Enclosure 1

MFN 08-888

Response to NRC Request for Additional Information Letter No. 253 Related to ESBWR Design Certification Application

Licensing Topical Report (LTR) NEDO-33337 ESBWR Initial Core Transient and Accident Analysis

RAI Numbers 15.2-42, 15.2-44 through 15.2-47, 15.2-49 and 15.2-51

NRC RAI 15.2-42:

Transients with one or more variables increasing at the assumed cutoff time, provide an extension of the plots until steady state is reached. NEDO-33337, for those transients with one or more variables changing at the assumed cutoff time, provides an extension of the plots until steady state is reached. As an alternative, provide an explanation of the trends.

GEH Response:

The purpose of each safety analysis is to ensure that the safety analysis acceptance criteria (DCD Tables 15.0-3 through 15.0-5) are satisfied for limiting event paths identified in the Nuclear Safety Operational Analysis (NSOA) in DCD 15.1. Once the consequences are known through the safety analysis, the NSOA focuses on the long-term response to bring the plant to a stable safe condition. Because the acceptance criterion is met for all of the transient events, there is no need to extend the transient run time. For example:

(1) In all Anticipated Operational Occurrences (AOO)/Infrequent events, the reactor coolant pressure is below the acceptance criteria and is either steady or decreasing.

(2) In AOO/Infrequent events, the level remains above top of active fuel. In most events the level is either steady or increasing. An exception is the Turbine Trip with Total Turbine Bypass Failure (TTNBP) event. This event is very similar to the Generator Load Rejection with Total Turbine Bypass Failure (LRNBP) event shown in Figure 2.4-5c. The LRNBP event run time is 50 seconds and shows the level recovery; therefore, there is no need to extend the transient run time for the TTNBP. The Stuck Open Safety Relief Valve event is another event in which the water level is decreasing. When the water level decreases to level 2, the High Pressure Control Rod Drive is re-activated and maintains water level above the top of active fuel. If the High Pressure Control Rod Drive is not available, the water level decreases to level 1, the Automatic Depressurization System is initiated and the Gravity-Driven Cooling System is started to control water level as shown in DCD Figure 15.1-31. LOCA analyses in DCD Section 6.3 demonstrate that water level remains above the top of active fuel.

(3) In all AOO/Infrequent events, the Critical Power Ratio (CPR) is either steady or increasing. An exception is the Generator Load Rejection with Turbine Bypass and Turbine Trip with Turbine Bypass events. This has been addressed in RAI Response 15.2-28 (via GEH letter MFN 08-676 dated September 10, 2008), which concludes that the CPR is approaching steady state, and the limiting CPR value will not fall below the minimum CPR value. The turbine trip with total turbine bypass failure event follows the generator load rejection with turbine trip with total bypass failure event and is shown in Figure 2.4-5g. The trend in the CPR response is not important once a scram has occurred. After a scram occurs there is significant CPR margin. The DCD plots typically do not show CPR after the scram has occurred because the large margins would result in a large scale

that would make the plots ineffective in demonstrating the CPR response before the scram.

DCD or LTR Impact:

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 15.2-44:

NEDO-33337, the initial core average void fraction at t=0 seconds is different for some transients (either 0.31 or 0.33). This results in significantly different initial mass. Provide an explanation for the difference.

GEH Response:

This difference in void fraction results from the axial power shape at different exposures. NEDO-33337, Figure 2.2-3 shows the difference in axial power shape at beginning of cycle (BOC) middle of cycle (MOC) and end of cycle (EOC) exposure conditions. The MOC power shape results in a core average void fraction 0.33 while the EOC power shape results in 0.31. The exposures used are conservative with respect to critical power ratio results for each of the transients, which result in the difference in the initial core average void fraction.

DCD or LTR Impact:

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 15.2-45:

Table 2.3-1; include the delta T setpoint for loss of feedwater detection. NEDO-33337, Section 2.3.1.1.1, discusses loss of feedwater heating when the difference between the actual and reference temperatures exceeds a delta T setpoint. Include the setpoint value in Table 2.3-1.

GEH Response:

The feedwater temperature set point (16.7^{o}C [30°F] temperature drop) was included in Table 2.3-1 in the response to RAI 15.2-24, via GEH letter MFN 08-676 dated September 10, 2008.

