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YUCCA MOUNTAIN — REQUEST FOR ADDITIONAL INFORMATION —VOLUME 2, CHAPTER 2.1.1.4, SET 3 (DEPARTMENT OF ENERGY'S SAFETY ANALYSIS REPORT SECTION 1.7)

Reference : Ltr, Jacobs to Williams, dtd 6/3/09, "Yucca Mountain – Request for Additional Information – Volume 2, Chapter 2.1.1.4, Set 2 & Set 3 (Department of Energy's Safety Analysis Report Section 1.7)

The purpose of this letter is to transmit the U.S. Department of Energy's (DOE) supplemental response to Request for Additional Information (RAI) number 1, identified in the referenced letter above. The original DOE response to RAI number 1, Volume 2, Chapter 2.1.1.4, Set 3 was submitted on July 7, 2009.

A DOE reference, not previously submitted to the Nuclear Regulatory Commission (NRC), is provided on an optical storage media (OSM) as Enclosure 2. Additionally, an OSM, provided as Enclosure 3, contains electronic attachments associated with the reference. The electronic attachments on the OSM are data files provided in their native file format, consistent with Sections 2.2 and 2.17 of the NRC guidance on electronic submissions. They are required by NRC staff in their native format to evaluate DOE's responses. The electronic attachments are not intended to be placed on or accessed through ADAMS and will be made available to the public, upon request.

There are no commitments in the enclosed RAI supplemental response. If you have any questions regarding this letter, please contact me at (202) 586-9620, or by email to jeff.williams@rw.doe.gov.

Jeffrey R. Williams, Supervisor
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Office of Technical Management

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Enclosures (3):

1. Supplemental Response to RAI Volume 2, Chapter 2.1.1.4, Set 3, Number 1
2. Optical Storage Media – DVD containing one reference
3. Optical Storage Media – DVD containing electronic reference attachments

cc w/enclosure 1:
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EIE Document Components:
[184137]_800-KVC-VUE0-00700-000-00A.pdf 2,051 kB

RAI Volume 2, Chapter 2.1.1.4, Third Set, Number 1, Supplemental Question 8:

Ventilation efficiency of 86% was derived in *Ventilation Model and Analysis Report* (BSC 2004) based on instantaneous emplacement of all waste packages with a low linear heat load of 1.45 kW/m and an air flow of 15 m^3/sec. To clarify DOE's plan to ensure sufficient ventilation of waste packages to meet repository thermal limits, provide justification and documentation showing 86% ventilation efficiency can be achieved with the same air flow rate (15 m^3/sec) for the higher thermal load specified in SAR Section 1.3.1.2.5.

1. RESPONSE

Subsurface ventilation heat removal efficiencies for the repository during the preclosure period are documented in the following reports, for emplacement drift linear thermal loads of 1.45 kW/m and 2.0 kW/m, respectively:

- *Ventilation Model and Analysis Report* (BSC 2004)
- *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load* (BSC 2008).

Both of these documents assume instantaneous emplacement (i.e., the entire waste package inventory is emplaced at the beginning of the ventilation period), resulting in a conservatively high initial heat load rather than the more realistic and incrementally rising heat load over the emplacement period. The energy available from the waste packages from this stylized loading over the preclosure period is represented by the thermal decay rate functions presented in Table 1, with initial linear thermal loads of 1.45 kW/m for the *Ventilation Model and Analysis Report* (BSC 2004) and 2.0 kW/m for the *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load* (BSC 2008) calculation. Both reports use the same calculation method (developed in *Ventilation Model and Analysis Report* (BSC 2004)), and both use a nominal emplacement drift airflow rate of 15 m^3/s. The *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load* (BSC 2008) calculation provides information that includes the evaluation of the emplacement drift thermal response at selected locations as well as an evaluation of transient temperature response over the 100 year preclosure period.

