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MFN 07-017, Supplement 2

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 69 Related to ESBWR Design Certification Application – Safety Analyses – RAI Number 15.3-25S01**

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 NRC letter dated October 11, 2006. GEH response to RAI Number 15.3-25S01 is addressed in Enclosure 1. Enclosure 2 contains the associated DCD Markups reflected in the RAI response.

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

Sincerely,

Kathy Sedney for

James C. Kinsey
Vice President, ESBWR Licensing

D068

NRO

Reference:

1. MFN 06-381, Letter from U.S. Nuclear Regulatory Commission to David H. Hinds, GEH, *Request For Additional Information Letter No. 69 Related To ESBWR Design Certification Application*, dated October 11, 2006.

Enclosure:

1. Response to Portion of NRC Request for Additional Information Letter No. 69 Related to ESBWR Design Certification Application - Safety Analyses – RAI Number 15.3-25S01

2. DCD Markups

cc:	AE Cubbage	USNRC (with enclosure)
	GB Stramback	GEH/San Jose (with enclosure)
	RE Brown	GEH/Wilmington (with enclosure)
	eDRF	0000-0076-3388

Enclosure 1

MFN 07-017, Supplement 2

Response to NRC Request for Additional Information Letter No. 69 Related to ESBWR Design Certification Application

Safety Analyses

RAI Number 15.3-25 S01

NRC RAI 15.3-25 S01

Reference: RAI 15.3-25 in NRC letter dated October 11, 2006 GE response in MFN 07-017 dated February 16, 2007

(1) Concerning GE's response to Item B:

a) Add English Unit (curies) in the table or provide a new separate table with English units only.

b) Reference DCD Tier 2, Revision 3, Appendix 15B, LOCA Inventory, as responded to RAI 15.4-9.

c) Revise to read fuel exposure as 35 GWd/MTU core average.

(2) Revise Table 15.3-13 as follows:

a) Add number of fuel rods in core, condenser leak rate, release duration, and release points, to the table.

b) Correct typographical error to read Table 15.3-16 (instead of Table 15.4-19).

c) Add justification for the use of radial peaking factor of 1.5 for the 1000 fuel rods failed. What is the peak fuel rod average burnup? Is this radial peaking factor specified in ESBWR Technical Specifications?

d) Show or reference the control room X/Q values provided in Table 15.3-13 as 1000 fuel rod failure parameters" in DCD, Tier 2, Chapter 2, Table 2.0-1.

e) Add justification for the amount of iodine, noble gases, and alkali metals released from the failed fuel rods. Does it meet the maximum linear heat generation rate specified in Footnote 11 of Regulatory Guide 1.183, Table 3? (See DCD, Tier 2, Revision 3, Tables 6.3-1 and 6.3-11 for bounding peak linear heat generation rate specified).

(3) Revise Table 15.3-16 as follows:

a) Add the control room operator doses.

b) Reword EAB to read ... for any (worst) 2 hours rather than for the entire period of the radioactive cloud passage.

GEH Response:

1a)

The complete fission product inventory in the reactor core at 4590 MWth is provided in Enclosure 2 to this RAI response with SI and English Units.

1b)

Appendix 15B of DCD, Tier 2, Revision 4 has been revised to include compliance information with Regulatory Guide 1.183, Section 3.1 for core thermal power, fuel burn-up, and fuel enrichment.

1c)

Appendix 15B of DCD, Tier 2, Revision 4 has been revised to report a fuel exposure of 35 GWd/MTU.

2a, 2b, and 2d)

Table 15.3-13 has been revised to correct the typographical error and provide SI and English Units. The control room X/Q values have also been added to Table 15.3-13, which precludes the addition of a reference to Table 2.0-1.

2c)

The radial peaking factor is the ratio of the bundle power to the core average bundle power. The radial peaking factor value of 1.5 previously assumed for the 1000-rod dose consequence analysis may not be conservative. The 1000 rods assumed to fail in order to bound the various Infrequent Events may not result in the failure of the entire bundle; therefore, the peaking factor to be used in the 1000 rod dose consequence analysis will be based on the maximum allowable Linear Heat Generation Rate (LHGR). DCD, Tier 2, Revision 4, Table 6.3-1 states that the maximum permissible LHGR for the core is 13.4 kW/ft. That value is based on GE14E fuel. GNF is considering introducing a new fuel design that could potentially have a new limit of 14.4 kW/ft. The higher value will conservatively be used in the dose consequence calculation. The active fuel length for the ESBWR is 10 ft. There are 1132 bundles in the ESBWR core, and there are 87.333 full-length rods in a GE14E fuel bundle. The peaking factor assumed in the 1000 rod dose consequence analysis is determined as follows:

$$N_{rods,core} = \left(1132\,{}^{bundles}\!/_{core}\right)\left(87.333\,{}^{rods}\!/_{bundle}\right) = 98861.3 rods$$

$$LHGR_{coreavg} = \frac{4500MW}{(98861.3 rods)\left(10\,{}^{ft}\!/_{rod}\right)} = 4.552\,{}^{kW}\!/_{ft}$$

$$PF_{13.4kW/ft} = \frac{13.4\,{}^{kW}\!/_{ft}}{4.552\,{}^{kW}\!/_{ft}} = 2.94$$

$$PF_{14.4kW/ft} = \frac{14.4\,{}^{kW}\!/_{ft}}{4.552\,{}^{kW}\!/_{ft}} = 3.16 \Rightarrow 3.2$$

Therefore, a "peaking factor" of 3.2 will be assumed in the 1000 rod dose consequence analysis. The revised analysis will be included in DCD, Tier 2, Section 15.3, Revision 5.

2e)

Footnotes have been added to Tables 6.3-1 and 6.3-11 and will be reflected in DCD Revision 5 to clarify that the requirements of Regulatory Guide 1.183, Footnote 11 apply to the ESBWR as indicated in the GEH response to item 5 of MFN 07-17 S01 provided previously on August 22, 2007.

3a and 3b)

Table 15.3-16 has been revised to include the control room operator dose and the text accompanying the EAB entry has been reworded with the suggested text. Table 15.3-16 is provided in Enclosure 2 to this RAI response with SI and English Units:

DCD Impact:

DCD Tier 2, Revision 5, Appendix 15B will include both SI and English Units as well as compliance information with Regulatory Guide 1.183, Section 3.1 for core thermal power, fuel burn-up, and fuel enrichment as shown on the attached markup.

DCD, Tier 2, Revision 5, Tables 15.3-13, 15.3-14, 15.3-15, and 15.3-16 will be revised as shown on the attached markup with the SI and English units and control room χ/Q's.

Enclosure 2

MFN 07-017, Supplement 2

DCD Markups

Table 15.3-13

1000 Fuel Rod Failure Parameters

I. Data and assumptions used to estimate source terms	
A. Power level, MWt	4590
B. Number of bundles in core	1132
C. Number of fuel rods in core	98,861
D. Core fission product inventory released to coolant	Table 15.3-14
E. Equivalent full length fuel rods per bundle	87.33
F. Fuel rods damaged	1000
G. Peaking factor for failed rods	3.2
II. Data and assumptions used to estimate activity released	
A. Iodine released from failed fuel rods	10%
Noble gases released from failed fuel rods	10%
Alkali metals released from failed fuel rods	12%
B. Iodine released from reactor coolant	10%
Noble gases released from reactor coolant	100%
Alkali metals released from reactor coolant	1%
C. Iodine released from condenser	10%
Noble gases released from condenser	100%
Alkali metals released from condenser	1%
Fission product inventory released to environment	Table 15.3-15
III. Release pathway assumptions	
A. Release points	Main Condenser
B. Duration of condenser release	24 hours
C. Condenser leak rate	1% per day
IV. Dispersion and Dose Data	
A. Meteorology:	
EAB	2.00E-03 s/m^3
LPZ	

Table 15.3-13

1000 Fuel Rod Failure Parameters

0 – 8 hours	1.90E-04 s/m^3
8 – 24 hours	1.40E-04 s/m^3
1 – 4 days	7.50E-05 s/m^3
4 – 30 days	3.00E-05 s/m^3
B. Control Room	
0 – 2 hours	1.20E-03 s/m^3
2 – 8 hours	9.8E-04 s/m^3
8 – 24 hours	3.90E-04 s/m^3
1 – 4 days	3.80E-04 s/m^3
4 – 30 days	3.20E-04 s/m^3
C. Dose evaluations	Table 15.3-16

