RESPONSES TO RAI, ES-3100 Revision 10

ATTACHMENT 1

RAI RESPONSES

B&W Y-12 technical services LLC

Y-12 NATIONAL SECURITY COMPLEX

REQUEST FOR ADDITIONAL INFORMATION
MODEL ES-3100 PACKAGE

Certificate of Compliance No. 9315, Revision 10
Docket No. 71-9315
TAC No. L24444

Reference: Letter Kimberly J. Hardin,
U.S. NRC to James M. Shuler, U.S. DOE
(dated October 12, 2010)

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January 27, 2011

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Prepared by
Babcock & Wilcox Technical Services Y-12, LLC
Management & Operating Contractor
for the
Y-12 National Security Complex
under Contract No. DE-AC05-00OR22800
with the
U.S. Department of Energy
National Nuclear Security Administration

January 27, 2011

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RESPONSES TO RAI-ES-3100-REVISION 10

Chapter 3 Thermal Review

3-1 Confirm that the content change in the amendment did not affect normal conditions of transport (NCT) and hypothetical accident condition (HAC) calculations.

The content with a 0.4 CSI has been added to Table 1.3 (page 1-16 of the Safety Analysis Report), which indicates that the basis for the limit is hydrogen generation. Confirm that the decay heat and the thermal and hydrogen generation/pressure calculations under NCT and HAC remained the same as a result of this content change.

This information is needed to determine compliance with 10 CFR 71.43, 71.71, and 71.73.

The new entry in Table 1.3 revised the concentration of ^{235}U in HEU oxide. The total amount of oxide remains the same at 15.13 kg; however, the ^{235}U isotope increases to ~81%. These new values are still bounded by the analysis presented in Sect. 3 for the calculation of decay heat and pressure buildup during NCT and HAC. The isotopic percentages shown in Table 3.1 represent the worst isotopic distribution for decay heat, containment leakage rate criteria, and radiolysis analysis shown in Appendix 3.6.7. Decay heat is based on 35.2 kg of HEU with the isotopic distribution shown in Table 3.1. This equates to 19.32 kg of ^{235}U.

3-2 Confirm that the NCT and HAC analyses are not affected by the presence of silicone rubber pads and the use of carbon steel or stainless-steel can spacers.

a) Table 3.15 (page 3-23) indicates that the thermal analyses assumed silicone rubber pads were part of the model. Page 7-2 states that silicone rubber pads may not be used in the packaging. Confirm that the results with the silicone rubber pads bound the results if the silicone rubber pads are not used.

b) Likewise, the updated SAR (page 1-22) indicates that either carbon steel or stainless-steel can spacers will be used in the package. Confirm that the results from the NCT and HAC analyses are bounded by using either carbon steel or stainless-steel can spacers.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

The pressure calculations for NCT and HAC in Appendices 3.6.4 and 3.6.5 take into account the presence of the silicone rubber pads and can spacers. These items reduce the void volume inside the containment vessel, and the silicone rubber pad offgassing increases the total pressure. Therefore, higher containment vessel pressures are calculated when these items are included as opposed to a configuration where they are not included. Stainless-steel or carbon-steel can spacer design is nearly identical in external volume occupied. The stainless-steel can spacers use a crimped seal versus a paint-can–type lid closure used on the carbon-steel can spacers. Otherwise, the two can spacer designs are identical. Therefore, the can spacer design would have no effect on the NCT and HAC analyses presented in the SAR.

3-3 Clarify the temperature that the package was exposed to during the physical furnace test.

The temperature that the package was exposed to during the physical furnace test should be clarified. Page 3-33 of the SAR states that the furnace had a set point of 871°C (1600°F). However, page 3-34 of the SAR states that most of the thermocouples in the furnace were at 800°C (1475°F) during the test. Table 3.17 then lists component temperatures of 1600°F, implying that some of the temperatures listed include a 125°F margin (considering that regulations state a fire temperature of at least 1475°F). This should be clarified.

This information is needed to determine compliance with 10 CFR 71.73.

The furnace set point was 871°C (1600°F) as stated in Sect. 3.5.2. The 30-min fire test was not started until all thermocouples on the furnace walls and package support stand recorded a temperature of 800°C (1475°F) or higher. The actual temperatures achieved in the furnace and on the test packages during the thermal tests are shown in ORNL/NTRC-013/V1 (Appendix 2.10.7) on pp. 2-762 through 2-771 in the SAR.

3-4 Discuss the effects on package functionality considering that many of the packaging components are at temperatures near/at their allowable during the hypothetical accident condition.