The analysis and the calculation use typical emplacement drift lengths to represent the repository drifts. A length of 600 m is representative of an average length emplacement drift for the repository. A length of 800 m is representative of the longest emplacement drifts in the repository (BSC 2003, Attachment 1).

The waste package thermal decay modeled for the 2.0 kW/m initial thermal line load (Table 1) is proportionately scaled from the 1.45 kW/m thermal decay function using a factor of 2.0/1.45. Higher initial waste package heat output is normally associated with spent nuclear fuel that has a short time out of reactor and a greater decay rate than spent nuclear fuel that has been removed from the reactor for a longer time. Using the decay rate of the 1.45-kW/m initial heat load to represent the decay of the initial 2.0-kW/m load increases the thermal load slightly because the

decay rate of the cooler fuel (1.45 kW/m) is less than the actual decay rate for the hotter fuel (2.0 kW/m), hence artificially retaining heat longer as represented by the derived decay function. The derived 2.0 kW/m decay function also has a higher thermal load compared with other estimates of the 2.0 kW/m line load (as compared to the hottest segments as discussed in *Postclosure Analysis of the Range of Design Thermal Loadings*. (SNL 2008, Section 6.1.4)). Using this assumption provides conservative results of temperatures for the emplacement drift (BSC 2008, Section 3.2).

The subsurface ventilation efficiency of 86% is the integrated value of heat removed (temporally and spatially) derived by the total system performance assessment (TSPA) supporting analysis (BSC 2004) considering the 1.45 kW/m initial line load, the 15 m^3/s airflow rate, an 800-m long emplacement drift (88% for the 600-m long drift), and 50 years of preclosure ventilation (BSC 2004, Table 4-13, and Sections 6 and 8).

The *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load* (BSC 2008) calculation presents results graphically for waste package surface temperatures, drift wall temperatures, and ventilation exhaust air temperatures, for ventilation durations up to 100 years and for emplacement drift lengths in increments of 100 meters up to 800 meters (BSC 2008, Figures 1 through 8). The ventilation efficiencies for the 600-m and 800-m long drifts are summarized graphically over the preclosure period in Figure 1 (BSC 2008, Figure 9). The calculation results show that for the first few years of ventilation, the spatially integrated ventilation efficiencies are between 50% and 80%. With increased preclosure ventilation time, the ventilation efficiencies increase to values that are close to 90% after 100 years for a 600-m long emplacement drift, and 88% for an 800-m long emplacement drift (Figure 1).

The integrated heat removal efficiencies for 50 years of ventilation estimated by the preclosure calculation are approximately the same for the 600-m and 800-m long drifts as those values obtained in the *Ventilation Model and Analysis Report* (BSC 2004, Section 8.1). The results presented in the TSPA-supporting analysis and the preclosure calculation show that integrated ventilation efficiency generally increases with ventilation duration and has limited sensitivity to the host rock thermal conductivity. For 50 years of ventilation, the integrated heat removal efficiencies are approximately 2% smaller than the values for 100 years of ventilation for the 600-m and 800-m long drifts. Emplacement of the waste package inventory and thermal management, as described in SAR Section 1.3.1.2.5, considers ventilation durations in excess of 50 years. For example, for a ventilation duration of 75 years, integrated heat removal efficiencies of approximately 89% and 87% were obtained in the *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load* (BSC 2008, Figure 9), for the 600-m and 800-m long drifts (Figure 1). The repository ventilation system can, therefore, be operated at ventilation efficiencies higher than those obtained for the TSPA base case for the higher linear thermal load without increasing the ventilation airflow rate.

