Model
Error Resolution Document

Complete only applicable items.

Page 1 of 16

QA: QA 10-27-09

1. Document Number:	2. Revision/Addendum:	3. ERD:
ANL-EBS-MD-000005	04/00	04

4. Title:	5. No. Pages Attached:
Stress Corrosion Cracking of Waste Package Outer Barrier and Drip Shield Materials	5

6. Description of and Justification for Change (Identify applicable CRs and TBVs):

This ERD is in response to CR 13722. Six issues are addressed; the details of each are presented in the attached pages. A brief summary and justification of the issues are as follows:

Errors found in Table 8-13 and Table 8-14 of DTN: MO0702PASTRESS.002 and in Table 6-17, Table 6-37, Table 8-13, and Table 8-14, in ANL-EBS-MD-000005 REV 04 need to be corrected to address CR 13722. Therefore, replacing erroneous Table 8-13 and Table 8-14 of DTN: MO0702PASTRESS.002 and Table 6-17, Table 6-37, Table 8-13, and Table 8-14, in ANL-EBS-MD-000005 REV 04 with the corrected versions does not affect the technical product output of ANL-EBS-MD-000005 REV 04 and is not relevant to safety or waste isolation and does not have any impact on the results of the Safety Analysis Report or the Total System Performance Assessment. As indicated in ANL-EBS-MD-000005 REV 04, Table 8-15 (TSPA Parameter Information/Specification), TSPA uses Parameter WP_Crack_Area_Density_a to represent the seismic damaged "crack area density" for the waste package and Parameter DS_Crack_Area_Density_a to represent the seismic damaged "crack area density" for the drip shield. The uncertainty distribution used for these parameters (indicated in column 4 of ANL-EBS-MD-000005 REV 04, Table 8-15) is "Uncertainty uniformly distributed between 3.27×10^{-3} and 1.31×10^{-2} at room temperature" for the waste package and Uncertainty uniformly distributed between 4.67×10^{-3} and 1.875×10^{-2} at room temperature" for the drip shield. These uncertainty limits for crack area density are taken from the room temperature upper and lower bound limits from the last columns of ANL-EBS-MD-000005 REV 04, Tables 8-13 and 8-14 for the waste package and drip shield, respectively, and are identical to the values listed in Tables 6-17 and 6-37. Unlike some of the higher temperature values, these room temperature values listed in Tables 6-17, 6-37, 8-13 and 8-14 are correct in ANL-EBS-MD-000005 REV 04 and do not need revision since they remain the same in the corrected tables. Also, these room temperature values are listed in Tables 8-13 and 8-14 of DTN: MO0702PASTRESS.

	Printed Name	Signature	Date
7. Checker	Gopal C. De	Gopal De	10/27/09
8. QCS/QA Reviewer	Brian Mitcheltree	B Mitch	10/27/09
9. Originator	Gerald M. Gordon	Gerald M Gordon	10/27/09
10. Responsible Manager	Russell Jarek	Russell Jarek	10/27/09

Description of Changes:

In regard to CR 13722:

1. In ANL-EBS-MD-000005 REV 04, Table 6-17 (Section 6.7.3.3), Table 6-37 (Section 6.8.5.2.2), Table 8-13 (Section 8.3), and Table 8-14 (Section 8.3) are replaced with the corrected tables included below.

2. DTN: MO0702PASTRESS.002 is revised to incorporate corrected versions of the Excel and Word files related to the changes in Table 8-13 and Table 8-14 discussed herein.

3. The ANL-EBS-MD-000005 REV 04 Table of Contents is revised to reflect changes in table captions for corrected Table 6-17 and Table 6-37:

   Table 6-17 current caption: "Crack Characteristics for Hexagonal Geometry"

   Table 6-17 revised caption: "Crack Characteristics for Alloy 22 for Hexagonal Geometry

   Table 6-37 current caption: "Crack Characteristics for Hexagonal Geometry"

   Table 6-37 revised caption: "Crack Characteristics for Drip Shield for Hexagonal Geometry".

