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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 44 – Related to ESBWR Design Certification Application – RAI Numbers 4.6-28 and 4.6-34**

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

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

NRO

Reference:

1. MFN 06-255, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 44 Related to the ESBWR Design Certification Application*, July 25, 2006

Enclosures:

1. MFN 07-446 – Response to Portion of NRC Request for Additional Information Letter No. 44 – Related to ESBWR Design Certification Application – RAI Numbers 4.6-28 and 4.6-34

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH Wilmington (with enclosures)
	BE Brown	GEH Wilmington (with enclosures)
	eDRF	0000-0069-5324 and 0000-0072-5667

Enclosure 1

MFN 07-446

Response to Portion of NRC Request for

Additional Information Letter No. 44

Related to ESBWR Design Certification Application

RAI Numbers 4.6-28 and 4.6-34

NRC RAI 4.6-28

DCD Tier 2, Section 4.6.1.2 describes the CRD system functions including "provides for selected control rod run-in." An inadvertent control rod run-in would result in a redistribution of core power and potentially an approach to a fuel design limit. Please describe the core and plant systems' response to the limiting inadvertent control rod run-in event.

GEH Response

Selected control rod run-in (SCRRI) is an automatic function of the RC&IS and CRD system in the ESBWR design. The CRD system also provides Fine Motion Control Rod Drive (FMCRD) run-in. This automatic ATWS mitigation feature uses the FMCRDs to run-in all the control rods in an emergency.

The SCRRI function was enhanced in DCD Tier 2 Revision 3 to include simultaneous hydraulic insertion of rods known as Select Rod Insert (SRI). See DCD Tier 2 Subsection 7.1.5.4.10. With the addition of SRI an inadvertent SCRRI/SRI actuation is not significant. The quick response of the SRI rods reduces core power without creating an axial power transient that could potentially challenge fuel thermal limits. DCD Figure 15.2-4 shows the response to a Generator Load Rejection with Turbine Bypass. Except for the slight pressure transient at the beginning of the event the response is very similar to an inadvertent SCRRI/SRI. As can be seen the SRI quickly reduces the core power. Although the radial power distribution does change the core power reduction is significant enough to ensure thermal limits are not challenged.

To clarify that a manual initiation of SCRRI does not occur without also initiating SRI the DCD will be revised as shown below. As a result, an inadvertent SCRRI initiation without SRI is not anticipated and an inadvertent SCRRI/SRI is not expected to challenge fuel thermal limits.

The FMCRD run-in is an ATWS mitigation function. The signals to initiate FMCRD are common with the signals that initiate ARI (hydraulic insertion) including manual initiation. Therefore, an inadvertent FMCRD run-in without ARI is not anticipated and an inadvertent ARI/FMCRD run-in will not challenge fuel thermal limits.

Analysis shows that an inadvertent run in of a single FMCRD would not challenge thermal limits.

Normal manual operation of control rods is not addressed in this RAI response.

DCD Impact

The first paragraph of DCD Tier 2, Subsection 7.1.5.4.10 will be revised as described below:

> "N-DCIS will accept the redundant loss of feedwater heating signals from FWCS and the turbine trip and load reject signals from the turbine control system, perform two-out-of-three voting on each and combine them as an "OR" function to become the automatic SRI and SCRRI command signals. It will also be possible to initiate SRI or and SCRRI manually from the MCR, which is part of the DPS and RC&IS system's scope (for example note that the manual SCRRI function is implemented to be independent of the N-DCIS equipment scope). SRI and SCRRI may also be initiated by the diverse protection system (DPS)."

NRC RAI 4.6-34

DCD Tier 2, Section 4.6.1.2.6 describes a rod withdrawal block signal generated due to rod gang misalignment. Please quantify the allowable gang misalignment (prior to rod block) and the accuracy of measuring the misalignment. Is this misalignment accounted for in any safety analysis or LCOs?

GEH Response

The Rod Action and Position Indication (RAPI) A and B monitor the gang rod position and issue a Rod Block by sending appropriate rod block signals to the logic of the Rod server Processing Channels (RSPCs) in the Remote Communication Cabinets (RCCs) in the event the gang misalignment exceeds a pre-determined value. The gang misalignment is determined by continuously monitoring the maximum difference, in millimeters, in the absolute rod position values for all the individual control rods currently selected for gang movement (i.e., the distance between the most withdrawn selected rod and the least withdrawn selected rod of the applicable gang).

Currently, the final gang rod misalignment criterion is not defined for ESBWR, but is expected to be in the 120-150 mm range. This is based upon similar criteria applied for Japanese Advance Boiling Water Reactors (ABWRs) with the induction-motor FMCRD design.

The accuracy specification of the position measurement of each FMCRD is +/- 5 mm or better; therefore, the accuracy of determination of the gang misalignment is +/- 15 mm or better.

The gang misalignment criterion is not directly accounted for in any Chapter 15 safety analysis or any LCOs. But, based upon the ABWR plant precedence, it was deemed appropriate to set a reasonable criterion on the maximum allowable misalignment during gang rod movement and to initiate a rod withdrawal block when that criterion was exceeded. Analytical evaluations of the consequences of inadvertent rod withdrawal events (i.e. rod withdrawal error) involving gang rod withdrawal typically assume that all control rods of the gang move without any misalignment. It is judged that the results of such analytical evaluations would not be significantly affected if such evaluations were performed with the gang misalignment being simulated. The following discussion provides the basis for that judgement.