In summary, the preclosure ventilation calculation shows that the integrated heat removal efficiencies with the 2.0 kW/m initial line load and up to 75 or 100 years of ventilation are slightly greater than the integrated efficiencies obtained for the 1.45 kW/m initial line load and 50 years of ventilation for the same ventilation airflow rate. The development of the waste package thermal decay for the 2.0 kW/m initial thermal line load, proportionately scaling from

the 1.45 kW/m thermal decay function, results in a slight overestimation of the overall heat input as compared to the hottest segments discussed in *Postclosure Analysis of the Range of Design Thermal Loadings* (SNL 2008, Section 6.1.4). Overstating the heat with the scaling of the thermal decay function may result in a less accurate estimation of the integrated ventilation efficiencies. However, in relative terms, the *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load* (BSC 2008) demonstrates that the repository ventilation system operating at the same nominal airflow rate but for a longer duration can maintain a thermal environment that does not result in exceedance of the repository thermal limits for a linear thermal load greater than the TSPA base case and for the same ventilation airflow rate.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2003. *Underground Layout Configuration*. 800-P0C-MGR0-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20031002.0007.

BSC 2004. *Ventilation Model and Analysis Report*. ANL-EBS-MD-000030 REV 04. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20041025.0002.

BSC 2008. *Preclosure Emplacement Drift Temperature Calculation for the 2.0 kW/m Thermal Load*. 800-KVC-VUE0-00700-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080110.0001.

SNL (Sandia National Laboratories) 2008. *Postclosure Analysis of the Range of Design Thermal Loadings*. ANL-NBS-HS-000057 REV 00. Las Vegas, Nevada: Sandia National Laboratories. ACC: DOC.20080121.0002.

Table 1. Overall Thermal Decay for the Preclosure Period

Years	1.45 kW/m Thermal Decay	2.0 kW/m Thermal Decay		Years	1.45 kW/m Thermal Decay	2.0 kW/m Thermal Decay
0	1.450	2.000		51	0.584	0.805
1	1.399	1.929		52	0.576	0.794
2	1.357	1.871		53	0.568	0.783
3	1.321	1.822		54	0.560	0.773
4	1.289	1.777		55	0.553	0.763
5	1.259	1.737		56	0.546	0.753
6	1.232	1.699		57	0.538	0.743
7	1.206	1.663		58	0.531	0.733
8	1.181	1.629		59	0.525	0.724
9	1.157	1.596		60	0.518	0.715
10	1.135	1.565		61	0.511	0.706
11	1.110	1.531		62	0.505	0.697
12	1.088	1.501		63	0.499	0.688
13	1.068	1.473		64	0.493	0.679
14	1.049	1.448		65	0.487	0.671
15	1.033	1.424		66	0.481	0.663
16	1.012	1.396		67	0.475	0.655
17	0.993	1.370		68	0.469	0.647
18	0.976	1.346		69	0.464	0.640
19	0.960	1.324		70	0.459	0.633
20	0.944	1.302		71	0.453	0.625
21	0.927	1.278		72	0.448	0.618
22	0.910	1.256		73	0.443	0.611
23	0.895	1.234		74	0.438	0.604
24	0.881	1.214		75	0.433	0.598
25	0.867	1.195		76	0.429	0.591
26	0.853	1.176		77	0.424	0.585
27	0.838	1.156		78	0.419	0.578
28	0.824	1.137		79	0.415	0.572
29	0.811	1.119		80	0.410	0.566
30	0.799	1.102		81	0.406	0.560
31	0.786	1.084		82	0.402	0.554
32	0.773	1.066		83	0.398	0.549
33	0.761	1.050		84	0.394	0.543
34	0.749	1.034		85	0.390	0.538
35	0.738	1.018		86	0.386	0.532
36	0.726	1.002		87	0.382	0.527
37	0.715	0.986		88	0.378	0.522
38	0.704	0.971		89	0.375	0.517
39	0.694	0.957		90	0.371	0.512

Years	1.45 kW/m Thermal Decay	2.0 kW/m Thermal Decay		Years	1.45 kW/m Thermal Decay	2.0 kW/m Thermal Decay
40	0.684	0.943		91	0.368	0.507
41	0.673	0.929		92	0.364	0.503
42	0.663	0.915		93	0.361	0.498
43	0.653	0.901		94	0.358	0.494
44	0.644	0.888		95	0.355	0.489
45	0.635	0.876		96	0.351	0.485
46	0.626	0.863		97	0.348	0.481
47	0.617	0.851		98	0.345	0.476
48	0.608	0.839		99	0.343	0.472
49	0.600	0.828		100	0.340	0.468
50	0.592	0.816		–	–	–

Source: BSC 2008, Table 1.

