Department of Energy
National Nuclear Security Administration
P.O. Box 5400
Albuquerque, NM 87185

June 9, 2017

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Dear Sir:

This letter is in regard to Docket No. 71-9370, CAC No. L25109. The purpose of this letter is to submit the National Nuclear Security Administration's (NNSA) response to the Nuclear Regulatory Commission's (NRC) Request for Additional Information for the Model 380-B Transport Package. The NRC's request was contained in the NRC letter from Norma Garcia-Santos to Ahmad M. Al-Daouk, subject: *Request for Additional Information for Review of the Certificate of Compliance No. 9370, for the Model 380-B Packaging (CAC No. L25109)*, dated March 16, 2017. NNSA's responses are included in the enclosures.

Questions regarding this application may be addressed to Chad E. Thompson at 505-845-4114.

Sincerely,

A.M. Al-Daouk

Ahmad M. Al-Daouk
NNSA Certifying Official
Deputy Associate Administrator for Enterprise Stewardship

Enclosures:
1. *NNSA Responses to NRC Request for Additional Information, Docket No. 71-9370, Certificate of Compliance No. 9370, Model No. 380-B* – 1 hard copy
2. *380-B Transport Package Safety Analysis Report*, Revision 1 – 1 hard copy
3. 380-B SAR Rev. 0 to Rev. 1 Roadmap – 1 hard copy

cc w/o enclosures:
N. Garcia-Santos, NRC NMSS/DSFM/SFLB MS:4 B34
R. Murphy, NA-LA
T. Taplin, NA-212
C. Thompson, NA-531
K. Schwendenman, NA-531

NMSS01

NNSA Responses to NRC Request for Additional Information

Docket No. 71-9370
Certificate of Compliance No. 9370
Model No. 380-B

By letter dated March 16, 2017, NRC provided the applicant with a request for additional information (RAI) concerning the 380-B package, docket no. 71-9370, based on an application dated April 6, 2016, and as supplemented on October 13 and October 20, 2016. Following are the NRC requests and the responses of the applicant. A revised SAR, Revision 1, has also been provided.

Containment Evaluation

RAI-Co-1 Provide the following information related to gas generation due to radiolysis as described in items (a), (b), and (c) below.

a. explain how the energy depositions of 98.456, 346.826, and 745.697 megaelectron volts per gram per second (MeV/g per s), as shown in Table 5-6 of Section 5.5.4, "Gas Generation due to Radiolysis," of the application, for small, medium, and large devices, respectively, within the Model No. 380-B, are determined using the MCNP model.

b. derived the gas volume per average gas temperature, at room temperature, for the Model No. 380-B.

The applicant derived the gas volume by multiplying moles of gas byd 22.4 liters/mole (L/mol). The gas volume of 22.4 L/mol is based on standard atmospheric conditions (1 atm and a room temperature of 25°C). The multiplication of gas mole and 22.4 L/mol may be not accurate under a higher gas temperature (> 25°C) within the Model No. 380-B cavity.

c. explain how the total void volume of the Model No. 380-B corresponding to0.057 L, 0.20 L, 0.4 L, and 4.6 L are derived/calculated in order to ensure that these parameters will remain below 5% (per volume) of flammable gas, as specified in Section 3.5.4.2, "Maximum Normal Operating Pressure," of NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

The applicant mentioned in Section 5.5.4, "Gas Generation due to Radiolysis," of the application that the total void volume of the Model No. 380-B will typically be much larger than 4.6 L and that the minimum required void volumes (to remain below 5% (per volume) of flammable gas) are 0.057 L, 0.20 L and 0.4 L for small, medium and large devices, respectively, in one year.

The applicant used a G value of 4.5 (flammable gas in wood) and the following formula depicted in Section 5.5.4 of the application (page 5.5.4-2) to calculate total amount of gas generated due to radiolysis:

$$\text{Moles of Gas} = G / 100 \times (E \times 10^6) \times T \times M / A$$

In Table 5-6 of the application, the applicant presented the calculated gas moles and volumes of small, medium, and large devices within the Model No. 380-B.

This information is required to determine compliance with 10 CFR 71.35(a) and 71.43(d).

Co-1 Response:

a) The 6th paragraph on page 5.5.4-2 states "Energy deposition is calculated in MCNP using an F6 tally." To clarify the discussion, this statement has been added as a footnote to Table 5-6. In addition, the MCNP input and output files relating to the energy deposition calculation have been supplied as part of the RAI responses.

   Note: to rectify a typographical error and for consistency with the prior section, Table 5-3, Table 5-4, Table 5-5, and Table 5-6 have been renumbered to Table 5.5-3, Table 5.5-4, Table 5.5-5, and Table 5.5-6, respectively.

b) The analysis assumes a fixed quantity of hydrogen is released by radiolysis into a fixed quantity of air inside the cask. (Depending on the type of preshipment leakage rate test employed, the gas inside the cask may be air or helium). The pressure and temperature of both the hydrogen and the air are necessarily the same. Thus, using the perfect gas law:

$$V_{Hyd} = n_{Hyd}R\left(\frac{T}{p}\right)_{Cask}$$

$$V_{Air} = n_{Air}R\left(\frac{T}{p}\right)_{Cask}$$

$$\frac{V_{Hyd}}{V_{Air}} = \frac{n_{Hyd}}{n_{Air}}$$

   Since the moles of hydrogen and air are fixed, then the volume ratio (i.e., the percent) of hydrogen to air is independent of the temperature or pressure within the cask.

   To clarify this, a sentence has been added to the paragraph at the top of page 5.5.4-3 which reads: "The volume ratio of hydrogen to air is independent of the temperature or pressure inside the cask because the quantities of gas are fixed." In addition, the first use of the word 'void' in Section 5.5.4 has been changed to read: "...void (air)...".

c) The void (air) volume within the 380-B cask is a function of the volume displaced by the payload device and its shoring material. Although this void volume is relatively large, it is not known definitively. However, all of the payload and shoring must fit below the inner cover, which is located just below the closure lid. The space between the inner cover and the closure lid is the minimum void (air) volume. The diameter of this space is 38.25 inches (from drawing 1916-02-02-SAR, Sheet 4, Section E-E) but is conservatively taken as 38.0 inches. The thickness is calculated using the distance between the top of the cask body and the inner cover mounting bracket of 5.13 inches (Sheet 4, Section E-E; this dimension has been revised from 5.1 inches to more accurately show the actual design dimension), the depth of the closure lid engaging the cask opening of 4.38 inches (Sheet 6, Section L-L), and the thickness of the inner cover plate (item 12) of 0.5 inches. The calculated thickness of the air space is 5.13 – 4.38 – 0.50 = 0.25 inches. Thus, the absolute minimum void volume is 283 in^3, or 4.6 L. As described in Section 5.5.4, the maximum amount of hydrogen that could possibly be generated in one year would remain below a concentration of 5% as long as the void volume was at least 0.4 L. Since the actual absolute minimum void volume is at least 4.6 L, there is a large margin of safety on the concentration of flammable gas inside the cask.

RAI-Co-2 Describe how the personel performing leak testing will be qualified per the recommended practices in accordance with the American Society of Non-Destructive Testing and the ANSI.

The applicant mentions a general description of the leak tests per ANSI N14.5, "American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment," (1997) that it would be performing for the Model No. 380-B in the following sections of the application:

1. Section 7.4, "Preshipment Leakage Rate Test,"
2. Section 8.1.4, "Fabrication Leakage Rate Tests," and
3. Section 8.2.2, "Maintenance/Periodic Leakage Rate Tests."

The description provided in the sections of the application mentioned above do not clearly state that the leakage test procedures will be approved by qualified personnel in accordance with the American Society of Non-Destructive Testing Recommended Practice No. SNT-TC-1A.

ANSI N14.5, "American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment," (2014), Appendix A, notes the following:

1. "The application of leak testing technology expertise early in the design process is required……This Standard assumes the application of the leak testing technology expertise of a Leak Testing Engineer — Practitioner or <u>Leak Testing Level III specialist</u> during the design process," and

2. "A <u>leak testing NDT Level III</u> specialist can be of great value in the design of a high reliability, economical leak testing program, selection of methods, equipment, and generation of procedures. Early involvement of

> a leak testing engineer in the design of the package for leak testing can be very useful in producing designs that are suited to economical, reliable leak testing "

The staff issued this recommendation (regarding the use of ANSI N14.5 (2014)) in March 2016 in NRC's Information Notice (IN)-16-04, "ANSI N14.5-2014 Revision and Leakage Rate Testing Considerations."

This information is required to determine compliance with 10 CFR 71.37(b).

Co-2 Response: The application has been revised to change the reference from the 1997 issue of N14.5 to the 2014 issue of the standard. Following the 2014 issue will ensure that personnel of the appropriate level of training to Reference 5 of the standard (*Recommended Practice No. SNT-TC-1A*, American Society for Nondestructive Testing, Inc.) will participate in the development and execution of the specific leakage rate test procedures of the 380-B. This change has been made to the footnote on page 1.1-1, and to the text of Section 1.3.1, Section 2.12.1, Section 4.5.1, Section 7.5.1, and Section 8.3.1.