4. The sentence on p. 6-125 which reads "Table 6-17 shows that the range of the crack area density (crack area per unit of seismically damaged area) ranges from 3.27×10^{-3} to 1.31×10^{-2} at room temperature, and 2.82×10^{-3} to 1.19×10^{-2} at 150°C." is replaced with "Table 6-17 shows that the range of the crack area density (crack area per unit of seismically damaged area) ranges from 3.27×10^{-3} to 1.31×10^{-2} at room temperature, and 2.82×10^{-3} to 1.13×10^{-2} at 150°C."

5. The sentences on p. 6-177, which read:

   "Values of the yield strength of Titanium Grade 7 from room temperature (21°C) to 150°C (the temperature at which the structural calculations of the waste package exposed to ground motion were conducted (SNL 2007 [DIRS 176828])) and the modulus of elasticity from room temperature to 204°C are shown in Table 4-7. Taking the average of values of yield strength, these values are also presented in the second and third columns of Table 6-37.

   Table 6-37 shows the crack length, crack density, crack width, crack opening area, and crack area density for cases 1 and 2 at room temperature and 150°C with assumed barrier thickness of 10 mm, 15 mm, and 20 mm. In Table 6-37, the values of the barrier thickness are for illustration purposes only. The crack length equals $\frac{2t}{\sqrt{3}}$ for case 1 and *2t* for case 2 (Section 6.7.3). The crack density equals $\frac{\sqrt{3}}{2t^2}$ for case 1 and $\frac{2}{\sqrt{3}t^2}$ for case 2 (Section 6.7.3). The crack width of a single crack is calculated by equation 29 ($\delta = \frac{(4c)\sigma}{E}$) for the given thickness for each case. The crack opening is calculated from Equation 30 ($A_{SCC} = \pi\left(\frac{\delta}{2}\right)\left(\frac{2c}{2}\right) = \pi\left(\frac{(2c)\sigma}{E}\right)c = \frac{(2\pi c^2)\sigma}{E}$) for the two cases. The crack area density is calculated from

Equation 33 ($\rho_{SCC} A_{SCC} = \frac{\sqrt{3}}{2t^2} \frac{(2\pi t^2)\sigma}{3E} = \frac{\pi\sigma}{\sqrt{3}E} \cong 1.81\frac{\sigma}{E}$) for case 1 and Equation 36 ($\rho_{SCC} A_{SCC} = \frac{2}{\sqrt{3}t^2} \frac{(2\pi t^2)\sigma}{E} = \frac{4\pi\sigma}{\sqrt{3}E} \cong 7.26\frac{\sigma}{E}$) for case 2.

Table 6-37 shows that the crack area density (crack area per unit of seismically damaged area) ranges from 4.67×10^{-3} to 1.88×10^{-2} at room temperature and 3.15×10^{-3} to 1.33×10^{-2} at 149°C."

Are replaced with:

"Values of the yield strength of Titanium Grade 7 from room temperature (21°C) to 149°C and the modulus of elasticity from room temperature to 204°C are shown in Table 4-7. The temperature at which the structural calculations of the waste package exposed to seismic ground motion were conducted (SNL 2007 [DIRS 176828]) is 150°C. The impact of the use of 149°C versus 150°C is discussed below.

Table 6-37 shows the crack length, crack density, crack width, crack opening area, and crack area density for cases 1 and 2 at room temperature and 149°C with assumed barrier thickness of 9 mm, 12 mm, and 15 mm. In Table 6-37, the values of the barrier thickness are for illustration purposes only. The crack length equals $\frac{2t}{\sqrt{3}}$ for case 1 and *2t* for case 2 (Section 6.7.3). The crack density equals $\frac{\sqrt{3}}{2t^2}$ for case 1 and $\frac{2}{\sqrt{3}t^2}$ for case 2 (Section 6.7.3). The crack width of a single crack is calculated by Equation 33 for the given thickness for each case. The crack opening is calculated from Equation 34 for the two cases. The crack area density is calculated from Equation 37 for case 1 and Equation 40 for case 2.