Per Table 3-17, many of the package components are at temperatures near/at their allowable during the hypothetical accident condition (silicone bronze nut, top plug, Kaolite 1600, Cat 277-4, etc.). There should be a discussion that explains the reasons this is acceptable. Specifically, the degradation that is expected if the temperature exceeds the allowable limits of these components should be discussed. This information is needed to determine if these parts still maintain their containment, shielding, and criticality functions.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

Footnote "a" of Table 3.15 will be revised as follows:

> [a] In accordance with *Kaolite SuperLightweight Insulating Castables* (Appendix 2.10.3), the recommended use limit temperature for Kaolite 1600 material is 871°C (1600°F). This temperature is the established limit for material in immediate contact with the Kaolite 1600 material and is based on continuous service.

Section 3.3.3 will be revised as follows:

> Tables 3.16 and 3.17 summarize the results of thermal analysis and testing in accordance with NCT and HAC regulatory requirements. Margins of safety have not been calculated. However, the predicted or calculated results of individual components are compared with their allowable continuous service limit for NCT in Table 3.16 and for HAC in Table 3.17. For all components, the values calculated during NCT (Table 3.16) do not approach their allowable limits stated in Table 3.15. The temperature values predicted or calculated for the Kaolite 1600 material, the top plug stainless steel, the silicon bronze nuts, and the Cat 277-4 neutron poison do approach and/or exceed their allowable continuous service limits during HAC thermal testing. However, short-term excursions above these allowable limits as shown in ORNL/NTRC-013/V1

do not reduce the ability of the packaging components to provide their safety functions during HAC. Justification of this statement is provided by the following information:

1. As discussed in Sect. 3.5.2, the thermal tests were conducted in compliance with ASTM E 2230-02 and SG 140.1 using the steady state environmental method to comply with 10 CFR 71.73(c)(4). In order to maintain a 800 °C thermal environment at all locations inside the furnace and on all external surfaces of the shipping package, the set point of the furnace had to be adjusted upward to 871 °C (1600 °F). A direct result of this action was that some of the external thermocouples on the package surface exceeded 871 °C (1600 °F) for short periods of time during the timed thermal test.

2. In accordance with National Bronze & Metals, Inc., the silicon bronze nuts remain solid or crystalline in nature up to a temperature of 1032 °C (1890 °F). Their only safety function during and following the thermal test is to keep the lid attached to the drum assembly. By remaining solid during and following HAC testing, the silicon bronze nuts performed their safety function. All lids remained attached to the drum assembly following HAC thermal testing.

3. In accordance with ASM Aerospace Specification Metals Inc., Type 304/304L stainless steel has a continuous service temperature of 927 °C (1700 °F). During the thermal test, the safety function of the stainless steel in the top plug is to encapsulate the Kaolite 1600 insulating material. As shown in ORNL/NTRC-013/V1, the external temperature does intermittently exceed the continuous service limit of the Kaolite 1600 material. However, these short-term temperature excursions do not diminish the ability of the stainless steel to maintain the boundary around the insulating material. The solidus temperature for stainless steel is ~1399 °C (2550 °F); therefore, there is a significant thermal margin of safety in the stainless steel. All top plugs were intact following HAC thermal testing.

4. As documented in Appendix 2.10.3, the recommended use limit temperature for Kaolite 1600 is 871 °C (1600 °F) and the melting point is 1260 °C (2300 °F). This use limit temperature is also the established limit for material in immediate contact with the Kaolite 1600 material and is based on continuous service at this temperature. As previously stated, the external temperature does intermittently exceed the continuous service limit of the Kaolite 1600 material during the thermal test, but it remains well below its melting point. The safety function of the Kaolite 1600 material is to keep the containment vessel as cool as possible and to meet the leaktight criteria established in ANSI N14.5-1997. Based on temperature and pressure calculations, the containment vessel maintains containment during and after thermal testing to the above criteria. Therefore, short-term temperature excursions above 871 °C do not diminish the ability of the Kaolite 1600 material to perform its safety function.

5. By using the appropriate temperature adjustments shown in Table 3.20, the maximum recorded HAC temperature shown in Table 3.9, and the data for Node 4740 in Fig. 21 of Appendix 3.6.2, the 277-4 material reaches its peak temperature (~320 °F) ~2 h following the thermal test. Figure 21 in Appendix 3.6.2 also shows that this peak temperature drops ~15 °F ~4 h after furnace removal and continuously drops thereafter. The maximum temperature in the 277-4 material occurs at the top of neutron absorber cavity (Node 4740 in the analytical models). As shown in Tables 3.7 and 3.8, the temperature in other regions of the 277-4 (e.g., Nodes 351 and 3888) is well below this maximum temperature for the entire length of time associated with the thermal test and cool-down period. For HAC

criticality safety analysis, the entire mass of the 277-4 material is conservatively assumed to have the properties resulting from exposure to 320°F for 4 h.

Based on these results, the ES-3100 components will perform their safety functions during both NCT and HAC.

3-5 Discuss the length of time that the Cat 277-4 is at 320°F (Table 3.17) during the HAC; confirm that it is less than four hours.