RAI-Co-3 Explain in detail why the maintenance/periodic leakage rate tests may be performed as an option to the pre-shipment leakage rate test for 380-B package.

The applicant noted Section 4.4.3, "Preshipment Leakage Rate Tests," and Step #22b of Section 7.1.2, "Loading of Contents," that the maintenance/periodic leakage rate tests, described in Section 8.2.2, "Maintenance/Periodic Leakage Rate Tests," of the application may be performed as an option, in lieu of the pre-shipment leakage rate tests.

ANSI N14.5 (2014) indicates the pre-shipment leakage rate testing as follows:

> "Pre-shipment leakage rate testing shall be performed before each shipment, after the contents are loaded, and the containment system is assembled."

The maintenance/periodic leakage rate tests are performed with a (1) leakage rate criteria of 10^{-7} reference-cubic centimeters per second (ref-cm^3/s), (2) no contents loaded in the package, and (3) a 12-month period or after maintenance, repair, or replacement. The preshipment leakage rate test is performed with (1) a leakage rate criteria of 10^{-3} ref-cm^3/sec, (2) contents loaded, and (3) before shipment. Given these discrepencies, the applicant should explain or describe the conditions in detail why the maintenance/periodic leakage rate tests may be performed as an option, in lieu of the pre-shipment leakage rate tests.

This information is required to determine compliance with 10 CFR 71.43(f) and 71.51(a)(1).

Co-3 Response: It is not the intent of the application that preshipment leakage rate testing is optional nor that a prior maintenance/periodic leakage rate test may be used to demonstrate the leakage rate at the time of shipment. At the time of shipment, a preshipment leakage rate test must be performed. If the criteria of Section 7.1.2, step #22(a) are met, the preshipment leakage rate test must follow Section 8.2.2. If the criteria of Section 7.1.2, step #22(b) apply, then the preshipment leakage rate test must be either the test delineated in Section 7.4, or it must be the test delineated in Section 8.2.2. To clarify this, the second paragraph of Section 4.4.3 has been revised to read:

"As an option, the maintenance/periodic leakage rate tests, described in Section 8.2.2, *Maintenance/Periodic Leakage Rate Tests*, may be performed at the time of shipment instead of the tests described in Section 7.4, *Preshipment Leakage Rate Test*."

In addition, Section 7.1.2, step #22(a) and step #22(b) have been revised as follows:

a. "If the containment (inner) O-ring seal has been replaced or the corresponding sealing surface repaired, or if the vent port plug or sealing washer has been replaced or the mating sealing surface repaired, the preshipment leakage rate tests shall be performed according to Section 8.2.2, *Maintenance/Periodic Leakage Rate Tests*.

b. If the criteria of step (a) above do not apply, preshipment leakage rate testing shall be performed either according to Section 7.4, *Preshipment Leakage Rate Test*, or according to Section 8.2.2, *Maintenance/Periodic Leakage Rate Tests*."

Materials Evaluation

RAI-M-1 Provide the tolerances for the package dimensions. Also, as part of your response:

a. explain how dimensional tolerances are considered in the structural and thermal evaluations, and
b. revise the drawings with tolerances related to the package dimensions and incorporate these changes into the application.

Staff's guidance in NUREG-5502, "Engineering Drawings for 10 CFR Part 71 Package Approvals," Section 3.2, "General Arrangement of Packaging and Contents," mentions that all dimensions indicated on drawings should include tolerances that are consistent with the package evaluation. Based on the information reviewed by the staff, it is not clear how the applicant considered the dimensional tolerances in the package evaluation and how the tolerances used in the evaluation were incorporated into the drawings.

The applicant did not include tolerances for some of the package components depicted in the drawings submitted in the application. The applicant included tolerances for the seal grooves in Detail M of drawing No. 1916-02-02-SAR, "LANS 380-B Package Assembly SAR Drawing," Sheet 6 of 6. Nevertheless, the applicant did not include tolerances for the following components:

1. the Lid Assembly (drawing No. 1916-02-02-SAR, Sheet 6 of 6),
2. the Inner Cover Assembly (drawing No. 1916-02-02-SAR, Sheet 5 of 6), or
3. the Cask Body Assembly (drawing No. 1916-02-02-SAR, Sheet 4 of 6).

Also, the applicant notes in Section 2.3.1, "Fabrication," of the application that the containment shell fabrication complies with the tolerances of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code (ASME B&PV Code or ASME Code), Section NE, Article NE-4220. It is not clear if the allowable tolerances in ASME B&PV Code, Section NE, Article NE-4220, are sufficient to avoid inadequate clearances between the inner cover and the cask body, and the lid assembly and the cask body. In addition, the requirements in ASME B&PV Code, Section NE, Article NE-4220, do not address design requirements for shielding. The applicant should revise the application to ensure that the applicable standards are used for the design of the Model No. 380-B.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-1 Response: The drawings supplied in Chapter 1 of the application include tolerances by means of a tolerance block at the bottom right corner of the first sheet of each drawing. All dimensions are subject to a tolerance based on the required accuracy of the dimension, and are determined by the number of decimal digits shown in the dimension. In some cases, these tolerances are overridden by explicit tolerances, such as for the containment O-ring groove dimensions shown on drawing 1916-02-02-SAR, Sheet 6, Detail M.

Tolerances are included in critical evaluations, such as the containment O-ring compression evaluation given in Section 4.1.3. Tolerances are generally small compared to the part dimensions to which they apply, and do not affect the margins of safety significantly in light of the conservative analysis methods used in the safety analyses.

The use of ASME B&PV Code, Subsection NE, Article NE-4220 is invoked to ensure the applicability of Code Case N-284 for the shell buckling analysis.

RAI-M-2 Provide the following information for items 19 and 20 in drawing No. 1916-02-02-SAR, "LANS 380-B Package Assembly SAR Drawing":

a. the revised drawing with welding symbols indicating the type of weld joint (e.g., square, V, bevel, U, etc.), and
b. the nondestructive examination methods used for the welds related this drawing, with the corresponding justification for using such methods.

Incorporate the revised drawings and the discussion related to item b. of this question in the application.

The bill of materials in drawing No. 1916-02-02-SAR, Sheet 1 of 6, indicates that the inner and outer shell are manufactured from ASTM A240, Type 304, plate material. This material would need to be formed into a cylinder and include at least one axial weld. Nevertheless, drawing No. 1916-02-02-SAR did not show or describe the welds that will be used when fabricating the Model No. 380-B inner and outer shells.

The design, fabrication aspects, and examination of the welds are important for the structural performance of the packaging. In terms of nondestructive examination, the applicant notes in Section 2.3.1 of the application that all containment boundary welds are full penetration joints and that would apply to the inner shell plate welds (item 19 in drawing No. 1916-02-02-SAR), but it is unclear if the same would apply to the outer shell weld (item 20 in drawing 1916-02-02-SAR). For both of these shells, there is no statement in Section 2.3.2, "Examination," of the application that identifies the type of nondestructive examination that that the applicant would require on these welds to ensure compliance with the applicable regulatory requirements.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-2 Response:

a) The welds joining the cask's end structures (drawing no. 1916-02-02-SAR, item nos. 17 & 18) to the inner and outer shells (item nos. 19 & 20) are specified as complete joint penetration welds. These welds (shown on Section E-E on Sheet 4 of the drawing) are specified using the complete joint penetration (CJP) symbol identified in Section 7.2.8, *Joint Geometry Not Specified, Complete Joint Penetration*, of AWS 2.4:2012. The symbol requires the weld to fuse the entire thickness of the joint, regardless of the groove type employed. The applicant believes it is important to allow the fabricator to employ the groove type most in accordance with the fabricator's expertise and approved weld procedures. Given the NDE applied to the weld, the final joint has the same integrity as if a specific groove configuration had been specified.
b) Each weld symbol on the drawing shows, using flag notes, the NDE which is applied to the weld. The flag note details the type of NDE and its specification. In addition, the NDE of each weld is discussed in detail in Section 2.3.2 and Table 8.1-1 of the SAR.

Of note, up to two longitudinal (axial) welds are specified for each shell (item nos. 19 & 20) using Flag Note 26.

RAI-M-3 Provide a revised drawing No. 1916-02-02-SAR with the welding symbols indicating the type of weld joint (e.g., square, V, bevel, U, etc.) for welds joining of items 17 to 19, 17 to 20, 18 to 19, and 18 to 20 in drawing No. 1916-02-02-SAR. Incorporate this change into the application.

In drawing No. 1916-02-02-SAR, Sheet 4 of 6, the applicant identifies items 17 to 19 and 20 and items 18 to 19 and 20 as complete joint penetration welds that are welded all around and examined using ultrasonic testing (UT) and penetrant testing (PT). However, the information in these items is not consistent with the applicable industry code and standard American Welding Society (AWS) 2.4, "Standard Symbols for Welding, Brazing, and Nondestructive Examination." Moreover, Note 1 on Sheet 1 of drawing No. 1916-02-02-SAR specifies that the weld joint information should be consistent with AWS 2.4.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-3 Response: Please see the response to RAI M-2.