Table 6-37 shows that the crack area density (crack area per unit of seismically damaged area) ranges from 4.67×10^{-3} to 1.87×10^{-2} at room temperature and 3.15×10^{-3} to 1.27×10^{-2} at 149°C."

6. In ANL-EBS-MD-000005 REV 04, Section 9.4, the listed output DTN: MO0702PASTRESS.002 submittal date: "04/24/2007" is revised to read "09/28/2009".

Corrected Replacement for Table 6-17 and Table 8-13.

Crack Characteristics for Alloy 22 for Hexagonal Geometry

T (°C)	Yield Strength (MPa)	Modulus of Elasticity (GPa)	Case	Barrier Thickness[1] (mm)	Crack Length[2] (mm)	Crack Density[3] (/mm^2)	Crack Width[4] (mm)	Crack Opening Area[5] (mm^2)	Crack Area Density[6]
Room	372	206	1	t	$\frac{2t}{\sqrt{3}}$	$\frac{\sqrt{3}}{2t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 1.81\frac{\sigma}{E}$
				18	20.78	2.67E−03	0.075	1.23	3.27E−03
				20	23.09	2.17E−03	0.083	1.51	3.27E−03
				23	26.56	1.64E−03	0.096	2.00	3.27E−03
				25	28.87	1.39E−03	0.104	2.36	3.27E−03
			2	t	$2t$	$\frac{2}{\sqrt{3}t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 7.26\frac{\sigma}{E}$
				18	36.00	3.56E−03	0.130	3.68	1.31E−02
				20	40.00	2.89E−03	0.144	4.54	1.31E−02
				23	46.00	2.18E−03	0.166	6.00	1.31E−02
				25	50.00	1.85E−03	0.181	7.09	1.31E−02
150	310	199	1	t	$\frac{2t}{\sqrt{3}}$	$\frac{\sqrt{3}}{2t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 1.81\frac{\sigma}{E}$
				18	20.78	2.67E−03	0.065	1.06	2.82E−03
				20	23.09	2.17E−03	0.072	1.31	2.82E−03
				23	26.56	1.64E−03	0.083	1.73	2.82E−03
				25	28.87	1.39E−03	0.090	2.04	2.82E−03
			2	t	$2t$	$\frac{2}{\sqrt{3}t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 7.26\frac{\sigma}{E}$
				18	36.00	3.56E−03	0.112	3.17	1.13E−02
				20	40.00	2.89E−03	0.125	3.92	1.13E−02
				23	46.00	2.18E−03	0.143	5.18	1.13E−02
				25	50.00	1.85E−03	0.156	6.12	1.13E−02

Source: Output DTN: MO0702PASTRESS.002, *Model Output DTN.doc*, Table 8-13.

[1] Barrier thickness values are for illustration purposes only.
[2] Crack length equals $2t/\sqrt{3}$ for case 1 and $2t$ for case 2.
[3] Crack density equals $\sqrt{3}/2t^2$ for case 1 and $2/\sqrt{3}t^2$ for case 2.
[4] Crack width of a single crack is given by Equation 33 for the given thickness for each.
[5] Crack opening is calculated from Equation 34 for the two cases.
[6] Crack area density is calculated from Equation 37 for case 1, and Equation 40 for case 2.

Corrected Replacement for Table 6-37 and Table 8-14.