Table 3.15 (page 3-23) states that Cat 277-4 has an allowable temperature range between -40°F and 302°F. The maximum temperature of Cat 277-4 experienced under HAC is listed as 320°F (Table 3.17), which is the (short term, per Table 3.15) allowable limit (Table 3.17). The degradation that occurs and the effect on package performance, including containment, criticality, and shielding, should be discussed. This is necessary because according to page 5 of the RSI response, the 320°F allowable limit is valid for four hours and (uncorrected) Cat 277-4 temperatures reach high temperatures (approximately 225 - 265°F) for greater than four hours (pages 3-117, 118). There should be a discussion on the time period that the CAT 277-4 exists at 320°F during the HAC and explicitly stated in the Table.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

See the response to RAI 3-4.

3-6 Clarify the allowable temperature of the Viton O-ring and the temperature of the Viton O-ring during HAC.

a) Page 5 of the RSI response (footer date of 7-22-10), Table 3.17 and Table 3.16 lists the maximum Viton O-ring temperature as 400°F. However, Table 3.15 lists the allowable temperature as 302°F. Confirm the allowable temperature of the Viton O-ring. It is important to consider that the O-ring will have a different allowable temperature limit than the VCO metal fitting.

b) Page 4 of RSI response (Table 3.17, footer date of 7-22-10) lists the maximum Viton O-ring temperature under HAC as 306°F, which is greater than the 302°F maximum allowable temperature listed in Table 3.15. The text on page 5 states that the maximum ethylene propylene O-ring temperature is 286°F. The maximum corrected temperature of the Viton O-ring should be clarified.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

Tables 3.16 and 3.17 list the Viton O-ring and brass material temperature limit as 400°F based on the continuous service temperature listed in the *Parker O-ring Handbook* for a fluoroelastomer material. Table 3.15 for this same O-ring material also lists the temperature limit as 400°F. This particular Viton O-ring is the one that is assembled with the modified VCO fitting covering the preshipment leakage check port. This modified VCO fitting and Viton O-ring are not considered part of the containment boundary. The sole purpose of this item is to keep debris out of the leak check port. However, it is still shown to not exceed its continuous service temperature during NCT and HAC.

3-7 Provide the uncertainty (°F) of the temperature indicator patches.

The uncertainty (°F) of the temperature indicator patches used to determine component temperatures at the hypothetical accident condition should be provided. In addition, confirm whether the temperature indication is conservative (i.e., are the temperatures indicated/measured always higher than actual?).

This information is needed to determine compliance with 10 CFR 71.73.

The fourth paragraph in Sect. 3.5.3 defines the temperature indicator patch adjustment as 6.11 °C (11 °F). This adjustment is always positive to provide a degree of conservatism. In Table 3.19, several different temperature ranges are shown for each type. For example, a Type "B" temperature indicator patch covers a range from 77–127 °C (171–261 °F) in 6.11 °C (11 °F) increments. Therefore, if the patch adjacent to the 77 °C blacks out during the thermal test, this temperature is recorded as indicated (or blacked out); however, the final temperature is adjusted upward by 6.11 °C (11 °F).

3-8 Clarify whether the vapor pressure of melted uranyl nitrate crystals was considered in the package pressure calculations.

The maximum temperature of the containment vessel under HAC is given as 141.22 °C (page 3-31). A potential content of the package is uranyl nitrate (page 1-13), which has approximate melting and boiling points of 60 °C and 118 °C, respectively. Is the <u>vapor pressure</u> of melted crystals significant, and if so, was it taken into account in the package pressure calculations during HAC?

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

The vapor pressure of the melted uranyl nitrate crystals will be considered in the package pressure calculations for both NCT and HAC. The maximum NCT containment vessel pressure increases from 138.43 to 198.98 kPa (20.077 to 28.859 psia). The maximum HAC containment vessel pressure increases from 280.62 to 595.99 kPa (40.701 to 86.441 psia). These values and other calculations based on these pressures will be revised throughout the SAR as shown below:

The fourth sentence in the "Compliance" paragraph under "10 CFR 71.43(c)" in Sect. 2.1.2.1 will be revised as follows:

> The internal design pressure exceeds the maximum differential pressure of 173.98 kPa (25.233 psi) and 494.64 kPa (71.741 psi) attained during NCT (Sect. 2.6.2) and HAC (Sect. 3.5.3), respectively.

The seventh and eighth sentences of the fifth paragraph in Sect. 2.1.2.2 will be revised as follows:

> The maximum normal operating pressure calculated for NCT in accordance with 10 CFR 71.4 and 10 CFR 71.71(c)(1) for the bounding load case is 198.98 kPa (28.859 psia). The maximum internal gauge pressure calculated for NCT is 173.98 kPa (25.233 psi), which is the maximum normal operating pressure minus the reduced external pressure condition of 10 CFR 71.71(c)(3) [198.98 - 25.00 kPa (28.859 - 3.626 psia)] (Sect. 2.6.3).