RAI-M-4 Provide the dimensions (including schematics), composition of materials of construction, and moisture content of the proposed contents (i.e., sources and source containers) and dunnage. As part of your response,

a. demonstrate how the Model No. 380-B package would maintain:
   i. positive clearances between the inner cavity and the lodgment, both axially and radially, under normal conditions of transport (NCT) and hypothetical accident conditions (HAC), and
   ii. an allowable maximum normal operating pressure (considering dunnage as well as proposed contents).

b. explain how the chemical form and moisture content of the blockage and dunnage material were used to determine the maximum pressures in the package during NCT and HAC.

Section 1.2.2 of the application mentions that the details of the device designs may not be known and that blocking/dunnage materials are metallic structures, polyurethane foam, or wood. Section 3.1.4, "Summary Tables of Maximum Pressures," and Table 3.1-2, "Summary of Maximum Pressures," of the application describe the maximum pressure rise that would occur assuming a fill gas at one atmosphere of pressure and an initial temperature of 70°F. In this analysis, the applicant did not consider moisture content of the materials inside the package. At elevated temperatures, moisture could be released and vaporized resulting in a potential increase of internal pressure. Regulatory Guide (RG) 7.9, "Standard Format and content of Part 71 Applications for Approval of Packages for Radioactive Material," includes the following information related to the package internal pressure:

> ***For NCT***, Section 3.3.2, "Maximum Normal Operating Pressure," mentions that the calculation of pressures should consider possible sources of gasses including water vapor from the contents.
>
> ***For HAC***, Section 3.4.3, "Maximum Temperatures and Pressures," mentions that the evaluation of the maximum pressure in the package should be based on the maximum normal operating pressure, and should consider fire-induced increases in package temperatures, thermal combustion or decomposition processes, fuel rod failure, phase changes, etc. ...

This information is needed to determine compliance with 10 CFR 71.33(a)(5) and (b)(3).

M-4 Response: Figure 1.2-6 has been added to Chapter 1 of the SAR to provide a schematic depiction of the contents and dunnage arrangement within the 380-B. As described in Section 1.2.2, the payload device is a relatively compact metallic object of variable size. To prevent unwanted motion, it will be supported or blocked inside the cask using non-safety materials such as metal, polyurethane foam, or wood. The only material which could contain moisture beyond a trace amount is the wood. The payload device and the metallic dunnage will be dry. The polyurethane foam, since it is closed-cell and does not absorb water, will also be dry. Thus, galvanic reactions will not occur. The moisture which may be present in the wood is conservatively accounted for in the MNOP evaluation and the HAC fire case pressure evaluation in Section 3.3.2 and Section 3.4.3.1, respectively. To clarify this, the following text has been added to the end of the second paragraph of Section 1.2.2:

"All contents materials placed into the cask will be dry, except for the moisture normally present in the wood dunnage which may be used. For this reason, galvanic reactions will not occur. The effect of the wood's moisture content is evaluated in Section 3.3.2, *Maximum Normal Operating Pressure*, and Section 3.4.3.1, *Maximum HAC Pressures*. The effect of radiolysis on the contents is evaluated in Section 5.5.4, *Gas Generation due to Radiolysis*. A schematic of the contents is provided in Figure 1.2-6."

a) The SAR has been revised to require a gap to be present between the payload, the dunnage, and the cask cavity. The operating procedure has been revised to require a minimum of one-half inch of free space between the inner diameter of the cask and the materials of the payload and dunnage, and a minimum of one-half inch of free space between the top of the payload/dunnage and any part of the underside of the inner cover. Because the temperatures of the cask are relatively modest in both NCT and HAC, this clearance will be adequate to prevent the application of any forces caused by thermal differential expansion to the cask containment boundary. To implement this change, Section 7.1.2, step #11.c, has been revised to read:

   "Dunnage shall be configured to allow a minimum of one-half inch of free space between the inner diameter of the cask and the materials of the payload or dunnage, and a minimum of one-half inch of free space between the top of the payload or dunnage and any part of the inner cover."

b) The contents materials are resistant to the generation of gas. The payload devices are made from steel with metallic shielding such as lead, tungsten, or depleted uranium, and are not a source of gas or moisture. As stated in Section 7.1.2, non-essential components of the devices are removed, to the extent practical, prior to shipment. The moisture present as a component of the optional wood dunnage is conservatively evaluated as noted above.

   The payload devices generally include small amounts of non-metallic materials, such as a painted outer surface. An option (added in this revision of the SAR) allows the slings that were used to lift the payload to be left in the cask for use at the destination. A new section, Section 3.4.3.2, *Non-metallic Contents Materials Under HAC*, has been added to the SAR to discuss the effect of maximum HAC temperatures on the non-metallic materials inside the cask and to demonstrate that pressurization of the containment boundary, beyond the conservatively evaluated moisture, will not occur. The full text of the new section is as follows:

   "Several non-metallic materials may be present in the 380-B cask and could be exposed to elevated temperatures in association with the HAC fire event. Polyurethane foam or wood may be utilized as blocking or dunnage. Lifting slings may optionally be left inside the cask for use in removal of the contents. Other materials may be present on the shielded device in a way that makes them difficult or impracticable to remove (such as paint). Since heat is flowing into the package during the HAC fire event, the highest temperature experienced by any materials within the cask will be the peak temperature of the containment boundary cavity. Per Table 3.4-1, the peak temperature is for the inner shell sidewall, at 294 °F. Thus, the peak temperature of any material inside the cask is bounded by the peak sidewall temperature. Table 3.4-2 lists each non-metallic material and its minimum thermal decomposition temperature based on published reference information. The minimum thermal decomposition temperature is typically based on the mass loss of a sample measured using thermogravimetric analysis (TGA). As shown, each non-metallic material has a significant margin of safety on its temperature limit, and gas generation or pressurization from the thermal decomposition of these materials in association with the HAC fire event will not occur. Of note, none of these materials are important to safety, and consequently their function under NCT or HAC is not required. The potential evolution of water vapor from wood is conservatively evaluated in Section 3.3.2, *Maximum Normal Operating Pressure*, and Section 3.4.3.1, *Maximum HAC Pressure*."

RAI-M-5 Provide the following information related to drawing No. 1916-02-02-SAR, "LANS 380-B Cask assembly SAR Drawing":

a. material properties for ASTM A351, Grade CF8A, cast stainless steel identified in the "bill of materials" in items 14 (Lid Forging), 17 (Forging, Cask Upper), and 18 (Forging, Cask Bottom).
b. reference(s) used as the basis of response in item a. above.
c. revised drawing No. 1916-02-02-SAR with the correct material descriptions (forging, plate, etc.) of the components of the cask assembly.

For example, the following is information extracted from the "bill of materials" of drawing No. 1916-02-02-SAR, "LANS 380-B Cask assembly SAR Drawing":

ITEM NO.	BRIEF DESCRIPTION		SPECIFICATION
14	lid	Forging	ASTM A351, Grade CF8A,... or ASTM A240...
17	cask upper	Forging	
18	cask bottom	Forging	

The staff notes the following:

1. ***ASTM A351, Grade CF8A***, is a Type 304 stainless steel cast material and should not be described as a forged material. The applicant does not provide mechanical properties for this material in the application. ASME B&PV Code, Section II, Part D, includes the following information:
   i. ASTM A351, Grade CF8A, has a maximum allowable temperature of 700°F.
   ii. Other stainless steels such as A240 and A182 have an 800°F maximum temperature.

   The applicant treats A351 as if it has the same allowable temperature as A240 or A182, which is not correct.

2. ***ASTM A240*** plate is wrought material and should not be described as a forged material. The mechanical properties of A240 were provided in Table 2.2-1, "Mechanical Properties of Wrought Type 304 Stainless Steel," of the application.

3. ***Drawing No. 1916-02-02-SAR*** refers to components as "forgings" even though these components can be made from a cast or wrought (i.e., rolled plate) materials. The applicant should consider the differences in mechanical properties, allowable temperatures, and inspection methods of the materials.

Note that this question includes examples and the applicant should review and revise its drawings to ensure accuracy in the description of the materials used in the design of the Model No. 380-B.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

***M-5 Response*:** The application has been revised to remove the cast material as an option. This has been done because several cask fabricators have voiced their preference for forged material, thus the cast material option is unnecessary. References to the cast material in the text have been removed, and Footnote 7 has been removed from Table 2.2-2. In addition, drawing 1916-02-02-SAR has been revised to remove the cast material and correct the terminology of item nos. 14, 17, and 18. The material for these three items is now limited to the option of wrought material (ASTM A240, Type 304) or forged material (ASTM A182, Grade F304) only. Furthermore, the word "forging" has been removed from the description of the items. Item 14 is now described as "Lid Body", Item 17 is now described as "Cask Upper End", and Item 18 is now described as "Cask Lower End". References to cast material have been removed throughout the SAR.