During start-up and below the Low Power Set Point (LPSP), the Rod Worth Minimizer (RWM) monitors the positions of all the operable control rods and a rod block is initiated if the specified rod pattern constraints are violated. The rod pattern constraints imposed by the RWM limit the maximum reactivity worth for withdrawal of a single control rod or the gang of control rods. Therefore, the Chapter 15 Control Rod Withdrawal Error During Startup (RWE) event analysis can assume a reasonable upper bond for individual and gang rod withdrawal.

For the Control Rod Withdrawal Error During Startup, the most limiting analytical case is the assumed withdrawal of a gang of control rods belonging to Groups 1 through 4, with the reactor at or near critical conditions. The reactor power level is assumed to be very low (e.g. around 10E-04% of rated power level), such that there will be negligible void or Doppler reactivity feedback effects during the transient event. The Startup Range Neutron Monitor (SRNM) instruments of the Neutron Monitoring System (NMS) each have a low reactor period rod withdrawal block function as well as a SRNM lower period SCRAM initiation function. Any unbypassed SRNM instrument stops continuous rod withdrawal by initiating a rod block if the flux excursion, caused by rod withdrawal, generates a period shorter than approximately 20 seconds. However, for the Chapter 15 Control Rod Withdrawal Error During Startup evaluation, this non-safety rod withdrawal block function is not assumed to mitigate this transient event. If the unbypassed SRNM instruments of any two Divisions detect a period shorter than approximately 10 seconds, the Reactor Protection System SCRAM function will be initiated. The Chapter 15 Control Rod Withdrawal Error During Startup analysis assumes this safety related function would mitigate this event. Recent ABWR plant evaluations for the Control Rod Withdrawal Error During Startup event show that the reactor SCRAM function would be initiated in less than 60 seconds and that assumed adiabatic addition of energy to the fuel would be around 1 J/kg. This is a negligible fuel enthalpy increase and no fuel damage would occur. The fuel enthalpy increase during the gang withdrawal is so small because, even though the gang of control rods has a high overall withdrawal worth, the gang of rods move at a nominal speed of around 28 mm/second, which is very slow compared to the type of reactivity increase transient rates that occur for events such as a Control Rod Drop Accident that applies for conventional GE Boiling Water Reactor plants (and is included in the Chapter 15 event analyses for such plants).

With regards to the impact on the consequences of the Control Rod Withdrawal Error During Startup analysis results that would occur if the event were simulated with the gang rod movement misalignment effect simulated; when the reactor is at or near critical conditions and then becomes somewhat supercritical (such as during this RWE event) the dominant effect on the resulting local reactor neutron flux throughout the core is the overall core reactivity increase (with small influence by the transient neutron flux shape redistribution due to the moving gang of control rods). Therefore, all the SRNM instruments will detect approximately the same transient reactor period excursion. Therefore, the time to the SRNM low period scram function initiation will have relatively small influence (e.g. a few seconds) on the time for SCRAM function initiation and on the total fuel enthalpy increase, as compared to the evaluation that assumes no gang misalignment. So, given the expected small impact of the gang misalignment effect and the very small fuel enthalpy increase expected for the Control Rod Withdrawal Error During Startup event, it is judged that no special safety analyses that simulate the gang misalignment effect is required.

With respect to ganged withdrawals with the reactor thermal power conditions being above the LPSP, due to the strong void and Doppler reactivity feedback effects during such power range operation, a sustained low reactor period flux excursion is not possible. Therefore, it is instead important to prevent the violation of the fuel operating thermal limits during individual rod and gang rod withdrawals. The Automated Thermal Limit Monitor (ATLM) instruments provide the primary protection above the LPSP against violation of the operating thermal limits. The ATLM instrument continuously monitors the NMS Local Power Range Monitor (LPRM) signals, Average Power Range Monitor (APRM) signals, and control rod positions and uses a defined algorithm to predict whether the operating thermal limits will be violated. The ATLM instrument receives updates of the current operating limit conditions from the 3D MONICORE equipment, either automatically or by an operator initiated manual update. After completion of a successful update, the ATLM instrument information with regards to the current operating thermal limit conditions for all monitored regions of the core is consistent with the 3D MONICORE information.

The ATLM algorithms provide conservative predictions of the change in the operating thermal limits between the updates. During gang rod withdrawal movements, only one control rod of any particular region would be moving and the control rod position used in each region for the prediction of the change of the operation limit condition in that region is current rod position value (not an averaged value of the rods in the gang). Therefore, this algorithm is not sensitive to expected gang misalignment effects during gang rod movements that will occur when operating above the LPSP. In addition, the ATLM instrument is providing protection against violation of the operating thermal limits, including the operating limit MCPR, during gang rod withdrawal movements. For Chapter 15 evaluations, transients that could potentially violate the thermal limit are evaluated, instead. Therefore, given that the ATLM instrument algorithm automatically predicts each monitored region's operating thermal limit condition based upon the current rod position in each region (hence, factoring in potential gang misalignment effects) and that the ATLM instrument provides protection against violation of the operating thermal limits, it is judged no special safety analyses are required to simulate the gang misalignment effect for gang rod withdrawals that can occur during operation above the LPSP.

In ESBWR, the ATLM subsystem performs the associated rod block monitoring function in the event of a control rod withdrawal error during power operation.

The ATLM instrument is discussed in DCD, Revision 3, Tier 2, Subsection 15.3.9.1.

DCD Impact

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