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The fourth sentence in the first paragraph of Sect. 2.6 will be revised as follows:

> The maximum regulatory reference air leakage rate is $\leq 2.2976 \times 10^{-3}$ ref-cm^3/s.

The fourth sentence in the third paragraph of Sect. 2.6 will be revised as follows:

> As noted in these sections, the internal pressure is calculated to be 198.98 kPa (28.859 psia).

The sixth sentence in the third paragraph of Sect. 2.6 will be revised as follows:

> Thus, increasing the internal pressure of the containment vessel to a maximum of 198.98 kPa (28.859 psia) during NCT would have no detrimental effect.

The ninth sentence in the fourth paragraph of Sect. 2.6 will be revised as follows:

> The internal absolute pressure at an average gas temperature of 87.81 °C (190.06 °F) is 198.98 kPa (28.859 psi) for the ES-3100 containment vessel (Table 2.20).

The eleventh sentence in the fourth paragraph of Sect. 2.6 will be revised as follows:

> Therefore, the maximum cyclic pressure differential for the containment vessel from low to high temperatures is (198.98 − 76.74) kPa or 122.24 kPa (17.729 psi).

The last row in Table 2.20 will be revised as follows:

Average gas evaluation temperature °C (°F)	Containment vessel absolute internal pressure kPa (psia)
87.81 (190.06) [c]	198.98 (28.859)

The fifth sentence in the second paragraph of the "Analysis" section of Sect. 2.6.1 will be revised as follows:

> The maximum calculated internal absolute pressure in the containment vessel with solar insolation and using the bounding case parameters is 198.98 kPa (28.859 psia).

The seventh sentence in the second paragraph of the "Analysis" section of Sect. 2.6.1 will be revised as follows:

> Thus, increasing the internal pressure of the containment vessel to a maximum of 198.98 kPa (28.859 psia) during NCT would have no detrimental effect.

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The second column of Table 2.21 will be revised as follows:

Hot conditions [10 CFR 71.71(c)(1)] containment boundary stress @ 97.62 kPa 14.159 psi) gauge	
kPa (psi) or kg (lb)	**M.S.**
9.618×10^2 (139.5)	137
5.031×10^4 (7,297)	8.1
1.899×10^4 (2,754.4)	12.9
2.788×10^3 (404.4)	30.7
1.056×10^4 (1,532)	24.1
7.152×10^3 (1,037.3)	36.0
1.067×10^3 (2,351.7)	18.2
2.954×10^4 (4,284.9)	8
6.733×10^3 (976.5)	18.7
2.351×10^3 (1,066.7)	32.2

The second sentence in the first paragraph of the "Analysis" section of Sect. 2.6.3 will be revised as follows:

> This reduced pressure and a maximum internal pressure produces the maximum pressure differential across the containment boundary of 173.98 kPa (25.233 psi) [198.98 - 25 (28.859 - 3.626)].

The second column of Table 2.22 will be revised as follows:

Reduced external pressure [10 CFR 71.71(c)(3)] containment boundary stress @ 173.98 kPa (25.233 psi) gauge kPa (psi)	
kPa (psi) or kg (lb)	**M.S.**
1.714×10^3 (248.6)	76.2
5.526×10^4 (8,014.1)	7.3
2.019×10^4 (2,928.9)	12.1
4.969×10^3 (720.7)	16.8
1.321×10^4 (1,915.5)	19.0
1.275×10^4 (1,848.6)	19.8
1.192×10^3 (2,626.7)	16.2
3.348×10^4 (4,856)	6.9
1.200×10^4 (1,740.2)	10
1.192×10^3 (2,626.7)	28.8

The third sentence in the fifth paragraph of Sect. 2.7 will be revised as follows:

> The maximum normal absolute operating pressure due to insolation and the bounding case parameters is 198.98 kPa (28.859 psia) for the containment vessel.

The first sentence in the last paragraph of Sect. 2.7.4.1 will be revised as follows:

> The maximum HAC internal absolute pressure in the containment boundary of the ES-3100 has been calculated to be 595.99 kPa (86.441 psia).