RAI-M-6 Provide a reference for the mechanical properties of ASTM A276, Type 304 stainless steel.

Table 2.2-1, "Mechanical Properties of Wrought Type 304 Stainless Steel," of the application lists the material specification ASTM A276. For ASTM A276, Type 304, the applicant referenced the following sections of the ASME B&PV Code:

1. Section II, "Materials," Part D, "Properties," Tables 2A,
2. Section III, Division 1, Class 1, and
3. Section III, Division 3, Classes TC and SC, "Design Stress Intensity Values Sm for Ferrous Materials," Table U, "Tensile Strength Values Su for Ferrous and Nonferrous Materials," and Table Y-1, "Yield Strength Values Sy for Ferrous and Nonferrous Materials."

The applicant did not provide an equivalent material specification for ASTM A276, Type 304 stainless steel because the referenced ASME B&PV Code, Section II, Part D, Tables do not include material properties for ASME SA-276, Type 304 stainless steel.

This information is needed to determine compliance with 10 CFR 71.31(c) and 71.33(a)(5).

M-6 Response: As noted in the RAI, ASTM A276, Type 304 material does not appear in ASME B&PV Code, Section II, Part D. However, the material is included in Section II, Part A as SA276, Type 304. Therefore, it should be an acceptable material for construction of packaging.

Furthermore, it is reasonable to apply the elevated temperature properties of ASTM A479, Type 304, to ASTM A276, Type 304 material. ASTM A276, *Standard Specification for Stainless Steel Bars and Shapes* is equivalent to ASTM A479, *Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.* ASTM A479 is included in Section II, Part D, and appears in Table 2A, Table Y-1, and Table U. Of note, the chemical composition of ASTM A276, Type 304 and ASTM A479, Type 304 are nearly identical. (The only exception is that the range for nickel in ASTM A276 is 8.0 – 11.0%, whereas the range for nickel in ASTM A479 is 8.0 – 10.5%, which is negligible). Furthermore, the room temperature yield strength and ultimate tensile strength are identical. For these reasons, it is reasonable to assume that the mechanical properties at elevated temperatures for both specifications are also identical, and ASTM A276 material is therefore an acceptable substitute for ASTM A479 material.

Table 2.2-1 has been revised to remove ASTM A276 from the first column. Footnote 7 has been added to the table which reads: "Properties in this table apply to ASTM A276, Type 304 stainless steel bars and shapes."

RAI-M-7 Revise Tables 2.2-1, "Mechanical Properties of Wrought Type 304 Stainless Steel," and 2.2-2, "Mechanical Properties of Forged Type 304 Stainless Steel," to use consistent terminology for "Design Stress Intensity" (Sm) as referenced in ASME B&PV Code, Section II, Part D, Table 2A, and not "Allowable Strength."

Tables 2.2-1 and 2.2-2 of the application describe "Sm" as "Allowable Strength." The ASME B&PV Code, Section II, Part D, Table 2A, describes "Sm" as "Design Stress Intensity." Therefore, the applicant needs to revise the application to use the correct terminology.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-7 Response: In Table 2.2-1 and Table 2.2-2, the column heading "Allowable Strength" has been revised to read "Design Stress Intensity".

RAI-M-8 Justify the maximum temperatures for the ASTM A564, Grade 630, Condition H1100, Impact Limiter Attachment Bolts, provided in Table 3.1-1, "Maximum NCT and HAC Temperatures," Table 3.3-1, "NCT Temperatures for 380-B Package with Open Dunnage Support," and Section 3.2.3, "Component Specifications," of the application.

In Tables 3.1-1 and 3.3-1 and Section 3.2.3 of the application, the applicant indicates that the allowable temperature for ASTM A564, Grade 630, Condition H1100, bolts is 800°F. Section 3.2.3 of the application indicates that Type 630 stainless steels have an allowable temperature of 800°F per the ASME BP&V Code, Section III, "Rules for Construction of Nuclear Facility Components," Division 1, Subsection NB, Class 1 Components. The allowable temperature per ASME B&PV Code, Section II, Part D, is 650°F. Therefore, the temperatures listed in Tables 3.1-1 and 3.3-1 and Section 3.2.3 of the application exceed the maximum allowable temperature of 650°F listed in ASME BP&V Code, Section II, "Materials," Part D, "Properties," Table 4; Section III, Classes 1, TC, and SC; and Section VIII, Division 2, "Design Stress Intensity Values Sm For Bolting Materials."

This information is needed to determine compliance with 10 CFR 71.33(a)(5) and 71.51(a)(2).

M-8 Response: ASME B&PV Code, Section II, Part D, Table 4 lists material properties for ASTM A564, Grade 630, Condition 1100 bolting material, and shows an application limit of 650 °F. This limit does not apply to the application of this material in the 380-B. The reason for the temperature limit is explained in footnote G2 in Table 4. This material can experience a loss in toughness when exposed for 5,000 hours at a temperature of 600 °F or above. However, the duration of elevated temperature due to the HAC fire is very short compared to 5,000 hours, and the bolt material cannot be embrittled due to the HAC fire event. In addition, 10 CFR 71 does not specify any shock loading subsequent to the HAC fire. Thus, use of a value of 2/3S_y for allowable stress, and a temperature limit of 800 °F, is appropriate for this material. See also the response to RAI M-9.

Table 2.2-3 of the application has been revised to add the properties of the bolting material at 800 °F, which had been missing from table. The added row is as follows (header row included for clarity):

Temperature (°F)	① **Yield Strength, S_y (psi)**	② **Ultimate Strength, S_u (psi)**	③ **Allowable Strength, S_m (psi)**	④ **Elastic Modulus, E ($\times 10^6$ psi)**	⑤ **Thermal Expansion Coefficient, α ($\times 10^{-6}$ /°F)**
800	86,900	122,500	57,933	24.3	6.9

RAI-M-9 Justify design stress intensity values (Sm) values for SA-564, Grade 630, Condition H1100, bolts, in Table 2.2-3, "Mechanical Properties of ASTM A564, Grade 630, Condition H 1100, Stainless Steel," of the application. Provide applicable references as part of the response.

The applicant should use the values listed in ASME BP&V Code, Section II, Part D, Table 4, which are specific to SA-564, Grade 630, Condition H1100, instead of using generic guidance such as NUREG/CR-6007. The Sm values listed in Table 2.2-3 of the application are based on generic guidance of NUREG/CR-6007, "Stress Analysis of Closure Bolts for Shipping Casks," that is 2/3 of the yield strength (2/3 Sy). ASME BP&V Code, Section II, Part D, Table 4; Section III, Classes 1, TC, and SC; and Section VIII, Division 2, "Design Stress Intensity Values Sm For Bolting Materials," include specific values applicable to SA-564, Grade 630, Condition H1100, bolts for use in Class 1 systems. The values provided in the application exceed the Sm values listed in ASME B&PV Code, Section II, Part D, Table 4. Values of Sm in ASME BP&V Code, Section II, Part D, Table 4, are approximately ½ of the values based on generic guidance in NUREG/CR-6007 (2/3 Sy). Note that for bolts in Class 1 systems, ASME B&PV Code, Section III, "Rules for Construction of Nuclear Facility Components," Division 1, Subsection NB, "Class 1 Components," NB-3232.1, the maximum value of service stress, averaged across the bolt cross section and neglecting stress concentrations, shall not exceed two times the stress values of Section II, Part D, Subpart 1, Table 4.

This information is needed to determine compliance with 10 CFR 71.31(c) and 71.33(a)(5).

M-9 Response: If the 380-B cask were being designed as an ASME pressure vessel in accordance with the ASME B&PV Code, Subsection NB, Article NB-3232.1, the use of ASME B&PV Code, Section II, Part D, Table 4 material properties for the bolting material would be appropriate. However, the 380-B cask is being designed and analyzed using the guidance documents recommended by NRC for shipping casks. As stated in Section 2.1.2.1, the closure bolts are evaluated using the guidance of NUREG/CR-6007. This document includes both stress analysis methodologies as well as stress allowables. Of note, although developed differently, the applicable allowable stress is nearly identical numerically. NB-3232.1 specifies that the bolting allowable stress is two times S_m, where S_m from Section II, Part D, Table 4 is approximately equal to $1/3S_y$. The corresponding allowable stress from NUREG/CR-6007, Table 6.1, is $S_m = 2/3S_y$. At 150 °F, the numerical difference between these two stress limits is only 67 psi, or less than 0.1%. Thus the margin of safety would be essentially identical either way. Consequently, the applicant believes that it is appropriate to retain the bolting analysis and allowable stresses as shown in the SAR without change.

RAI-M-10 Provide and identify the allowable grades of ASTM B29 lead used for the shielding material of the Model No. 380-B.

Section 1.2.1.1, "Cask Assembly," of the application states the following:

> "All lead shielding is made from ASTM B29 lead or optionally, from lead per Federal Specification QQ-L-171E, Grade A or C."