DCD or LTR Impact:

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 15.2-46:

Explain the trip logic for turbine control valve closure and turbine bypass valve opening. NEDO-33337, Table 2.3-6, "Sequence of Events for Fast Closure of One Turbine Control Valve", the turbine bypass valve starts to open 1.02 seconds after the TCV completes closure. In Table 2.3-7,"Sequence of Events for Slow Closure of One Turbine Control Valve", the turbine bypass valve starts to open 0.3 seconds after the TCV completes closure. Explain the trip logic or provide a reference for the explanation.

GEH Response:

In both analyses, “Fast Closure of One Turbine Control Valve” and “Slow Closure of One Turbine Control Valve”, the closure of the turbine control valve (TCV) is an initiating input into the TRACG calculation. The valve closes in 0.08 seconds in the “fast” scenario and in 2.5 seconds in the “slow” scenario. The turbine bypass valve (TBV) operation is controlled by the Steam Bypass & Pressure Control System (SB&PC), as described in the ESBWR DCD, Tier 2, Subsection 7.7.5. The opening of the TBV is not a direct function of the closure of the TCV, rather it is dependent on the reactor dome pressure. For more detail on the logic, refer to DCD, Tier 2, Subsection 7.7.5 and Figure 7.7-5.

The dome pressure response for the two cases is different. In the fast-closure case, the TCV is completely closed in 0.08 seconds rather than in 2.5 seconds for the slow-closure case; therefore, the pressure increase is fast and the remaining TCVs open sooner compared to the slow-closure case. Figure 15.2-46-1 shows a plot of the pressure for the two cases with the timing of the TCV closure and the TBV opening. The figure reveals that the TBVs open at similar dome pressures.

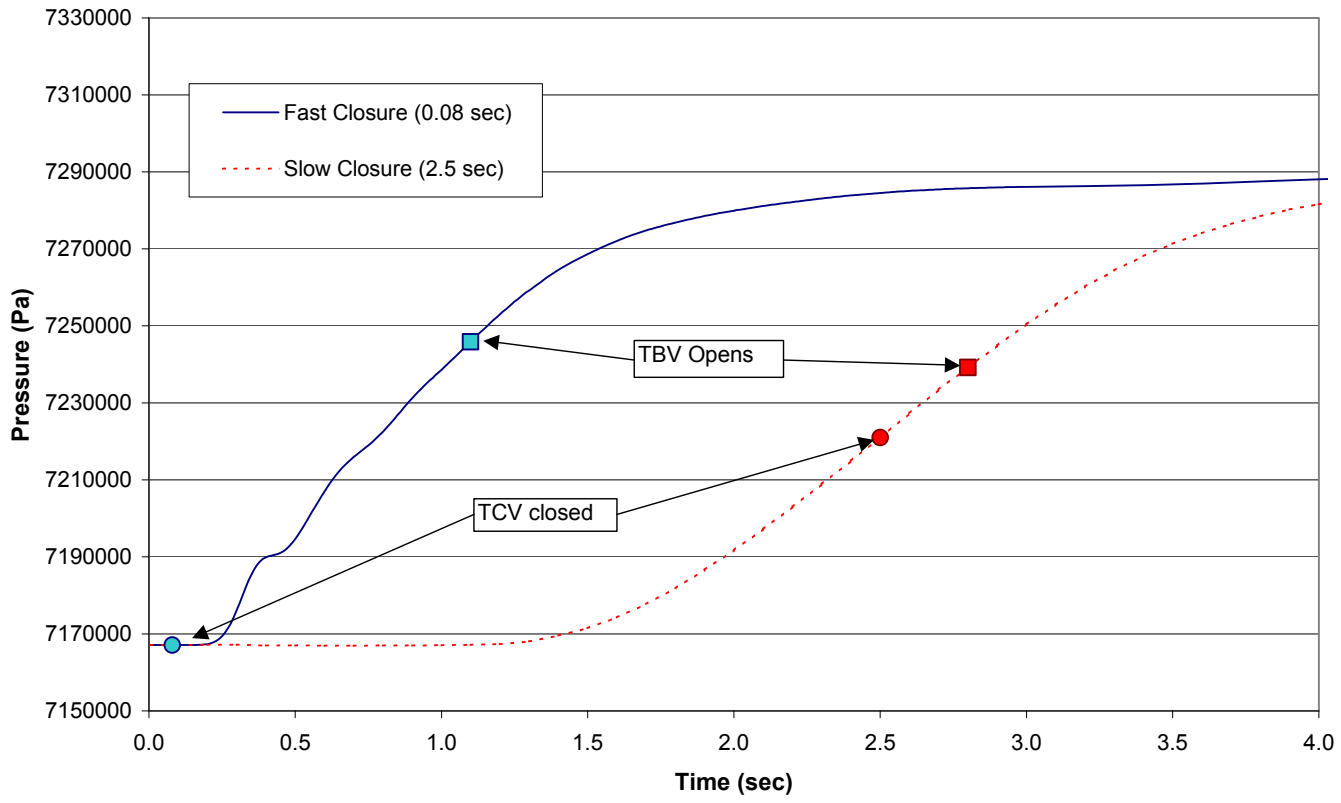
DCD or LTR Impact:

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

Figure 15.2-46-1

Closure of One Turbine Control Valve



NRC RAI 15.2-47:

Explain the mismatch between the steam/feedwater flow rate and power. NEDO-33337, Figure 2.3-4a and 2.3-6a, the steam flow rate and the feedwater flow rate are about 50 percent of rated while power is about 75 percent of rated. Provide the transient steam and feedwater temperatures or provide an explanation for the mismatch between steam/feedwater flow rate and power.

GEH Response:

The core power is affected by more parameters than just the feedwater flow rate; the feedwater temperature also affects it. Figure 15.2-47-1 shows a decreasing feedwater temperature for the "Generator Load Rejection with Turbine Bypass" event. The feedwater temperature during the "Turbine Trip with Turbine Bypass" event is similar. The decrease in feedwater temperature is the cause for the power and steam/feedwater flow rate mismatch because the reduced feedwater temperature increases the core inlet sub-cooling therefore more core power is used to increase the coolant to saturation therefore less power is available to generate steam. The exit steam is at the saturation temperature corresponding to the dome pressure and the steam temperature is constant after approximately 100 seconds as the dome and steam line pressure stabilizes, which can be seen in NEDO-33337 Figures 2.3-4d and 2.3-6d.

DCD or LTR Impact:

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

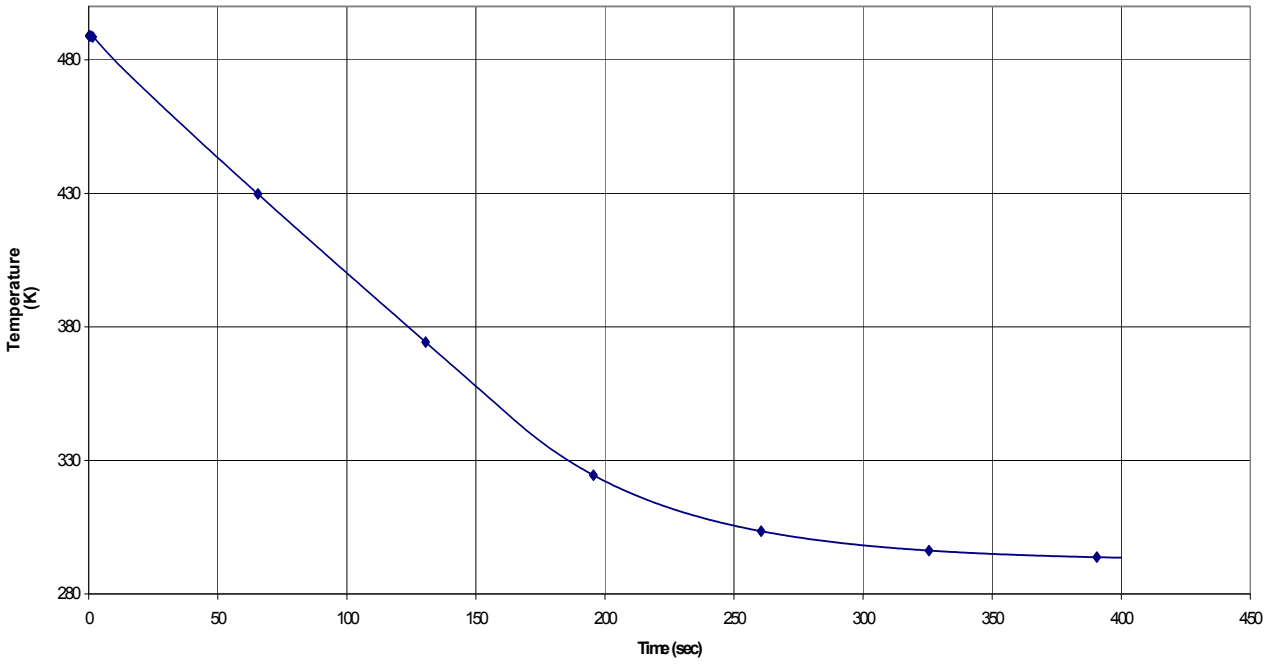


Figure 15.2-47-1 Feedwater Temperature Decrease During the "Generator Load Rejection with Turbine Bypass" event.

NRC RAI 15.2-49:

Explain why the void reactivity varies while the core average void fraction is essentially constant. NEDO-33337, Figure 2.4-1f, the core average void fraction is shown to be essentially constant, but the void reactivity varies in Figure 2.4-1e. Provide an explanation for this behavior. Does the location of the reported void fraction vary with control rod position?

GEH Response:

NEDO-33337, Figure 2.4-1e shows the reactivity changes for the event of Loss of Feedwater Heating with SCRRI/SRI Failure. Figure 2.4-1f shows the void fraction for the same event.