The second column of Table 2.51 will be revised as follows:

Thermal condition 10 CFR 71.73 (c)(4) containment boundary stress @494.64 kPa (71.741 psi) gauge & 123.85°C (254.93°F) kPa (psi)	
kPa (psi)	**M.S.**
4.873×10^3 (706.8)	26.2
7.603×10^4 (11,027)	5.0
2.525×10^4 (3,661.8)	9.5
1.413×10^4 (2,049)	5.2
2.431×10^4 (3,526.5)	9.9
3.624×10^4 (5,255.8)	6.3
1.715×10^3 (3,781.9)	11
5.002×10^4 (7,254.7)	4.3
3.411×10^4 (4,947.7)	2.9
1.715×10^3 (3,781.9)	19.7

The last row of Table 3.10 will be revised as follows:

CVA	n_a [b] (lb-mole)	n_v [b] (lb-mole)	n_{po} [b] (lb-mole)	n_{bo} [b] (lb-mole)	n_{tf} [b] (lb-mole)	n_{H2} [b] (lb-mole)	n_{O2} [b] (lb-mole)	n_T [b] (lb-mole)	P_T (psia)
7	4.5793E-04	2.4829E-04	0.0000E+00	0.0000E+00	2.2296E-05	2.5558E-05	1.2779E-05	7.6685E-04	28.859

The last sentence in the last paragraph of Sect. 3.1.4.1 will be revised as follows:

> This appendix also includes the hydrogen gas generation predicted by Appendix 3.6.7.

The body and footnote "b" of Table 3.11 will be revised as follows:

CVA	n_{MNOP} [b] (lb-mole)	n_{po} [b] (lb-mole)	n_{bo} [b] (lb-mole)	n_{tf} [b] (lb-mole)	n_{r-H2} (lb-mole)	n_{r-O2} (lb-mole)	n_{wv} [b] (lb-mole)	n_T [b] (lb-mole)	P_T (psia)
2	7.7228E-04	1.7302E-05	3.1529E-04	0.0000E+00	3.1895E-05	1.5948E-05	0.0000E+00	1.1527E-03	38.236
7	9.2831E-04	0.0000E+00	3.1529E-04	2.2296E-05	2.5558E-05	1.2779E-05	7.8428E-04	2.0885E-03	86.441

[b] n_{MNOP} –molar quantity of the gas mixture at maximum normal operating pressure at standard temperature [25°C (77°F)];
n_{po} –molar quantity of gas due to offgassing of the silicone rubber pads;
n_{bo} –molar quantity of gas due to offgassing of the polyethylene bags, bottles, and lifting sling;
n_{tf} –molar quantity of gas due to offgassing of the Teflon bottles;
n_{r-H2} –molar quantity of hydrogen gas due to radiolysis of water;
n_{r-O2} –molar quantity of oxygen gas due to radiolysis of water;
n_{wv} –molar quantity of water vapor due to efflorescence of UNX crystals; and
n_T –total molar quantity in the gas mixture.

The heading for the third column of Table 3.15 will be revised as follows:

> Allowable pressure range
> kPa (psi) gauge

The maximum containment vessel pressure shown in the "Calculated results" column in Table 3.16 will be revised from "137.92 (20.004)" to "198.98 (28.859)."

The maximum containment vessel pressure shown in the "Calculated results" column in Table 3.17 will be revised from "280.63 (40.701)" to "595.99 (86.441)."

The first sentence in the second paragraph of Sect. 3.4.1 will be revised as follows:

> Using the temperatures calculated for the conditions of 10 CFR 71.71(c)(1), Appendix 3.6.4 predicts that the maximum normal operating pressure inside the containment vessel will be 198.98 kPa (28.859 psia).

The third sentence in the second paragraph of Sect. 3.4.1 will be revised as follows:

> Thus, increasing the internal pressure of the containment vessel to a maximum of 198.98 kPa (28.859 psia) during NCT would have no detrimental effect.

The fourth sentence in the second paragraph of Sect. 3.4.2 will be revised as follows:

> The maximum calculated internal absolute pressure in the containment vessel with solar insolation and the bounding case parameters is 198.98 kPa (28.859 psia).

The third-to-last paragraph in Sect. 3.5.3 will be revised as follows:

> As shown in Appendix 3.6.5, the maximum adjusted average gas temperature and pressure in the containment vessel during accident conditions was calculated to be 123.85°C (254.93°F) and 595.99 kPa (86.441 psia), respectively.

Appendices 3.6.4 and 3.6.5 will be revised as shown in the attached SAR page changes.

The fourth and fifth sentences in the fifth paragraph of Sect. 4.3 will be revised as follows:

> As calculated in Appendix 3.6.4, the bounding case MNOP is 198.98 kPa (28.859 psia). The stresses at the maximum normal operating pressure [97.63 kPa (14.159 psig)] are insignificant compared to the allowable stresses (Table 2.21).