There are four grades of lead included in ASTM B29-14. The applicant should provide a complete specification for the materials used in the design of the Model No. 380-B.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

***M-10 Response*:** Any of the four grades of lead listed under ASTM B29 are acceptable shielding materials. All grades of ASTM B29 and Federal Specification QQ-L-171E, Grades A or C, are at least 99.9% pure lead. The application has been revised to clearly specify that any grade of lead under specification ASTM B29 may be used. This change has been made to drawing 1916-02-02-SAR, Section 1.2.1.1, Section 2.2, Section 3.1.1, and Section 3.2.1.

RAI-M-11 Provide the material properties for ASTM B16, C3600, Temper H02 Brass, and applicable references as part of the response. Also, as part of the response, include at least the following material properties:

a. yield strength,
b. ultimate strength,
c. design stress intensity,

d. elastic modulus, and
e. thermal expansion coefficients.

Regulatory Guide (RG) 7.9, Section 4.3, "Containment under Hypothetical Accident Conditions," notes that under HAC the structural performance of the containment system should be addressed, including seals, closure bolts, and penetrations, as well as leakage testing of the containment system. Section 4.1.1, "Containment Boundary," of the application indicates that the brass vent port plug is part of the containment boundary. The applicant provided Table 2.2-5, "Mechanical Properties of Brass Material," but did not provide material properties of brass as a function of temperature such as in Table 2.2-2, "Mechanical Properties of Forged Type 304 Stainless Steel."

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-11 Response: Table 2.2-5 shows the ASTM designation, hardness designation, and product form of the brass, and includes the minimum mechanical properties for the material. The table has been revised to include the elastic modulus and the coefficient of thermal expansion as follows:

Material	Minimum Mechanical Properties
ASTM B16, UNS C36000, Temper H02 (Rod Product Form)	Yield Strength, $\sigma_y = 20{,}000$ psi [43] Ultimate Strength, $\sigma_u = 50{,}000$ psi [43] Modulus of Elasticity, $E = 14\times10^6$ psi [44] Thermal Expansion Coefficient, $\alpha = 11.4\times10^{-6}$ /°F [44]

The references for this information are:

43. ASTM B 16/B 16M-10, *Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines*, American Society for Testing and Materials (ASTM).

44. ASM Handbook® (Formerly Tenth Edition, Metals Handbook), Volume 2, *Properties and Selection: Nonferrous Alloys and Special-Purpose Materials*, ASM International, page 310.

which have been added to Section 2.12.1. Because the material is not included in the property tables of Section II, Part D of the ASME B&PV Code, the design stress intensity and the properties as a function of temperature are not available. However, since the maximum temperature of the vent port plug does not exceed 400 °F under HAC, a significant degradation of properties is not to be expected. The coefficient of thermal expansion of 11.4(10^{-6}) in/in/°F is similar to that of the stainless steel closure lid (equal to 9.5(10^{-6}) in/in/°F at 400 °F), and since the dimensions of the vent port plug are very small (nominal 3/8-in diameter thread) and since the temperature of the two materials will be the same in contact, the differential expansion of the vent port plug and the closure lid interface will be negligible. Of note, this discussion is given in Section 2.1.2.3.2.1(5).

RAI-M-12 Describe the proposed process for ultrasonic testing (UT) including equipment description and procedures that demonstrate UT is sufficient to identify and size welding defects in:

a. the welds between the Plate, Inner Shell (item 19 in drawing 1916-02-02 SAR), and the Forging Cask Upper (item 17), and Forging, Cask Bottom (item no. 18), and
b. the welds between the Plate, Outer Shell (item 20), and the Forging, Cask Upper (item 17), and Forging, Cask Bottom (item 18), for the case where items 17 and 18 are manufactured from ASTM A 351, Grade CF8A, cast austenitic stainless steel.

As part of your response, demonstrate that the UT examination of the welds is sufficient to detect weld defects that may affect the structural performance of the package.

Section 2.3.2, "Examination," of the application mentioned that UT would be used to examine the welds mentioned in items a. and b. of this question. Ultrasonic examination (UT) of welds in cast austenitic stainless steels is known to be difficult owing to the microstructure of these materials which often contain a wide range of grain sizes that scatter ultrasonic waves. Generally, UT is not the preferred volumetric nondestructive examination method for cast austenitic stainless steels. Weld defects near the fusion line of the cast components could be difficult to detect using UT.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-12 Response: Since cast material has been removed from the design (see the response to RAI M-5), this question no longer applies.

RAI-M-13 Provide the following information for the ASTM A564, Grade 630, stainless steel closure lid bolts:

a. an analysis consistent with the information summarized in Table 3.1-1, "Maximum NCT and HAC Temperatures," under NCT and HAC,
b. the maximum temperatures along with allowable temperatures for NCT, and
c. temperature margins (Table 3.4-1, "Peak HAC Temperatures for 380-B Package," and Section 3.4.3," Maximum Temperatures and Pressure") under HAC for the ASTM A564, Grade 630, Condition H1100, stainless steel closure lid bolts.

Also, provide a demonstration that the package would remain leaktight at the maximum NCT and HAC temperatures in Table 3.1-1.

Table 3.1-1 of the application depicts a maximum temperature of 649°F for the closure lid (Type 304 stainless steel) under HAC (see also RAI-8 and RAI-9). The upper temperature for Type 630 stainless steel in ASME Code, Section II, Part D (Tables 1A, 2A, 3, and 4), is of 650°F. Since that the closure lid bolts are part of the containment boundary, the applicant needs to provide an analysis to demonstrate the package would remain leaktight under NCT and HAC.

This information is needed to determine compliance with 10 CFR 71.33(a)(5) and 71.51(a)(2).

M-13 Response: As demonstrated in the response to RAI M-8, the material properties of ASTM A564, Grade 630, Condition H1100 closure bolts will not be degraded by the HAC fire event. Thus no deterioration of the leaktight condition will occur.

RAI-M-14 Provide the following information for the "Forging Cask Upper" (item 17), "Forging Cask Bottom" (item 18), and "Lid Forging" (item 14) as depicted in drawing No. 1916-02-02-SAR:

a. an analysis consistent with the information summarized in Table 3.1-1, and
b. temperature margins (Table 3.4-1, "Peak HAC Temperatures for 380-B Package," and Section 3.4.3, "Maximum Temperatures and Pressure") under HAC, when these components are manufactured from ASTM A351, Grade CF8A.

Table 3.1-1 of the application includes temperatures of the closure lid, bottom forging, and top forging, under NCT and HAC conditions. The allowable temperature for these components under normal and accident conditions is listed as 800°F. The allowable temperature of 800°F is correct, if these components are manufactured from wrought (ASTM A240) or forged (ASTM A182) Type 304 stainless steel. However, if these components are constructed from ASTM A351, Grade CF8A, stainless steel as shown in the "bill of materials" in drawing No. 1916-02-02-SAR, Sheet 1 of 6, "LANS 380-B Cask Assembly SAR Drawing," the allowable temperature is 700°F per ASME BP&V Code, Section II, Part D, Table 2A.

This information is needed to determine compliance with 10 CFR 71.33(a)(5).

M-14 Response: As stated in the response to RAI M-5, cast material has been removed from the design and the terminology for the cask components has been revised.

RAI-M-15 Provide the applicable ASTM standard or other industry standard used for estimating the compressive stress of the polyurethane. If the testing and analysis is not based on a referenced standard, justify the testing and analysis methods.

Section 8.1.5.1.2.3.2, "Compressive Stress," of the application mentions testing of the foam in an "Universal Testing Machine." Regulatory Guide (RG) 7.9, Section 2.2.1, "Material Properties and Specifications," mentions that properties where material properties are determined by testing, this section ("Compressive Stress") should describe the test procedures, conditions, and measurements in sufficient detail to enable the staff to evaluate the validity of the results. The staff notes that ASTM D1621, "Standard Test Method for Compressive Properties of Rigid Cellular Plastics," has previously been used to describe the testing of polyurethane foam on impact limiters.

This information is needed to determine compliance with 10 CFR 71.31(c).

M-15 Response: The SAR has been revised to include ASTM D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics for the compression testing of the polyurethane foam material. Of note, this revision does not change any of the foam's properties. Section 8.1.5.1.2.3.2 has been revised to read:

1. Test samples taken from each foam pour shall be tested according to ASTM D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics [19]. The direction of compressive loading shall be parallel to the foam rise direction (for the perpendicular–to–rise direction, see below).
2. Determine and record the average parallel–to–rise compressive stress of the test samples from each batch pour for each foam density. As shown in Table 8.1-2, the average parallel–to–rise compressive stress for each foam pour shall be the nominal compressive stress ±15% at strains of 10%, 40%, and 70%.
3. Determine and record the average parallel–to–rise compressive stress of all test samples from each foamed component. As shown in Table 8.1-2, the average parallel–to–rise compressive stress for all foam pours used in a single foamed component shall be the nominal compressive stress ±10% at strains of 10%, 40%, and 70%.
4. Additional samples taken from each foam pour shall be tested according to ASTM D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics [19]. The direction of compressive loading shall be perpendicular to the foam rise direction.
5. Determine and record the average perpendicular–to–rise compressive stress of the test samples from each batch pour for each foam density. As shown in Table 8.1-3, the average perpendicular–to–rise compressive stress for each foam pour shall be the nominal compressive stress ±15% at strains of 10%, 40%, and 70%.
6. Determine and record the average perpendicular–to–rise compressive stress of all test samples from each foamed component. As shown in Table 8.1-3, the average perpendicular–to–rise compressive stress for all foam pours used in a single foamed component shall be the nominal compressive stress ±10% at strains of 10%, 40%, and 70%.