Table 15.3-14

1000 Fuel Rod Failure Fission Product Activity Released to Coolant

Isotope	Activity Released to Primary Coolant (MBq)	Activity Released to Primary Coolant (Ci)
Kr-85	5.66E+10	1.53E+06
Kr-85m	1.25E+12	3.39E+07
Kr-87	2.41E+12	6.52E+07
Kr-88	3.41E+12	9.23E+07
Rb-86	1.08E+10	2.91E+05
I-131	4.55E+12	1.23E+08
I-132	6.62E+12	1.79E+08
I-133	9.36E+12	2.53E+08
I-134	1.03E+13	2.80E+08
I-135	8.78E+12	2.37E+08
Xe-133	9.31E+12	2.52E+08
Xe-135	3.09E+12	8.35E+07
Cs-134	9.09E+11	2.46E+07
Cs-136	3.16E+11	8.54E+06
Cs-137	5.89E+11	1.59E+07

Table 15.3-15
1000 Fuel Rod Failure Fission Product Activity
Cumulative Release to Environment

Isotope	2 Hours (MBq)	2 Hours (Ci)	8 Hours (MBq)	8 Hours (Ci)	24 Hours (MBq)	24 Hours (Ci)
Kr-85	1.51E+05	4.07E+00	6.02E+05	1.63E+01	1.80E+06	4.87E+01
Kr-85m	2.85E+06	7.71E+01	7.60E+06	2.05E+02	1.02E+07	2.75E+02
Kr-87	3.81E+06	1.03E+02	5.66E+06	1.53E+02	5.73E+06	1.55E+02
Kr-88	7.11E+06	1.92E+02	1.58E+07	4.27E+02	1.81E+07	4.89E+02
Rb-86	3.41E+00	9.21E-05	1.36E+01	3.66E-04	4.00E+01	1.08E-03
I-131	1.21E+05	3.27E+00	4.78E+05	1.29E+01	1.38E+06	3.74E+01
I-132	1.31E+05	3.53E+00	2.62E+05	7.09E+00	2.86E+05	7.73E+00
I-133	2.41E+05	6.51E+00	8.73E+05	2.36E+01	2.01E+06	5.43E+01
I-134	1.33E+05	3.60E+00	1.67E+05	4.52E+00	1.68E+05	4.53E+00
I-135	2.10E+05	5.68E+00	6.30E+05	1.70E+01	9.87E+05	2.67E+01
Xe-133	2.47E+07	6.67E+02	9.69E+07	2.62E+03	2.76E+08	7.47E+03
Xe-135	7.61E+06	2.06E+02	2.46E+07	6.64E+02	4.37E+07	1.18E+03
Cs-134	2.88E+02	7.77E-03	1.15E+03	3.10E-02	3.43E+03	9.28E-02
Cs-136	9.98E+01	2.70E-03	3.96E+02	1.07E-02	1.16E+03	3.14E-02
Cs-137	1.87E+02	5.04E-03	7.45E+02	2.01E-02	2.23E+03	6.02E-02

Table 15.3-16

1000 Fuel Rod Failure Dose Results

Exposure Location and Time Period/Duration	**Maximum Calculated TEDE** Sv (rem)	**Acceptance Criterion TEDE** Sv (rem)
Exclusion Area Boundary (EAB) for any (worst) 2 hour period	3.33E-03 (0.333)	2.50E-02 (2.5)
Outer Boundary of Low Population Zone (LPZ) for the Duration of the Accident (30 days)	1.27E-03 (0.127)	2.50E-02 (2.5)
Control Room Operator Dose for the Duration of the Accident (30 days)	3.42E-03 (3.42E-01)	5.00E-02 (5.0)

15B. LOCA INVENTORY

This appendix provides additional detail on the design basis core source term assumed in the Chapter 15 dose consequence analyses. The source term was calculated using the computer code ORIGEN2 (Reference 15B-1). The source term meets the requirements of Regulatory Guide 1.183, Section 3.1.

The design power level for the ESBWR is 4500 MWt for a core with 1132 shortened GE14 fuel bundles. Considering a licensing power 2% above the design level gives a total core power of 4590 MWt or a bundle average power level of 4.054 MWt/bundle. The core inventory for licensing basis evaluations is based on the GE14 bounding bundle inventory. This inventory is based on a bundle enrichment of 4.6% and a core average exposure of 35 GWd/MTU. Also, it assumes a power level of 5.75 MWt/bundle. A full length GE14 bundle was used with a uranium mass of 182 kg, rather than the shorter bundle for the ESBWR, hence the higher bundle power assumption. The GE14 full length core inventory has been used for numerous power uprate licensing amendments. The linear heat generation rate is identical for both full length and ESBWR GE14 fuel. Also, when normalized to total length other parameters such as uranium mass are comparable. As such, use of a full length bundle has a negligible impact on the overall source term, thus the results are appropriate for the ESBWR.

