C. Kinsey

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Vice President, ESBWR Licensing

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NRO

References:

1. MFN 06-113, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, *Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application*, April 24, 2006
2. E-Mail from Shawn Williams, U.S. Nuclear Regulatory Commission, to George Wadkins, GE Hitachi Nuclear Energy, dated May 22, 2007 (ADAMS Accession Number ML071430342)

Enclosures:

1. MFN 08-254 - Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-6 S01
2. MFN 08-254 - Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-6 S01 - DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	eDRF	0000-0077-1828R1

Enclosure 1

MFN 08-254

Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-6 S01

NRC RAI 6.2-6 S01:

DCD, Tier 2, Revision 3, Section 6.2.1.1.2 states that "[t]here is sufficient water volume in the suppression pool to provide adequate submergence over the top of the upper row of horizontal vents, as well as the passive containment cooling system (PCCS) return vent, when water level in reactor pressure vessel (RPV) reaches one meter above the top of active fuel and water is removed from the pool during post-LOCA equalization of pressure between RPV and the wetwell."

If the ESBWR design relies on the suppression pool equalization line to maintain one meter depth of water above active fuel in RPV, the suppression pool equalization line should be designed as such. In response to RAI 6.3-40, GENE stated that the suppression pool equalization line will not open for 72 hours and beyond for all design basis LOCA scenarios. DCD, Tier 2, Revision 3, Section 6.3.2.7.2 states that "[s]uppression pool equalization lines have an intake strainer to prevent the entry of debris material into the system that might be carried into the pool during a large break LOCA." Please provide information on how the intake strainer is designed to prevent the entry of debris material into the system.

GEH Response:

The suppression pool equalization lines intake strainers are designed to prevent the ingestion of debris into the Gravity-Driven Cooling System (GDCS) that may damage components or potentially block coolant flow through the fuel. The design process of the intake strainers is in accordance with the current regulatory recommendations of Regulatory Guide 1.82, Revision 3. The design process determines the amount and type of debris that is generated by a postulated large break loss-of-coolant accident (LOCA). A debris transport analysis is performed to give the design basis volume of debris that is transported to the suppression pool and then to the strainers. The volume of debris transported to the strainers includes the debris in the suppression pool prior to a LOCA. The strainer configuration and size is designed to produce hydraulic performance of head loss caused by the transported debris blockage to be compatible with the design temperature and flow rates of the GDCS.

The suppression pool equalization lines intake strainers utilize a stacked-disk passive strainer design. The stacked-disk strainer design is based on a set of disks whose internal radius and thickness may be varied over the height of the strainer. The selected variation in these parameters provides an increased surface area. The holes in each disk are sized to prevent a deleterious quantity and size of debris particles from passing through strainer, but allow adequate fluid to pass through. A key feature in the design of these strainers is to collect debris where velocity is low, since the pressure drop across the debris bed is known to be proportional to the velocity through the bed. This minimizes head loss across the strainer.

The intake strainers are structurally evaluated for the effects of seismic and hydrodynamic loads. Suppression pool hydrodynamic loads resulting from postulated LOCA or Safety Relief Valve (SRV) actuations are calculated for the strainers, any strainer supports or attachments, the suppression pool penetrations, and associated

GDCS piping. Crush loads are evaluated for the strainer components subject to head loss pressure differences.

DCD Impact:

DCD Tier 2, Subsection 6.3.2.7.2 will be revised as shown in the attached markup.

Enclosure 2

MFN 08-254

Response to Portion of NRC Request for Additional Information Letter No. 18 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-6 S01

DCD Markups

head due to inventory drained from GDCS pool. 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 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 drywell, the flow through the deluge lines is required to flood the lower drywell 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 drywell.

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 drywell 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 drywell region directly via four GDCS injection drain lines (one each from two pools and two from the third pool) through 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 is 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 drywell. 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 meter 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 (S/P) horizontal vent and the centerline of the GDCS equalizing line RPV nozzle.

The GDCS deluge lines provide a means of flooding the lower drywell 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 drywell 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 drywell region basemat temperature indicative of molten fuel on the lower drywell 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 also sense the drywell 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 lower drywell. The 200-mm (8-inch) injection line continues after the 100-mm (4-inch) deluge line connection from the upper drywell region through the drywell 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

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

pressure and temperature. Figure 6.3-1 illustrates the arrangement of GDCS piping configuration.

The RPV injection line nozzles and the equalizing line nozzles all contain integral flow limiters with a venturi shape for pressure recovery. The minimum throat diameter of the nozzles in the short-term system is 76.2 mm (3 in) and the minimum throat diameter of the nozzles in the long-term system is 50.8 mm (2 in.). 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 drywell 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 cuased 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 allow 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 drywell 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 drywell region. Flow then drains to the lower drywell via permanently open drywell 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 strainer to prevent the entry of debris material into the system that might be carried into the pool during a large break LOCA. The design process of the intake strainers is in accordance with the regulatory recommendations of Regulatory Guide 1.82, Revision 3.

The GDCS pool airspace opening to the DW will be 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 ~~are~~ 38 mm (1.5 inch). A splash guard is provided at the opening to minimize any sloshing of GDCS pool water into the drywell following 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 nonsafety-related, 250 V DC.

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 and/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 is initiated following a confirmed ECCS initiation signal from NBS. The signal starts two sets of timers in each division; two injection valve timers for initiation of the short-term water injection lines and two longer equalization timers which create a permissive signal (in combination with RPV water level below Level 0.5 or 1 meter above TAF) for initiation of the long-term injection lines. After the injection valve timer expires after a confirmed ECCS initiation signal, 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 confirmed ECCS initiation signal and when RPV level reaches Level 0.5, which is 1 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 drywell (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 drywell and break flow losses in the mid-term. In the long term the equalizing lines provide for evaporation losses to the drywell.

The GDCS is designed to mitigate the consequences of a hypothetical severe accident with molten core material on the lower drywell floor. The lower drywell basemat is divided into 30 cells, with two thermocouples (channel A and B) installed in each cell, to sense the presence of molten fuel on the lower drywell floor. Temperature greater than setpoint sensed by channel A thermocouples in any two adjacent cells, coincident with channel B thermocouples also sensing