RAI-M-16 Explain the methodology to determine the presence of voids greater than 5% of the nominal lead thickness using dose rate measurements using a cobalt-60 source. As part of your response, indicate the expected variation in dose rate based on the allowable dimensional tolerances of the packaging materials.

Section 8.1.6.1, "Poured Lead Shielding," of the application mentions that poured lead shielding integrity shall be confirmed by using gamma scanning. The test is considered acceptable if it is determined that no voids exist that exceed 5% of the nominal lead thickness. The bases for a 5% of the nominal lead thickness should be consistent with the dimensional tolerances for the thickness of the lead material used for the shield.

This information is needed to determine compliance with 10 CFR 71.31(c).

M-16 Response: Section 8.1.6.1 has been revised to better ensure an adequate level of shielding is achieved from the lead pour. To start with, a requirement has been added to drawing 1916-02-02-SAR, Sheet 4, Zone B-4, that the minimum space between the inner and outer shells is 6.50 inches. This provision assures, regardless of manufacturing variations, a minimum thickness of lead.

Secondly, the 5% void acceptance criteria is no longer used. Instead, the gamma scan acceptance criteria will be established using an analytical shielding model of the cask which includes the minimum lead thicknesses analyzed in Chapter 5 of the SAR. The model results will be calibrated to the actual test source strength and detector characteristics using a calibration test mockup which uses the minimum steel shell thicknesses and minimum lead thickness used in the shielding analytical model. This sequence yields the final dose rate acceptance criteria. (Optionally, the un-collided gamma count may be used as the figure of merit.) The gamma scan test will then be conducted as already described in Section 8.1.6.1.

Due to manufacturing variability, the thickness of lead will vary somewhat around the cask body. However, using the revised gamma scan technique, the thickness of lead will not be less than the minimum thickness used in the shielding analysis in Chapter 5 of the SAR.

Section 8.1.6.1 has been revised to read:

"Poured lead shielding integrity shall be confirmed via gamma scanning. A gamma probe is used to scan the outer cask surface while a Cobalt–60 or similar gamma source of sufficient strength is positioned within the cask cavity. The cask outer surface is marked with a grid and a chart is made corresponding to the gridded surface. The source is first placed at one end of the cask cavity while the surface is scanned around its circumference. The source is then moved to the next axial grid position and the circumference is scanned again. This sequence is repeated until the entire cask outer surface is scanned. The maximum dose rate from each grid square is recorded on the chart. Acceptance criteria for each grid square will be established using the analytical shielding model from Chapter 5, *Shielding Evaluation*. The analytical model will be revised to account for the presence of a test lid and test base shielding, but the poured lead will be the same as in Chapter 5. The model dose rate results will be calibrated to the actual test source strength and detector characteristics using a calibration test mockup which uses the minimum steel shell thicknesses and minimum lead thickness used in the shielding analytical model. Optionally, the un-collided gamma count may be used instead of the dose rate."

Structural Evaluation

RAI-St-1 Revise the impact limiter assembly drawing No. 1916-02-03-SAR to identify the design details for the ¼-inch thick by 2-inch wide reinforcing ring to alleviate potential shell casing weld failure, which was observed for the certification test unit (CTU) accident sequence of the C.G.-over-corner free drop followed by a puncture drop.

Figure 2.12.3-36, "Impact Limiter Added Reinforcing Ring," of the application includes details of the reinforcing ring design. Drawing No. 1916-02-03-SAR should reflect the reinforcing ring design details depicted in Figure 2.12.3-36 to ensure control of the shipping packaging design and that such design is not altered.

This information is needed to determine compliance with the requirements in 10 CFR 71.33(a)(5)(iii).

St-1 Response: Drawing 1916-02-03-SAR has been revised to include the OD and ID of the reinforcing ring, item no. 3. The thickness, material, and attachment weld configuration is also shown on the drawing.

RAI-St-2 Revise the following sections of the application as follows:

a. Section 2.7.8, "Summary of Damage," of the application to identify the minimum margin of safety applicable to the containment system, which consists primarily of the cask body inner shell, inner bottom plate, and closure lid assembly.

b. Section 2.7.1.3, "Side Drop," to:

   i. identify the stress linearization section cuts and corresponding margins of safety for the side drop accident if it is judged to be the drop orientation for which the maximum damage is expected of the package containment boundary, and.

   ii. include a summary of stress analysis results for the containment boundary.

Section 2.7.1.3 of the application states the following:

> "[T]he minimum margin of safety..., which corresponds to the side drop impact case, is +0.06."

Per the applicant this margin of safety is associated with the stress at the bottom outside edge of the outer shell. The staff notes that the outer shell is not part of the containment boundary. A summary of stress analysis results for the containment boundary, which is the most indicative of the package structural capability, should be provided in Section 2.7.1.3 for the package subject to the 30-ft side drop accidents to determine that the minimum safety margins are acceptable.

This information is needed to determine compliance with the requirements in 10 CFR 71.73(c)(1).

***St-2 Response*:** Section 2.12.4, Section 2.7.1.2, Section 2.7.1.3, and Section 2.7.8 have been revised to include the stresses and margins of safety for the containment boundary components. Revision 0 of the SAR included margins of safety for the largest values of stress in the cask body, regardless of location, which generated lower bound margins of safety. The margins of safety for all containment boundary components are thus at least as large as the margins shown in Revision 0. However, for greater completeness, margins of safety for the containment boundary components have been added to the sections stated above.

RAI-St-3 Explain how the decoupling process may impact the finite element stress analysis of the cask body and closure lid components as mentioned in Section 2.12.4.4, "Load Cases and Allowable Stress," of the application.

Section 2.12.4.4 of the application, page 2.12.4-4, top paragraph, first sentence, states the following:

> "[F]or most cases, the maximum stress resulting from the model is evaluated by decoupling the primary stress from bending and secondary stress."

The stress analysis description does not appear to be conducive to a finite element stress analysis approach that are commonly practiced using a superposition principle. Therefore, the applicant should provide a clear description of a finite element analysis approach used for performing containment boundary the stress analysis mentioned in Section 2.12.4.4.

This information is needed to confirm that the stress analysis method, as described, was implemented properly for demonstrating the package structural performance in meeting the requirements of 10 CFR 71.35(a) and 71.41(a).

This information is needed to determine compliance with the requirements in 10 CFR 71.35(a) and 71.41(a).

St-3 Response: The use of the term "decoupling" was not intended to imply that the membrane and bending stresses are independent of each other. The intent was to separate the membrane and bending stresses in order to apply the appropriate allowables. The separation of stresses into components is described in ASME B&PV Code, Section III, Subsection NB-3221, and Figure NB-3221-1. To obtain the separation of stress categories for the 380-B evaluation, the stress linearization method in the POST1 module of the ANSYS computer program was used. This process resulted in a membrane stress and a maximum bending stress along each critical path. Each linearization was shown in the SAR in a figure, of which Figure 2.12.4-11 is an example. This method results in a valid stress evaluation. To avoid confusion, the paragraph at the top of page 2.12.4-4 has been revised to read:

"For most cases, the stress resulting from the model is separated, using a linearization technique, into membrane and bending components for application of appropriate stress allowables."

RAI-St-4 In terms of the structural analysis of the Model No. 380-B, provide the time-history comparison plots for the measured full-scale equivalent rigid body accelerations to corroborate the peak response results in Table 2.12.5-9 with respect to Figures 2.12.5-24 through -26 on the simulated accelerations for the end, C.G.-over-corner, and side drops.

Table 2.12.5-9, "Benchmark Results Comparison," of the application includes a comparison of the measured and simulated peak cask rigid body decelerations and the impact limiter deformations. The staff notes that, in addition to evaluating correlation between the measured and simulated peak accelerations, two other acceleration response attributes, namely, the pulse shape and pulse duration, should also be evaluated. The staff needs this information to verify that the impact limiter finite element analysis model is adequately benchmarked and it can be used in an evaluation by analysis approach to demonstrate that the package meets the structural performance requirements for the free drop test requirements.

This information is needed to determine compliance with the requirements in 10 CFR 71.71(c)(7) and 71.73(c)(1).

