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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 350 Related to ESBWR Design Certification Application – ATWS Stability – RAI Number 4.4-91**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. GEH response to RAI Number 4.4-91 is addressed in Enclosure 1. LTR markups associated with these responses are provided in Enclosure 2.

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

Sincerely,

Richard E. Kingston

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Vice President, ESBWR Licensing

Reference:

1. MFN 09-413, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 350 Related to ESBWR Design Certification Application,* June 15, 2009

Enclosures:

1. MFN 09-490 - Response to Portion of NRC Request for Additional Information Letter No. 350 Related to ESBWR Design Certification Application – ATWS Stability – RAI Number 4.4-91

2. MFN 09-490 Response to Portion of NRC Request for Additional Information Letter No. 350 Related to ESBWR Design Certification – ATWS Stability – RAI Number 4.4-91 – LTR NEDO-33338 Markups

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH (with enclosures)
	DH Hinds	GEH (with enclosures)
	eDRF	0000-0103-8252

Enclosure 1

MFN 09-490

Response to Portion of NRC Request for

Additional Information Letter No. 350

Related to ESBWR Design Certification Application

ATWS Stability

RAI Number 4.4-91

NRC RAI 4.4-91

ATWS-Stability event

In LTR NEDO- 33338, section A.4.2.1, provide the sequence of events for the ATWS calculation.

GEH Response

The sequence of events table that corresponds to the analysis provided in Section A.4.2.1 of NEDO-33338, Rev 1, for the stability evaluation of the turbine trip with full bypass ATWS event is provided in Table 4.4-91-1. The following paragraphs provide additional details.

In Reference 4.4-91-1, GEH originally performed analyses for two ATWS events at nominal operation conditions: Loss of Feedwater Flow and Turbine Trip with Full Bypass. The limiting ATWS stability case in Reference 4.4-91-2, as a result of resolving the TRACG dP loss coefficient issue, had the same methodology applied to the calculation as outlined in Reference 4.4-91-1.

In Table 15.5-3 of Reference 4.4-91-3, the maximum time delay from SCRRI/SRI command to Feedwater runback due to persisting elevated power levels is defined to be 30 seconds. Therefore, according to DPS Diverse Scram ATWS Mitigation Logic as specified in Section 7.8.1.1.4 of Reference 4.4-91-4, a delayed feedwater runback would initiate within **30** seconds after a SCRRI/SRI command because power levels persist higher than rated assuming all rod insertion fails. The reactor power at 30 seconds is approximately only 102% and the power will drop quickly once FW runback is initiated. However, feedwater runback in the current stability analysis is assumed to activate instead at 72 seconds into the transient, as shown in Table 4.4-91-1, for the following reasons,

1. As explained in Reference 4.4-91-1, reactor power will decrease quickly following FW runback initiation and it is initiated in less than 7 seconds after the high simulated thermal power scram setpoint (115%) is reached. This sets a conservative analytical limit because at 72 seconds the power is approximately at 121% of rated, which is more conservative from a stability perspective than the power condition at 30 seconds after SCRRI/SRI initiation (~102%) because of higher power level reached and more time for an instability to develop and grow.
2. A longer time delay results in a more conservative evaluation with respect to stability as it allows more time for instability to manifest itself. The 72 seconds time delay in the current case is set because it would result in reaching the Service Level C (emergency) RPV pressure limit when the bypass valves close on loss of condenser vacuum that would occur when reactor power reaches ~120%. Any delay beyond 72 seconds would possibly result in an unacceptable pressurization condition and is therefore not considered.

In summary, as shown in Table 4.4-91-1, the stability evaluation in Section A.4.2.1 of NEDO-33338, Rev 1 was performed conservatively at high power levels by delaying FW runback timing in the analysis further than the actual logic setpoint timing.

Table 4.4-91-1

Sequence of Events for ATWS Turbine Trip with Full Turbine Bypass

Time (s)	**Event**
0.0	Turbine trip initiates closure of main stop valves
0.0	Turbine trip initiates bypass operation
0.08	Turbine bypass valves start to open to regulate pressure
0.10	Turbine stop valves closed
0.20	SCRRI/SRI activated but not credited in analysis
0.41	Turbine bypass opened at 100%
30	Feedwater runback initiated with a maximum time delay of 30 seconds after SCRRI/SRI command and elevated power (not credited at this time)
72	Feedwater runback initiated
106	Level drops below L2 set point
118	HP CRD flow starts
138	MSIV closure starts
139	Isolation condenser initiates
141	Level drops below L1 set point
151	ATWS trip set at high pressure
164	SRV setpoint reached
298	SLC system injection starts
818	High pressure design volume of borated solution injected into bypass

Reference

4.4-91-1 MFN 08-092, “Response to Portion of NRC Request for Additional Information Letter No. 69 - Related to ESBWR Design Certification Application - RAI Number 21.6-51”, February 15, 2008.

4.4-91-2 MFN 09-114, “Submittal of Case Matrix to TRACG and Event Analyses Reflecting the dP Loss Coefficient Resolution”, February 10, 2009.

4.4-91-3 GE Hitachi Nuclear Energy, “ESBWR Design Control Document”, Tier 2, Chapter 15, 26A6642BP.

4.4-91-4 GE Hitachi Nuclear Energy, “ESBWR Design Control Document”, Tier 2, Chapter 7, 26A6642AW.

DCD Impact

No DCD changes will be made in response to this RAI. LTR NEDO-33338, Rev 2 will be revised as noted in the attached markup.

Enclosure 2

MFN-09-490

Response to Portion of NRC Request for

Additional Information Letter No. 350

Related to ESBWR Design Certification Application

ATWS Stability

RAI Number 4.4-91

LTR NEDO-33338 Markups

A.4.2.1 Stability During ATWS

Stability performance during ATWS was originally evaluated in Subsection 15.5.4.3 of the DCD (Reference A.4-1) for nominal operation condition. The same methodology is applied in the current study to examine coupled neutronic-thermal hydraulic instability in the core during ATWS initiating from operating conditions at low feedwater temperature of SP1M condition (100% rated power and FW temperature of 187.8°C [370°F]). Analysis was conducted for the equilibrium core at MOC exposure for regional oscillation mode, which is determined limiting in Section A.1.

Following the DCD limiting case, a regional perturbation was introduced at 75 seconds into Turbine Trip with Full Bypass ATWS event. The channel inlet liquid flows were perturbed in the out-of-phase mode when power-flow ratios are steady and high. The transient response to these perturbations is evaluated. Furthermore, the void reactivity coefficient is increased by 30% in the stability analysis to be conservative.

As illustrated in Figure A.4.2.1-1 for the comparison of limiting channel power response between cases with and without regional perturbation, initially the core response to the regional perturbation is a low amplitude limit cycle oscillation where the fuel does not reach dry out conditions. As the FW runback reduces downcomer water level below the dryer skirt, at approximately at 86 seconds, the core wide oscillation becomes dominant, which immediately overwrites the limit cycle regional response and results in a core wide in-phase oscillation for both cases. As the feedwater flow and total reactor power continue to be reduced, the limiting channel power oscillations are quickly dampened.

Table A.4.2-1 presents a sequence of main events that occur during the Turbine Trip with Full Bypass ATWS transient.

A.4.2.2 References

A.4-1 GE Hitachi Nuclear Energy, "ESBWR Design Control Document," Tier 2, Chapter 15, 26A6642BP.

Table A.4.2-1

Sequence of Events for ATWS Turbine Trip with Full Turbine Bypass

Time (s)	Event
0.0	Turbine trip initiates closure of main stop valves
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