Table 15B-1 contains values applicable to the ESBWR for the 60 isotopes used by the NRC computer code RADTRAD (Reference 15B-2).

15B.1 COL INFORMATION

None

15B.2 REFERENCES

15B-1 CCC-371, "RSICC Computer Code Collection – ORIGEN 2.1", Oak Ridge National Laboratory, May 1999.

15B-2 NUREG/CR-6604, "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation," USNRC, April 1998.

Table 15B-1

ESBWR Core Concentrations

	Isotope	Activity (MBq)	Activity (Ci)		Isotope	Activity (MBq)	Activity (Ci)		Isotope	Activity (MBq)	Activity (Ci)
1	Co-58	2.34E+10	6.32E+05	21	Ru-103	6.88E+12	1.86E+08	41	Cs-136	3.16E+11	8.54E+06
2	Co-60	2.26E+10	6.11E+05	22	Ru-105	4.60E+12	1.24E+08	42	Cs-137	5.89E+11	1.59E+07
3	Kr-85	5.65E+10	1.53E+06	23	Ru-106	2.39E+12	6.46E+07	43	Ba-139	8.43E+12	2.28E+08
4	Kr-85m	1.25E+12	3.38E+07	24	Rh-105	4.18E+12	1.13E+08	44	Ba-140	8.11E+12	2.19E+08
5	Kr-87	2.42E+12	6.54E+07	25	Sb-127	4.75E+11	1.28E+07	45	La-140	8.35E+12	2.26E+08
6	Kr-88	3.41E+12	9.22E+07	26	Sb-129	1.45E+12	3.92E+07	46	La-141	7.69E+12	2.08E+08
7	Rb-86	1.08E+10	2.92E+05	27	Te-127	4.82E+11	1.30E+07	47	La-142	7.45E+12	2.01E+08
8	Sr-89	4.56E+12	1.23E+08	28	Te-127m	6.29E+10	1.70E+06	48	Ce-141	7.70E+12	2.08E+08
9	Sr-90	4.48E+11	1.21E+07	29	Te-129	1.42E+12	3.84E+07	49	Ce-143	7.18E+12	1.94E+08
10	Sr-91	5.72E+12	1.55E+08	30	Te-129m	2.11E+11	5.70E+06	50	Ce-144	6.25E+12	1.69E+08
11	Sr-92	6.15E+12	1.66E+08	31	Te-131m	6.52E+11	1.76E+07	51	Pr-143	7.02E+12	1.90E+08
12	Y-90	4.76E+11	1.29E+07	32	Te-132	6.48E+12	1.75E+08	52	Nd-147	3.07E+12	8.30E+07
13	Y-91	5.84E+12	1.58E+08	33	I-131	4.55E+12	1.23E+08	53	Np-239	8.87E+13	2.40E+09
14	Y-92	6.18E+12	1.67E+08	34	I-132	6.62E+12	1.79E+08	54	Pu-238	1.54E+10	4.16E+05
15	Y-93	7.09E+12	1.92E+08	35	I-133	9.36E+12	2.53E+08	55	Pu-239	1.84E+09	4.97E+04
16	Zr-95	8.24E+12	2.23E+08	36	I-134	1.03E+13	2.78E+08	56	Pu-240	2.39E+09	6.46E+04
17	Zr-97	8.48E+12	2.29E+08	37	I-135	8.79E+12	2.38E+08	57	Pu-241	6.95E+11	1.88E+07
18	Nb-95	8.27E+12	2.24E+08	38	Xe-133	9.30E+12	2.51E+08	58	Am-241	7.82E+08	2.11E+04
19	Mo-99	8.70E+12	2.35E+08	39	Xe-135	3.09E+12	8.35E+07	59	Cm-242	1.84E+11	4.97E+06
20	Tc-99m	7.71E+12	2.08E+08	40	Cs-134	9.08E+11	2.45E+07	60	Cm-244	8.90E+09	2.41E+05

Figure 15B-1. Iodine Airborne Inventory in Primary Containment as a Function of Time (Deleted)