***St-4 Response*:** The SAR has been revised to include a comparison of the acceleration time histories for the three benchmark cases. The last sentence at the bottom of page 2.12.5-11 has been deleted, and a new paragraph added as follows:

"Comparison of the certification test and benchmark run acceleration time histories are provided in Figure 2.12.5-24 through Figure 2.12.5-26. The accelerometer data provided in Appendix 2.12.3 for the accelerometer number stated in the chart legend was converted to full scale by multiplying the time scale by two and the acceleration scale by 0.5. The C.G.-over-corner data was divided by cos(40) to obtain the acceleration perpendicular to the ground. As shown, the pulse shape and duration of the benchmark and test data impact records compare well, and support the conclusion that the LS-DYNA® impact analyses of the 380-B are conservative."

In addition, Figure 2.12.5-24 through Figure 2.12.5-26 have been replaced by the comparison figures noted in the text above.

Thermal Evaluation

General Thermal Discussion: The thermal model has been rerun in order to implement the response to RAIs Th-1 and Th-6. In addition, the mesh density of the closure lid has been refined in order to more accurately capture the peak HAC temperature of the vent port sealing washer and the closure bolts, both of which had not been explicitly reported in Revision 0 of the SAR. Details of the mesh refinement study of the closure lid are given in Section 3.5.3.7. The resulting HAC peak temperature of the vent port sealing washer (392 °F) is higher than that reported for the "closure seals" line item of 301 °F shown in Table 3.4-1 of Revision 0. However, as noted in Section 3.2.3 of the SAR, the butyl material has been successfully tested for leaktight performance after one hour at 430 °F and 8 hours at 400 °F, as documented in Reference 9 of Chapter 3. Since the temperature excursion of the vent port sealing washer under HAC is brief (the sealing washer temperature exceeds 350 °F for only 20 minutes), the leaktight performance of the vent port sealing washer is not of concern.

The key package temperatures provided in Table 3.4-1 have shifted up and down somewhat compared to SAR Revision 0 as a result of the changes made to the model (primarily the mesh refinement). The shifts are however relatively small and the thermal margins of safety remain very significant. The allowable temperature for the vent port sealing washer is given as 400 °F (representing a soak time of 8 hours) for consistency with the main containment seal allowable temperature. However, given the brevity of the thermal excursion and the existence of additional test data showing leaktight performance for at least one hour at 430 °F, the margin shown in Table 3.4-1 (8 °F) significantly underestimates the actual thermal margin of safety for the vent port sealing washer.

RAI-Th-1 Provide the basis for determining the distribution of the content's decay heat percentage as described in Section 3.1.2, "Content's Deacy Heat" of the application.

The Model No. 380-B is designed for a maximum decay heat of 205 watts. In Section 3.1.2 of the application, the applicant provides the following assumptions related to the thermal analyses:

1. 86% of the content's decay heat deposited on a 10.6-inch height of the inner shell directly opposite of the irradiation device (shield device), and
2. 14.0% of the heat load located on the underside of the inner cover and the upper 16.8 inches of the inner shell on an area basis.

The applicant did not provide justification or basis for these values (86% and 4.0%).

This information is required to determine compliance with 10 CFR 71.35(a) and 71.71(c)(4).

***Th-1 Response*:** The heat distribution from the closed dunnage case was distributed on the package cavity assuming that 86% percent of the 205 W decay heat was transferred directly to the inner shell by radiative heat transfer, and 14% was transferred via convection. To simplify the distribution of the payload decay heat, the thermal analysis of the closed dunnage case has been revised to conservatively assume 100% of the decay heat is deposited on the area of the inner shell having a view of the payload, or a height of 9.3 inches. To develop a firm basis for this dimension, a maximum heat-density payload has been defined by limiting the heat density to 0.1 W per pound. The resulting generic payload has a diameter of approximately 9.3 inches and a height of 18.6 inches. Thus the minimum height of the area with a view of the sidewall (required by Section 7.1.2, step #11) is 18.6/2 = 9.3 inches. This places the entire decay heat flux over the minimum area, to obtain the bounding temperatures.

Section 3.1.2 and Section 3.5.3.1 have been revised to clarify and justify the distribution of the payload decay heat on the 380-B package cavity. Section 7.1.4 has been revised to impose the limit of 0.1 W per pound of device weight. The model thermal results in Table 3.1-1, Table 3.3-1, Table 3.3-2, and Table 3.4-1 have been updated.

RAI-Th-2 Justify using the peak inner shell temperature plus 50% as appropriate or conservative in the maximum normal operating pressure (MNOP) calculation.

The applicant stated in Section 3.3.2, "Maximum Normal Operating Pressure," of the application that the MNOP is estimated based on no payload outgassing, but will rise from ideal gas expansion and outgassing from the payload dunnage. To calculate the pressure-rise from the ideal gas expansion, the applicant assumed that the bulk gas temperature is equal to the peak inner shell temperature plus 50%, since the applicant did not explicitly model the payload.

Since that the peak gas temperature can be higher than the peak inner shell temperature, the applicant needs to explain and justify using the peak inner shell temperature plus 50% in the MNOP calculation.

This information is required to determine compliance with 10 CFR 71.33(b)(5) and 71.71(c)(4).

***Th-2 Response*:** The assumption of the package cavity bulk gas temperature being bounded by 150% of the peak side wall temperature has been replaced with an explicit calculation. This calculation conservatively estimates the bulk gas temperature by assuming the entire 205 Watt heat load from the payload is being transferred to the package body via convection only. The package cavity surface area is also conservatively limited to the lower lid surface. The convection correlation chosen was for a horizontal plate with gas convecting upwards to the lower surface of the cooler plate, as cited from Reference 22 of Chapter 3. The correlation and convection heat transfer equations were iteratively solved for the corresponding convection coefficient and bulk gas temperature values.

The resulting bulk gas temperature is 232°F. (Note that neglecting radiation results in a very conservative estimate of bulk gas temperature.) This was only 28°F higher than the 150% approximation, and therefore the bounding 10 psig MNOP value remains unchanged in Section 3.3.2. The calculations described above have been incorporated into Section 3.3.2 and Table 3.3-3.

RAI-Th-3 Provide Table 4.2.19 of Reference No. 29 depicted in Section 3.5.1, "References," of the application to verify the water/moisture saturation pressure. Incorporate Table 4.2.19 of Reference #29 in Section 3.3.2 of the application.

The applicant stated in Section 3.3.2, "Maximum Normal Operating Pressure," of the application that dunnage fabricated of wood has the potential of contributing to the pressurization of the package cavity due to long-term evaporation of the moisture content in the wood. The applicant evaluated a saturation pressure of 2.6 psi for water/moisture at the peak inner shell temperature (i.e., 136°F) from Table 4.2.19, "Mark's Standard Handbook for Mechanical Engineers," 10th Edition (Reference #29 listed in Section 3.5.1, "References," of the application).

This information is required to determine compliance with 10 CFR 71.71(c)(4).

***Th-3 Response*:** Since the referenced table is part of a copyrighted source, AFS cannot legally include the table in the application. However, the reference (Mark's Standard Handbook) is widely available. As discussed in the teleconference on April 12, the staff member no longer requires this information.

RAI-Th-4 Estimate impact of the loss of polyurethane foam during a HAC fire, including both the 30-minute transient fire and its post-fire cooldown. As part of your response, explain the following:

a. whether a loss of <u>more than</u> 2.7 inches of polyurethane from is needed to reflect the feature in the HAC 30-minute fire, and
b. whether a loss of polyurethane foam can be less conservative in the post-fire cooldown and even in a HAC fire event.
c. how the safety margins for a fire event will be maintained.

As described in Section 3.4.1, "Initial Conditions," the applicant modeled the HAC fire by assuming a loss of 2.7 inches of polyurethane foam from the impact limiter due to thermal decomposition to enhance heat input into the package during the HAC 30-minute fire. The staff needs to verify how safety margins are maintained.

This information is required to determine compliance with 10 CFR 71.73(c)(4).

Th-4 Response: The upper impact limiter of the 380-B is designed to prevent the elastomeric containment seals in the 380-B package from exceeding their allowable temperatures during the regulatory HAC fire event. The impact limiter is fabricated from General Plastics Manufacturing Co. LAST-A-FOAM® FR-3700 rigid polyurethane foam encased in a stainless steel shell. This polyurethane foam offers a variety of mechanisms to mitigate thermal assault as stated in Reference 12 (hereinafter, [12]) of Chapter 3, namely:

- low thermal conductivity
- self-extinguishing chemistry
- the endothermic dissociative mechanisms from polymer to gas and intumescent char
- the gas transport of heat from inside the impact limiter to outside the package

These mechanisms are noted in Section 3.5.4, '*Last-A-Foam' Response under HAC.*

Several conservativisms, described in Section 3.5.3.5, were included in the thermal model of the impact limiter to simulate the worst case thermal protection that the impact limiter will provide these cask components. One conservativism is the immediate removal, at the start of the fire, of the maximum amount of foam expected to gradually thermally decompose over the course of the regulatory fire event. The resulting void space is conservatively modeled as air with added heat transfer via radiation within the impact limiter enclosures with an emissivity of 0.925. This method conservatively neglects additional thermal protection due to the formation intumescent char when the polyurethane foam decomposes.