The leak rates in Table 4.5 will be revised as follows:

Verification activity	Fast absorption		Medium absorption		Slow absorption	
	L_{RN-air} (ref-cm^3/s)	L_{RN-He} (cm^3/s)	L_{RN-air} (ref-cm^3/s)	L_{RN-He} (cm^3/s)	L_{RN-air} (ref-cm^3/s)	L_{RN-He} (cm^3/s)
Design	2.6892E-03	2.9222E-03	2.5775E-03	2.8048E-03	2.2976E-03	2.5098E-03

The leak rates in Table 4.7 will be revised as follows:

Verification activity	Fast absorption		Medium absorption		Slow absorption	
	L_{RA-air} (ref-cm^3/s)	**L_{RA-He} (cm^3/s)**	**L_{RA-air} (ref-cm^3/s)**	**L_{RA-He} (cm^3/s)**	**L_{RA-air} (ref-cm^3/s)**	**L_{RA-He} (cm^3/s)**
Design	5.6523	5.4158	5.4161	5.1909	4.8245	4.6273

Appendix 4.6.2 will be revised as shown in the attached SAR page changes.

3-9 Clarify the source of the "flaming or smoking" event during the furnace testing.

Page 3-34 discusses that the package was "flaming or smoking" after the furnace test. It is stated on page 1-6 that Kaolite 1600 does not undergo chemical decomposition at temperatures below 1260°C (2300°F). Therefore, discuss what was burning as a result of the furnace testing and was it a component important to safety?

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

The source of the flaming or smoking during the furnace testing was attributed to the top plug pad deterioration and not the Kaolite 1600 insulation material. A visual observation of this pad deterioration is shown in Figs. 5.4–5.10 of ORNL/NTRC-013/V1 (Appendix 2.10.7). This smoking or burning is not detrimental to the ability of the package to survive HAC testing.

3-10 Confirm the maximum pressure of the containment vessel under HAC.

Table 3.17 states that the maximum containment vessel pressure during HAC is 40.701 psia. Page 3-17 (footer date of 2-26-2009) lists 42.288 psia. Page 3-161 lists 40.701 psia (footer date of 2-26-2009). Clarify the maximum containment vessel pressure for the HAC.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

The maximum pressure of the containment vessel under HAC has been revised as discussed in the response to RAI 3-8 and is now consistent.

3-11 Discuss the comparisons between the furnace test and finite element temperature results.

Page 3-36 mentions that MSC.Patran / ABAQUS finite element models were used to determine adjustments to the component temperatures measured during the HAC test. A brief discussion that compares the HAC experimental temperatures and the PATRAN and ABAQUS modeling results should be provided to confirm the appropriateness of the finite element model.

This information is needed to determine compliance with 10 CFR 71.41 and 71.73.

The finite element model and the test units are not comparable because the test units are damaged and the finite element model represents the package as fabricated. Therefore, only the variables not addressed during actual thermal testing are derived from results predicted by the finite element model. Considerable time and money would be required to make the finite element model represent a damaged test unit. Additional time and money would also be needed to determine thermal properties of the package materials resulting from structural deformation and higher temperature extremes.

3-12 Confirm that thermal adjustment five is conservative, considering the potential differences in the crush/impact effects of using BoroBond4 and Cat 277-4 shielding material.

The 10 CFR 71.73 tests (including thermal) were performed with packaging made with BoroBond4 shielding material. Page 3-37 states that thermal adjustments were made to account for the use of Cat 277-4 shielding material (thermal adjustment seven) and the changes in the packaging geometry during crush/impact tests, etc. (thermal adjustment five). Would using Cat 277-4 as the shielding material during the impact tests, etc., have caused significantly different packaging geometry changes and, therefore, a significantly greater temperature adjustment (thermal adjustment five)?

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

No significant change in the temperature is anticipated due to changing the neutron poison. Based on the results shown in Sect. 2.7.8, the LS-DYNA-3D simulations compared very well between actual test units and the analytical models with a different neutron poison material. Therefore, with the structural deformation similar, the fifth adjustment would be comparable among them.

3-13 Confirm the use of the G value in the radiolysis calculations.

The HAC analysis on page 3-160 indicates a 0.25 G value in the third equation, which is based on testing at 200°F (NCT analysis, per page 3-152) whereas the 0.8 and 7.0 G values in the first and second equation are based on 286°F testing. In order to be conservative, the 0.25 G value in the third equation should also be based on the higher temperature to reflect the HAC conditions.

This information is needed to determine compliance with 10 CFR 71.73.

Appendices 3.6.4 and 3.6.5 containing the value of 0.25 cm^3/g at standard temperature and pressure have been revised as shown in the attached SAR page changes. The value of 0.25 cm^3/g is the offgassing value for Teflon. Samples of Teflon were tested and recorded as shown on Fig. 10 in Y/DZ-2720 (Appendix 2.10.9). The value shown in this report was recorded as ~0.125 cm^3/g over the temperature range seen during both NCT and HAC. For conservatism, this value was doubled when used in Appendices 3.6.4 and 3.6.5.

3-14 Clarify the radiolysis of water effect on pressure calculations.

Page 3-154 took into account the radiolysis of water when determining the NCT pressure. However, it does not appear on page 3-161 that radiolysis of water was taken into account for the HAC pressure. This should be clarified.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

See the response to RAI 3-8.

