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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 34 Related to ESBWR Design Certification Application – Auxiliary Systems – RAI Numbers 9.3-11 and 9.3-25**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Reference:

1. MFN 06-198, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 34 Related to ESBWR Design Certification Application,* June 22, 2006

Enclosure:

1. MFN 06-282 – Response to Portion of NRC Request for Additional Information Letter No. 34 Related to ESBWR Design Certification Application – Auxiliary Systems – RAI Numbers 9.3-11 and 9.3-25

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRFs 0000-0056-7211 and 0000-0056-8022

ENCLOSURE 1

MFN 06-282

Response to Portion of NRC Request for

Additional Information Letter No. 34

Related to ESBWR Design Certification Application

Auxiliary Systems

RAI Numbers 9.3-11 and 9.3-25

NRC RAI 9.3-11

DCD Tier 2, Section 9.3.5.3 (Page 9.3-11) states: "The extremely rapid initial rate of isotopically enriched boron injection ensures that hot shutdown boron concentrations are achieved within several minutes of SLCS initiation based on initial reactor water inventory."

Specify the time it takes to reach hot shutdown in the most limiting ATWS scenario.

GE Response

The most limiting ATWS scenario is Main Steam Isolation Valve Closure (MSIVC), as stated in NEDE-33083P Supplement 2, Section 2.8. The shutdown time is 384 seconds, as stated in Table 8.1-4 of the same document.

No changes to the DCD are necessary as a result of this RAI.

NRC RAI 9.3-25

The staff identified several phenomena that could challenge the capability of the core's natural circulation patterns to disperse boron uniformly. First, the SLCS injects into the core bypass region within the core shroud. It is expected that the presence of fuel channels and, in the instance of the middle of cycle, some control rods, will inhibit planar flow. Second, this core has an unconventionally large diameter, which not only poses another challenge to passive means of boron mixing, but means that the core is less neutronically coupled than conventional BWRs. Third, restrictions imposed by two-phase flow will inhibit core upflow, and thus further limit boron transport in the core. Additional challenges to axial mixing include the presence of chimneys on top of the core, which would prevent the boron from traveling upward though the bypass and downward into the core via density-driven flow mechanisms, and flow reversal in the event of a main steamline isolation valve (MSIV) closure.

Provide additional information about local boron concentrations at various regions within the core and bypass during the evolution of the ATWS/MSIV closure scenario. Discuss the technical bases underlying the 25% (non-uniformity) and 15% (RWCU/SDC) numerical conservatisms used to calculate the boron concentration requirements.

Describe the flow path for the borated solution that develops during the ATWS/MSIV closure scenario and its impact on the distribution of boron in the core, additionally describe how the resulting distribution affects shutdown time.

GE Response

(1) In the TRACG analysis of the ATWS event, the presence of fuel channels and control rods is accounted for by conservatively assuming that the injected boron will not be able to move radially into the central bundle region. The flow in the TRACG model is blocked both in the radial and azimuthal directions at the time of boron injection. Thus, the flow must move down to the lower tie plate before it has the opportunity to move to the central regions of the core. Section 8.1 of NEDE 33083P Supplement 2 further describes the conservatisms built into the TRACG ATWS model. If the ATWS occurs in the middle of the cycle, when some control rods are inserted in the core, the ATWS transient will be milder. As the rods are in a checker board pattern, the lateral flow paths around the channels will not be blocked.

(2) The diameter of the core is modeled in the TRACG ATWS calculation and, subsequently, the neutronic interactions account for the core diameter in the event analysis. TRACG has been shown to be capable of modeling regional oscillations that could result from decoupling of core regions in a large core.

Because the TRACG analysis of the ATWS event assumes that the boron flow does not move into the central regions of the core until it has sunk to the lower tie plate, the central regions of the core do not benefit from the boron solution until it reaches the bottom of the core. Thus, the calculation is independent of the diameter of the core until the boron reaches the bottom, which is a conservative modeling approach. The diameter of the core is not only modeled into the calculation, but blocking the flow in the radial direction creates an extra degree of conservatism to the boron transport calculation.

(3) As described in NEDE 33083P Supplement 2, the flow in the core bypass is slightly negative at the time of boron injection. The shutdown of the core is achieved by the boron moving downward through the peripheral bypass to lower tie plate and inward to the central regions of the core. At the time of boron injection the flow inside the majority of the channels is upward. Thus, as the boron moves into the center of the core, it becomes entrained in the channels through the lower tie plate leakage paths. The pressure drop from the two-phase flow is calculated in the TRACG ATWS analysis model. The upward flow helps to transport the boron up the fuel channel rather than representing a challenge to the movement of boron in the channels.

(4) The chimneys are modeled in the TRACG analysis. The density driven flow loop leads to downflow in the bypass and upflow through the core rather than the other way around as suggested by the question. Thus, the chimney partitions do not inhibit the radial mixing of boron in the bypass region. The boron injection occurs well after MSIV closure so there is no impact of the closure on the boron flow direction. Boron will be introduced after lowering the downcomer water level to reduce the flow and reactor power. In these circumstances, the flow in the bypass region will be downwards.

(5) Please refer to the response to RAI 21.6-42 for graphs of boron concentrations throughout the core bypass and lower plenum with respect to time.

(6) The 25% and additional 15% numerical conservatisms to calculate the boron concentration requirements are as stated in NEDC-33084, ESBWR Design Document. In both ABWR and BWR SLC System designs, 125% of the required concentration (based on uniform dilution) is the typical design margin for non-uniformities for the SLCS injection solution concentration, per Lungmen SLCS System Design description, 31113-0C41-2010 Rev 2 and Design Specification 22A3130 Rev. 5, respectively. The 15% additional conservatism is new to the ESBWR and represents greater conservatism to the conventional design. As SLC System actuation closes the inboard and outboard RWCU/SDCS isolation valves, or prevents them from opening if closed, as stated in Section 5.8.1.5 of ESBWR Design Control Document Tier 2, this requirement is precautionary and conservative.

(7) The flow path of the boron solution in the ATWS MSIV Closure scenario is described in detail in Section 5.1.1 of NEDE-33083P Supplement 2. The distribution of boron through the core can be seen in the graphs of boron concentrations throughout the core bypass region with respect to time, as given in response to RAI 21.6-42. The shutdown time for this event (with this boron path and distribution) is given in Table 8.1-4 of NEDE 33083P Supplement 2. The overall boron reactivity is affected initially by the boron concentration in the peripheral bundles and subsequently by the boron concentration in the interior

bundles and interior bypass regions. The shutdown time is affected by the integrated boron reactivity in the core and bypass.

No changes to the DCD are necessary as a result of this RAI.