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MFN 06-528, Supplement 2

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 60 Related to ESBWR Design Certification Application – Radiation Protection – RAI Number 12.2-19S01**

Enclosure 1 contains GHNEA's response to the subject NRC supplemental RAI transmitted via Reference 1.

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

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NRO

Reference:

1. MFN 06-342 – Letter from US Nuclear Regulatory Commission (NRC) to David H. Hinds, *Request for Additional Information Letter No. 60 Related to ESBWR Design Certification Application,* dated September 18, 2006

Enclosures:

1. Response to NRC Request for Additional Information Letter No. 60 Related to ESBWR Design Certification Application – Radiation Protection, RAI Number 12.2-19S01

cc:	AE Cubbage	USNRC (with enclosures)
	GB Stramback	GHNEA /San Jose (with enclosures)
	RE Brown	GHNEA /Wilmington (with enclosures)
	eDRF	0068-0367

Enclosure 1

MFN 06-528, Supplement 2

Response to Portion of NRC Request for Additional Information Letter No. 60 Related to ESBWR Design Certification Application

Radiation Protection

RAI Number 12.2-19S01

NRC RAI No. 12.2-19 S01:

From an email received from Marlayna Vaaler on March 6, 2007:

Reference: GE response Letter MFN-06-528, dated December 22, 2006, which addressed NRC RAI Letter No. 71.

The shielding analysis provided in RAI 12.2-19 is based on 35 GWd/MTU exposure of a GE-14 fuel bundle. However, Figure 4A-18e lists several bundles in the core with burn-ups greater than 35 GWd/MTU (e.g. the bundle at 5,17 has a maximum average exposure of 50.38). In addition, Topical Report NEDC-33242P (currently under review in concert with the ESBWR design review) indicates a peak bundle average exposure of 67 GWd/MTU. Clarify how the RAI response provides a bounding analysis of the operational event in question.

GHNEA Response:

The basis for the fuel bundle used in the response to RAI 12.2-19 (MFN Letter # 06-528) is provided in the DCD markup associated with the response to RAI 15.4-9 (MFN Letter 07-199 submitted on May 2, 2007). In this markup, additional text is provided for DCD Tier 2, Appendix 15B, for the design basis core source term. A summary of the fuel bundle characteristics used in determining the core source term is presented below:

Fuel	GE14
Bundle exposure	35 GWd/MTU
Bundle average power level	5.75 MWth
Bundle enrichment	4.6%
Bundle mass	182 kg

As stated in the above mentioned DCD markup, the fuel bundle assumed for the ESBWR dose analyses is the GE14 bundle, not the shorter GE14E bundle. The GE14 bundle is 150 inches in length, while the GE14E ESBWR bundle is only 120 inches long. As a result, the uranium mass of the GE14E bundle is proportionally less than the GE14 bundle, which results in the ORIGEN2 inventory for the GE14 bundle being 25% greater (more conservative) than the GE14E bundle.

Other conservatisms include the bundle average power level assumed in calculating the 35 GWd/MTU source. A bundle average power of 5.75 MWth is used in the analysis, while the average bundle power for ESBWR is only 4.054 MWth (equal to 4500 MWth x 1.02 for measurement uncertainty / 1132 bundles in core).

A comparison is made of the gamma source at burnups of 35 GWd/MTU and 58 GWd/MTU. The value of 58 GWd/MTU is chosen as it is significantly higher that the bundle burnups in DCD Tier 2, Appendix 4A. The NEDC-33242P (Revision 1 dated February 2007) peak bundle average of 67 GWd/MTU cited in this RAI refers to the peak bundle average exposure for GE14 bundles based on operating experience as of 10/31/05. It does not reflect the peak bundle exposure for ESBWR. The comparison between burnups as a function of mean gamma energy is provided in the table below.

Mean Gamma Energy (MeV)	GE14 35 GWd/MTU Gamma Source @ 24 Hour Decay (photons/sec)	GE14 58 GWd/MTU Gamma Source @ 24 Hour Decay (photons/sec)	% Diff
0.01	1.27E+17	1.59E+17	125%
0.025	1.72E+16	1.86E+16	108%
0.0375	2.05E+16	2.17E+16	106%
0.0575	1.38E+16	1.65E+16	120%
0.085	2.50E+16	3.05E+16	122%
0.125	6.03E+16	7.49E+16	124%
0.225	4.74E+16	5.75E+16	121%
0.375	1.34E+16	1.50E+16	112%
0.575	4.17E+16	4.65E+16	112%
0.85	3.95E+16	4.24E+16	107%
1.25	5.40E+15	7.49E+15	139%
1.75	9.56E+15	9.72E+15	102%
2.25	4.56E+14	7.43E+14	163%
2.75	3.45E+14	3.44E+14	100%
3.5	3.01E+12	3.03E+12	101%
5	2.12E+10	1.63E+10	77%
7	4.33E+05	2.64E+06	608%
9.5	4.99E+04	3.03E+05	607%
Total	4.22E+17	5.01E+17	119%

Although there is a large (600%) increase in the gamma source at higher energies by moving to the higher burnup, the contribution of this source to the total is miniscule (10^{-10}%). The total increase in gamma source is less than 20% as the bundle burnup increases to 58 GWd/MTU.

In addition, a comparison is made for activities of the 60 RADTRAD isotopes between the 35 GWd/MTU and 58 GWd/MTU burnups.