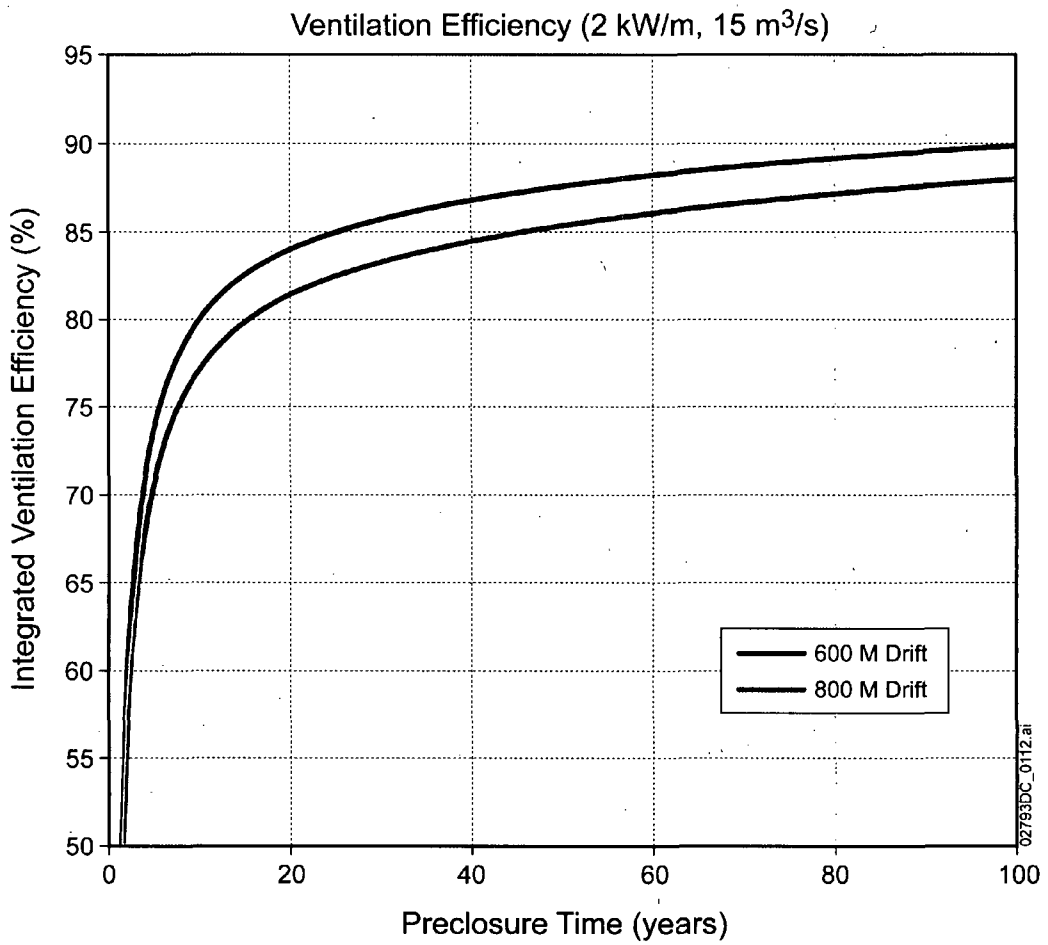

Figure 1. Integrated Ventilation Efficiency as a Function of Ventilation Duration for the Preclosure Period

Source: BSC 2008, Figure 9.