3-15 Provide a reference (or basis) for the 0.2 mol % hydrogen concentration due to permeation and diffusion.

Page 3-165 states that the steady-state concentration of hydrogen can be 0.2 mol%. A reference or basis for this value should be provided.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

The basis for the 0.2 mol % hydrogen concentration due to permeation and diffusion is the calculations presented in Sect. 3.6.7.9, "Initial H_2 concentration," of Appendix 3.6.7.

3-16 Provide a reference (or basis) for assuming a temperature difference of 9°F between the gaps within the package.

Page 3-96 states that calculations assumed a temperature difference of 9°F between gaps. The basis or reference for this assumption should be provided.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

The actual temperature differences across the air gaps in the ES-3100 package are calculated by the thermal analysis code. The 9°F temperature difference mentioned on p. 3-96 (Appendix 3.6.2) of the SAR was only used in a scoping calculation to demonstrate that the heat transfer due to natural convection across a small air gap in a shipping package is insignificant compared to the radiant heat transfer across the small gap. The 9°F temperature difference across the gap used in the scoping calculation represents a typical temperature differential predicted across a gap in a similar Y-12 shipping package. However, as previously stated, this 9°F temperature difference is not used in the ES-3100 thermal models (the actual temperature differences across the gaps are calculated assuming radiant heat transfer across the gaps).

RESPONSES TO RAI-ES-3100-REVISION 10

Chapter 7 Operating Procedures Review

7-1 Clarify the time period between closing a container and closing the containment vessel.

Page 3-165 states it is not necessary to vent containers before loading them into the ES-3100. This may be reasonable only if the time between closing a container and loading it into the ES-3100 is a short period. For example, closing a container and leaving it closed for a long time period before putting it in the containment vessel would mean that the amount of generated gas within the vessel is greater than that analyzed in the SAR. a) What is the time between closing the container, placing it in the containment vessel, and then closing the containment vessel? b) Where in Chapter 7 does it indicate that there is a time limit associated with closing the container and it being placed within the ES-3100?

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

a) Consistent with the analyses presented in Appendix 3.6.7 and the response to RAI 3-15, the calculated steady-state concentration of hydrogen in a closed convenience container is <0.2 mol %. Consequently, there is no time limit between closing the convenience container, placing it in the containment vessel, and closing the containment vessel.

b) Since Chapter 7 does not impose any time limitations or venting requirements for closed convenience containers, the steady-state hydrogen concentration in the containers was included in the Appendix 3.6.7 analyses to determine the time to reach 5 mol % of hydrogen in the containment vessel.

7-2 Clarify the operation of the nylon plugs in Chapter 7 of the SAR.

Page 1-5 and Page 3-30 indicates there are nylon plugs that prevent the pressurization of the package "... in the event of a thermal accident." Considering their importance, the plugs should be mentioned explicitly and the task of checking them should be included in Chapter 7.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

As noted in Sects. 1.2.1.1 and 3.4.2, the vent holes relieve pressure in the event of a thermal accident, and the nylon plugs, which are installed in the vent holes, provide a moisture barrier for the cast refractory insulation during NCT and storage. Although the vent hole plugs are mentioned in Step 3 of Sect. 7.1.3.2 in the context of material compatibility concerns with decontamination solutions, the following revisions will be made to Chapter 7 to clarify the drum body and top plug vent hole inspection requirements. While considering these revisions to Chapter 7, the following additional revisions will be incorporated: (1) the lifting hardware for the top plug will be revised from "eye bolts" to "site-approved lifting hardware" to allow for acceptable alternative hardware such as hoist rings and (2) the requirement to check the cleaning solution for contamination in Sect. 7.1.3.2 will be deleted.

Table 7.1 will be revised to include the following row entry for aluminum tape:

Part	Description	Material	Specification/ Drawing[a]
Aluminum tape	Duct tape, low temperature (−40 to +250°F), 2-in. wide, McMaster Carr Part No. 7616A21 or equivalent	Aluminum foil	M2E801580A002

Steps 3–9 of Sect. 7.1.2.2 will be replaced with the following, and the subsequent steps will be renumbered accordingly:

3. The aluminum foil tape applied over the neutron-absorbing material cavity fill and vent holes (four places) located on the drum liner lower shelf (Drawing M2E801580A002, Appendix 1.4.8) is visually inspected for damage such as tears, holes, or loose edges.

4. The loaded CV is lifted using the swivel hoist ring and site-approved lifting equipment.

5. The CV is positioned in the drum (Drawing M2E801580A001, Appendix 1.4.8), and the swivel hoist ring is removed.

6. The CV flange pad is placed on top of the containment vessel, and the plug pad is placed on the inner liner shelf.

7. The nylon plug is installed in the top plug vent hole, and site-approved lifting hardware is attached to the top plug threaded lifting holes.