RADTRAD Isotope #	Isotopes	GE14 35 GWd/MTU Activity @ 24 Hr Decay (Ci/MWth)	GE14 58 GWd/MTU Activity @24 Hr Decay (Ci/MWth)	% Diff
1	Co-58	1.37E+02	1.60E+02	117%
2	Co-60	1.33E+02	2.22E+02	167%
3	**Kr-85**	**3.33E+02**	**4.71E+02**	**142%**
4	**Kr-85m**	**1.82E+02**	**1.46E+02**	**80%**
5	**Kr-87**	**3.00E-02**	**2.31E-02**	**77%**
6	**Kr-88**	**5.73E+01**	**4.39E+01**	**77%**
7	Rb-86	6.11E+01	1.25E+02	205%
8	Sr-89	2.65E+04	2.03E+04	77%
9	Sr-90	2.64E+03	3.79E+03	144%
10	Sr-91	5.85E+03	4.65E+03	80%
11	Sr-92	7.82E+01	6.45E+01	83%
12	Y-90	2.77E+03	4.02E+03	145%
13	Y-91	3.42E+04	2.73E+04	80%
14	Y-92	1.15E+03	9.51E+02	83%
15	Y-93	8.14E+03	7.03E+03	86%
16	Zr-95	4.80E+04	4.51E+04	94%
17	Zr-97	1.87E+04	1.86E+04	100%
18	Nb-95	4.87E+04	4.57E+04	94%
19	Mo-99	3.98E+04	4.12E+04	103%

RADTRAD Isotope #	Isotopes	GE14 35 GWd/MTU Activity @ 24 Hr Decay (Ci/MWth)	GE14 58 GWd/MTU Activity @24 Hr Decay (Ci/MWth)	% Diff
20	Tc-99m	3.80E+04	3.92E+04	103%
21	Ru-103	3.98E+04	4.62E+04	116%
22	Ru-105	6.59E+02	8.59E+02	130%
23	Ru-106	1.41E+04	2.26E+04	160%
24	Rh-105	1.78E+04	2.34E+04	131%
25	Sb-127	2.37E+03	2.87E+03	121%
26	Sb-129	1.84E+02	2.06E+02	112%
27	Te-127	2.59E+03	3.12E+03	120%
28	Te-127m	3.70E+02	4.51E+02	122%
29	Te-129	1.01E+03	1.14E+03	113%
30	Te-129m	1.22E+03	1.38E+03	113%
31	Te-131m	2.22E+03	2.40E+03	108%
32	Te-132	3.09E+04	3.17E+04	103%
33	**I-131**	**2.49E+04**	**2.58E+04**	**104%**
34	**I-132**	**3.18E+04**	**3.26E+04**	**103%**
35	**I-133**	**2.54E+04**	**2.51E+04**	**99%**
36	**I-134**	**1.38E-03**	**1.28E-03**	**93%**
37	**I-135**	**4.18E+03**	**4.13E+03**	**99%**
38	**Xe-133**	**5.28E+04**	**5.13E+04**	**97%**
39	**Xe-135**	**1.40E+04**	**1.33E+04**	**95%**
40	Cs-134	5.34E+03	1.32E+04	247%
41	Cs-136	1.77E+03	3.51E+03	199%
42	Cs-137	3.47E+03	5.63E+03	162%
43	Ba-139	3.22E-01	3.09E-01	96%
44	Ba-140	4.52E+04	4.35E+04	96%

RADTRAD Isotope #	Isotopes	GE14 35 GWd/MTU Activity @ 24 Hr Decay (Ci/MWth)	GE14 58 GWd/MTU Activity @24 Hr Decay (Ci/MWth)	% Diff
45	La-140	4.82E+04	4.81E+04	100%
46	La-141	7.14E+02	6.81E+02	95%
47	La-142	1.04E+00	9.82E-01	94%
48	Ce-141	4.46E+04	4.28E+04	96%
49	Ce-143	2.57E+04	2.38E+04	92%
50	Ce-144	3.67E+04	3.57E+04	97%
51	Pr-143	4.09E+04	3.75E+04	92%
52	Nd-147	1.70E+04	1.67E+04	99%
53	Np-239	3.92E+05	5.19E+05	132%
54	Pu-238	9.06E+01	3.45E+02	380%
55	Pu-239	1.09E+01	1.34E+01	123%
56	Pu-240	1.41E+01	2.67E+01	190%
57	Pu-241	4.09E+03	5.42E+03	132%
58	Am-241	4.62E+00	7.29E+00	158%
59	Cm-242	1.08E+03	2.56E+03	236%
60	Cm-244	5.24E+01	5.19E+02	991%
	Total	**1.21E+06**	**1.35E+06**	**111%**

The overall activity when considering all isotopes is about 11% higher for 58 GWd/MTU than for 35 GWd/MTU. The table above indicates that for the noble gases and iodines, which are significant contributors to dose, there is no significant difference between the activities at 35 GWd/MTU and 58 GWd/MTU burnups (differences highlighted in bold in the table), with the exception of Kr-85. In fact, the activity levels for many of the iodines and noble gases decrease with the increase in burnup.

Based on the data above, it can be seen that an increase in the fuel burnup from 35 GWd/MTU to 58 GWd/MTU yields about a 120% increase in the gamma source term and a minimal increase in activity. Since the fuel source assumed for ESBWR dose evaluations contains 25% more material, and as a result, a 25% greater gamma source

term and activity, this conservatism adequately negates the slight increase in gamma source term and activity due to an increase in burnup. Therefore, the gamma source term used in actual ESBWR evaluations is reasonable and appropriate for the range of operation for ESBWR fuel. No additional actions are warranted.

DCD Impact:

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