GEH agrees with the Staff's observation, the void reactivity varies while the void fraction remains essentially constant. This is attributed to the "void reactivity" term including reactivity changes resulting from the water density increase of the cooler feedwater. Other reactivity terms result from fuel temperature and control rods to comprise the total reactivity. Most of the other infrequent events are steam pressure events (e.g. turbine trip, load rejection, pressure regulator failure, MSIV closure), which result in substantial void fraction changes. However, for the Loss of Feedwater Heating, the void fraction remains essentially constant, but the denser water increases the neutron moderation, resulting in increased reactivity.

The reported void fraction is a core-wide average. It is not associated with any particular control rod position.

DCD or LTR Impact:

No DCD changes will be made in response to this RAI.

No changes to the subject LTR will be made in response to this RAI.

NRC RAI 15.2-51:

NEDO-33337, Table 2.4-3, the Sequence of Events for Feedwater Controller Failure Maximum Demand specifies the time at which L2 is reached as "Later". Complete the transient sequence, including isolation condenser start.

GEH Response:

The last line of Table 2.4-3 completes the transient sequence that states that the Isolation Condensers and High Pressure Control Rod Drive (HP CRD) makeup water recover level and the Main Steam Isolation Valves (MSIVs) are isolated. The exact time this occurs is not important. For this event, the reactor has scrammed, pressure is decreasing, and the reactor water level remains above the top of active fuel; therefore, there are no Critical Power Ratio (CPR) or high pressure concerns. Once the reactor water level reaches Level 2, the Isolation Condensers and HP CRD initiate, and the MSIVs isolate. If the HP CRD makeup water function is not available, the Isolation Condensers in combination with the MSIV isolation are available for level control as shown in DCD Figure 15.1-18. The effectiveness of the Isolation Condensers to maintain the level above the active core is evident in the Station Blackout (SBO) analysis (NEDO-33337, Subsection 2.5.5), and the SBO analysis bounds the Feedwater Controller Failure – Maximum Flow Demand event with respect to maintaining water level above the top of the active fuel. The timing for the last line will be changed to be greater than 20 seconds in NEDO-33337 and DCD, Tier 2, Chapter 15.

DCD or LTR Impact:

DCD Tier 2, Table 15.3-3 will be revised as noted on the attached markup.

LTR NEDO-33337, Table 2.4-3 will be revised as noted on the attached markup.

Enclosure 2

MFN 08-888

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RAI 15.2-51 DCD and LTR Markups