Crack Characteristics for Drip Shield for Hexagonal Geometry

T (°C)	Yield Strength (MPa)	Modulus of Elasticity (GPa)	Case	Barrier Thickness[1] (mm)*	Crack Length[2] (mm)	Crack Density[3] (/mm²)	Crack Width[4] (mm)	Crack Opening Area[5] (mm²)	Crack Area Density[6]
Room	276	107	1	t	$\frac{2t}{\sqrt{3}}$	$\frac{\sqrt{3}}{2t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 1.81\frac{\sigma}{E}$
				9	10.39	1.07E−02	5.37E−02	0.44	4.67E−03
				12	13.86	6.01E−03	7.16E−02	0.78	4.67E−03
				15	17.32	3.85E−03	8.95E−02	1.22	4.67E−03
			2	t	$2t$	$\frac{2}{\sqrt{3}t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 7.26\frac{\sigma}{E}$
				9	18.00	1.43E−02	9.30E−02	1.31	1.87E−02
				12	24.00	8.02E−03	1.24E−01	2.34	1.87E−02
				15	30.00	5.13E−03	1.55E−01	3.65	1.87E−02
149	176	101	1	t	$\frac{2t}{\sqrt{3}}$	$\frac{\sqrt{3}}{2t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 1.81\frac{\sigma}{E}$
				9	10.39	1.07E−02	3.62E−02	0.30	3.15E−03
				12	13.86	6.01E−03	4.83E−02	0.53	3.15E−03
				15	17.32	3.85E−03	6.04E−02	0.82	3.15E−03
			2	t	$2t$	$\frac{2}{\sqrt{3}t^2}$	$\delta = \frac{(4c)\sigma}{E}$	$A_{SCC} = \frac{(2\pi c^2)\sigma}{E}$	$\rho_{SCC} A_{SCC} \cong 7.26\frac{\sigma}{E}$
				9	18.00	1.43E−02	6.27E−02	0.89	1.27E−02
				12	24.00	8.02E−03	8.36E−02	1.58	1.27E−02
				15	30.00	5.13E−03	1.05E−01	2.46	1.27E−02

Source: Output DTN: MO0702PASTRESS.002, *Model Output DTN.doc*, Table 8-14.

[1] Barrier thickness values are for illustration purposes only.
[2] Crack length equals $2t/\sqrt{3}$ for case 1 and $2t$ for case 2.
[3] Crack density equals $\sqrt{3}/2t^2$ for case 1 and $2/\sqrt{3}t^2$ for case 2.
[4] Crack width of a single crack is given by Equation 33 for the given thickness for each.
[5] Crack opening is calculated from Equation 34 for the two cases.
[6] Crack area density is calculated from Equation 37 for case 1 and Equation 40 for case 2.

Analysis of Impacted Documents:

The changes listed have no impact on the conclusions of or the outputs from ANL-EBS-MD-000005 REV 04. The corrected values contained in Table 8-13 and Table 8-14 of DTN: MO0702PASTRESS.002 and Table 6-17, Table 6-37, Table 8-13, and Table 8-14, in ANL-EBS-MD-000005 REV 04 are not cited in any other documents. Therefore, there is no impact on the following documents that cite ANL-EBS-MD-000005 REV 04: ANL-DS0-NU-000001 Rev. 00; ANL-EBS-MD-000076 Rev. 00, ACN 01; ANL-EBS-PA-000011 Rev. 00, ANL-EBS-PA-000013 Rev. 00, ANL-EBS-PA-000014 Rev. 00; ANL-WIS-MD-000024 Rev. 01; ANL-WIS-PA-000001 Rev. 03; CAL-DN0-NU-000002 Rev. 00C; MDL-WIS-PA-000003 Rev. 03; MDL-WIS-PA-000005 Rev. 00 and Addendum 01; TDR-MGR-MD-000056 Rev. 00; TDR-PCS-SE-000001 Rev. 05, Addendum 01; TDR-WIS-PA-000014 Rev. 00; ANL-WIS-MD-000027 Rev. 00.

SAR Sections Evaluated:

LASAR-1.03.04; LASAR-1.05.02; LASAR-2.01; LASAR-2.02; LASAR-2.03.04; LASAR-2.03.06; LASAR-2.04.