8. The top plug is installed in the drum (Drawing M2E801580A001, Appendix 1.4.8), and the lifting hardware is removed.

9. The drum lid, the drum washers, and bronze drum nuts are installed.

10. The nuts are tightened to 40.67 ± 6.78 N·m (30 ± 5 ft-lb) of torque with no sequence specified. No impact wrench shall be used.

11. A nylon plug is installed in each of the four drum vent holes.

Step 3 of Sect. 7.1.3.2 will be revised as follows:

3. The drum vent holes are covered with nylon plugs (Drawing M2E801580A002, Appendix 1.4.8).

Step 5 of Sect. 7.1.3.2 will be deleted.

Step 8 of Sect. 7.2.2 will be revised as follows:

8. Site-approved lifting hardware is attached to the top plug threaded lifting holes, and the top plug is removed.

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Chapter 8 Acceptance Tests and Maintenance Program Review

8-1 Discuss how one will ensure that the condition of Kaolite is acceptable over the life of the package.

Cracks exist within the Kaolite insulation following casting and vibration testing (page 3-28). This indicates that cracking of Kaolite can occur over the life of the package (vibrations due to shipment, etc.). Recognizing that Kaolite provides the thermal barrier under hypothetical accident conditions, fractured Kaolite could allow continuous void spaces that provide pathways for the fire to the interior of the package where lower allowable temperature limited components reside. There should be a maintenance procedure to confirm the condition of Kaolite is acceptable.

This information is needed to determine compliance with 10 CFR 71.43 and 71.73.

In 1997, a Model ES-2M package test unit (with Kaolite insulation) was vibration tested for 42 h at Wyle Laboratories in Huntsville, Alabama. This ES-2M test unit was radiographed before and after the vibration testing, and the post vibration test radiographs showed that cracks existed in the Kaolite insulation. To determine the effects on the ES-2M package due to Kaolite cracking, the test unit was subjected to subsequent HAC testing (30-ft drop, puncture, and thermal tests). When this vibrated test unit was compared to other ES-2M test units that were not vibration tested, no significant difference was observed between the test units following HAC testing. This testing, which is referenced in Sects. 2 and 3 of the ES-3100 SAR, is documented in GAB1296-2, *Vibration Test Report of the ES-2M Shipping Package*, and summarized in Y/LF 565, *Advantages of Using a Fireproof Inorganic Cast Refractory Material in Hazardous Content Shipping Packages* which is included in Appendix 2.10.3 of the SAR.

A series of test units with Kaolite insulation (Models MD-2, DPP-2, ES-2100, ES-3100, and ES-4100) functioned well during their regimen of 10 CFR 71 compliance testing and have been certified as Type B(U) fissile material packages. Under routine handling and transportation conditions, the ES-2M vibration testing would reasonably characterize the bounding condition for NCT. Compliance tests of Kaolite-insulated packages have demonstrated that the insulation will not be degraded to any extent that would impair package performance.

The top plug and drum assembly of the ES-3100 are inspected for damage (Sects. 7.1, 7.2, and 8.2.5.3). Also, their weights are monitored during periodic maintenance (Sects. 8.2.3 and 8.2.5.6) to ensure that there has been no significant weight change (i.e., loss of material) from the as-manufactured baseline.

In addition to the documents included in Appendix 2.10.3 of the SAR, the following supplemental documents support the conclusion that Kaolite cracking does not adversely impair the operational capabilities of the package to withstand accident conditions:

Report No. 45918-01, *Vibration Testing of an ES-2 Shipping Container*, Wyle Laboratories, Feb. 21, 1997.

GAB1296-2, *Vibration Test Report of the ES-2M Shipping Package*, G. A. Byington, Lockheed Martin Energy Systems, Inc., Oak Ridge Y-12 Plant, Sept. 3, 1997.
PATENT CONFIDENTIAL INFORMATION.

U.S. Patent 6,299,950 B1, G. A. Byington et., al., *Fireproof Impact Limiter Aggregate Packaging Inside Shipping Containers*, Oct. 9, 2001.

ORNL/NTRC 005, rev. 0, *Test Report of the ES-2100 Package*, L. B. Shappert et.al., UT-Battelle, Oak Ridge Natl. Lab., Natl. Transportation Research Center, June 25, 2003.

A CD containing the documents listed above (as well as PowerPoint presentations and photographs showing various details of vibration testing, weld damage following testing, and radiographs of the Model ES-2M, ES-2100, DPP-2, and MD-1 packages) is being submitted with this response document. In addition, video showing the vibration casting process, real-time radiography before and after testing, and HAC testing of the ES-2M package is being submitted on a separate DVD.

No SAR changes are recommended.

RESPONSES TO RAI-ES-3100-REVISION 10

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