The maximum foam recession depth after 30-minutes of exposure was determined using the correlation published by General Plastics Manufacturing Co. for their FR-3700 series polyurethane foam [12]. The correlation was developed by experimental testing of nominal foam densities of 6.74 to 25.77 pcf and is valid within this density range. The correlation is:

$$y = -0.94681 - 11.64 \times \log(x)$$

where: y - the recession depth at the end of 30-minutes of exposure, cm

x - the nominal foam density (g/cm³)

Note: The density used in the correlation above is measured at ambient temperature using similar methods to those employed by Section 8.1.5.1.2.3.1.

The foam in the 380-B is specified as being 16 pcf foam with a ±15% allowable manufacturing tolerance (13.6 to 18.4 pcf). Because the recession depth is inversely related to density, the low tolerance density (i.e. 13.6 pcf or 0.218 g/cm³) is used in the correlation above to predict a maximum expected recession of 2.7 inches.

The reference [12] also notes that this correlation is only valid if there is no "chimney effect" where hot combustion gases impede the formation of the intumescent char. There was no damage observed to the impact limiter during the HAC free drop and puncture events that would indicate this could occur. Therefore, it is the applicant's position that a recession depth of more than 2.7 inches of polyurethane is not required to predict the bounding safety related component temperatures in the HAC fire event.

If the 380-B impact limiter were manufactured at the highest acceptable density (i.e. 18.4 pcf) there would be less recession, which would result in less heat reaching the cask lid, and thus lower cask component temperatures at the end of the fire. In addition, the payload decay heat of 205 W is insignificant relative to the heat load of the fire. This assertion is justified by the rapid decrease in peak temperatures of the cask components near the impact limiters at the end of the fire as observed in Figure 3.4-5. Therefore, explicit modeling of lower bound foam recession is not required to establish the thermal performance of the 380-B.

The polyurethane foam is allowed to thermally decompose in the HAC fire event. Thus, this component does not have a maximum allowable temperature or related safety margin as shown in Table 3.4-1. The temperature of the modeled foam at the end of the fire is presented in Figure 3.4-1.

Section 3.5.3.5 and Section 3.5.4 have been revised to improve clarity in the discussion of the treatment of the polyurethane foam in the thermal analysis.

RAI-Th-5 Provide the convection heat transfer coefficients used in the model analyses for the HAC 30-minutes transient fire and its post-fire cooldown.

The applicant stated in Section 3.4.2, "Fire Tests Conditions," of the application that the convection heat transfer coefficients between the package and the ambient air during the HAC 30-minute fire event are derived based on an average gas velocity of 10 meters per second (m/s). Following the 30-minute fire event, the convection heat transfer coefficients are derived based on still air in the post-fire cooldown.

Instead of "based on an average gas velocity of 10 m/sec during the 30-minute fire and based on still air in the post-fire cooldown," the applicant needs to provide values of the convection heat transfer coefficients (with units) used in the model analyses for the HAC 30-minutes transient fire and its post-fire cooldown.

This information is required to determine compliance with 10 CFR 71.73(c)(4).

***Th-5 Response*:** The heat transfer convection coefficients used in the thermal analysis of the 380-B vary over the surface in accordance with the orientation, shape, and temperature of the surface. Section 3.5.3.6 has been revised to state the range of convection coefficients that are used in NCT and in the HAC post-fire analysis. In addition, the constant convection coefficient used during the HAC fire is more completely detailed. Section 3.5.1 has been revised to include an additional reference.

RAI-Th-6 Demonstrate the adequacy of the bounding solar absorptivity value described in Section 3.4.2 of the application for the package exterior surfaces during the HAC post-fire cooldown.

The applicant stated in Section 3.4.2 of the application that the ambient condition of 100°F with insolation is assumed following the HAC 30-minute fire event. A solar absorptivity of 0.9 is assumed for the exterior surfaces to account for potential soot accumulation on the package surfaces during the post fire cooldown.

NUREG 1609 recommends the use of a bounding absorptivity of 1.0 for the package exterior surfaces to maximize the solar heat input to the package and use of a solar emissivity of less than 0.8 in order to minimize the decay heat out of the package during the post-fire cooldown.

This information is required to determine compliance with 10 CFR 71.73(c)(4).

***Th-6 Response*:** NUREG-1609, page 3-10, states that the post-fire period shall include "full insolation". This is interpreted to mean that the solar absorptivity must be equal to 1.0. The thermal analysis has been revised to use a solar absorptivity of 1.0 during the fire and in the post-fire cooldown period. The SAR text has been changed in Section 3.2.2, Section 3.4.1, Section 3.4.2, and Section 3.5.3.5. Table 3.1-1 and Table 3.4-1 have been updated.

RAI-Th-7 Provide and include a description of a temperature survey in Section 7.1.3 of the application to ensure that the limit specified in 10 CFR 71.43(g) (for an exclusive use shipment) is not exceeded.

The applicant stated in Section 7.1.4 of the application that the user needs to verify that the total heat is less than or equal to 205 watts to meet the decay heat limit for the package. Besides the limit of heat load, the applicant needs to provide and include a description of a temperature survey in Section 7.1.3, "Preparation of the Package for Transport," of the application to verify that the limit of 185°F, specified in 10 CFR 71.43(g) for an exclusive use shipment, is not exceeded.

This information is required to determine compliance with 10 CFR 71.43(g) and 71.87(k).

***Th-7 Response*:** 10 CFR §71.87(k) requires the licensee to ensure that the accessible surface temperature will not exceed the limits of 10 CFR §71.43(g) at any time during shipment. This is has been done by analysis of accessible surface temperature provided in Chapter 3 of the application. The evaluation presented in Chapter 3 is based on well-established heat transfer properties and methodologies. Due to the presence of the personnel barrier, the peak accessible temperature is reported in Table 3.1-1 as 103 ºF. The calculated peak temperature takes into account the maximum decay heat, a steady ambient temperature of 100 ºF, and applies to the fully equilibrated condition. This temperature is only 3 °F above ambient, and the requirement of 10 CFR §71.87(k) is easily met by a conservative thermal analysis. Note also that a maximum temperature of 185 °F is permitted by 10 CFR §71.43(g) for exclusive use shipments. This temperature cannot be approached by the 380-B package under any scenario. Consequently, a physical temperature survey is not necessary.

Performing a physical temperature survey is fraught with difficulties. At the time of the survey, the ambient temperature could be less than 100 °F, but could rise during transport, invalidating the initial measurement. In addition, a considerable length of time (days) would be needed before the package would reach thermal equilibrium. During this time, the ambient temperature would be varying through a day-night cycle, and could be changing due to weather conditions. If it is necessary to store the package outdoors, varying solar conditions would come into play. Thus, it would be nearly impossible to take a measurement from the accessible surface of the package that relates in a meaningful way to the requirement of 10 CFR §71.87(k). The only practical way to determine that the requirement of 10 CFR §71.87(k) is met is by the analysis presented in Chapter 3 and by following the loading procedure prescribed in Chapter 7.

Additional Changes Made to the Revision 1 SAR:

- Drawing 1916-02-03-SAR, Sheet 1, General Note 4 has been revised to include intermittent and tack welds along with seal welds as not requiring liquid penetrant examination. This is to avoid false indications at the ends of seal, intermittent, and tack welds.
- A typographical error has been corrected in Section 2.6.4, page 2.6-9, 4th paragraph: Table 1-1 has been corrected to Table 2.1-1.
- In Section 7.1.2, the required visual inspections of packaging components may now be performed at any time during the loading sequence. This change makes it possible for any conditions requiring correction to be identified and corrected prior to loading the cask. The following sentence has been added at the beginning of Section 7.1.2:

  "NOTE: The visual inspections of packaging components delineated in the following steps may be performed at any time during the loading sequence."
- In Section 7.1.2, an option has been added to permit the lifting slings used to load the payload into the cask to be left in the cask during transport, for later use in unloading the cask. The potential for gas generation from the non-metallic sling materials under the HAC fire event is evaluated in the new Section 3.4.3.2. Step #12 of Section 7.1.2 has been revised to read:

  "Lower the shielded device into the cask, along with dunnage as necessary. As an option, lifting slings made of steel, nylon, polyester, or Kevlar© may be left inside the cask during transport."
- In Section 7.1.2, an additional requirement was included to visually inspect the O-ring grooves if the O-rings are removed. Removal of the O-rings remains optional. If the O-rings are removed, however, the groove surfaces must be inspected for damage that could affect the leak tight capability of the seal. Step #15 of Section 7.1.2 has been revised to read:

  "As an option, remove and sparingly apply vacuum grease to the O–ring seals and/or sealing surfaces, and reinstall the O–rings into the grooves in the closure lid. NOTE: If the O-rings are removed, perform a visual surface finish inspection of the O-ring grooves for scratches or dents that could impair containment integrity. If necessary, repair the damaged surfaces per Section 8.2.3.2, *Sealing Area Routine Inspection and Repair.*"

- In order to vent the cask cavity prior to removing the closure lid, Section 7.2.2 has been revised to include a new Step 1 which reads:

  "Remove the vent port cover, and loosen the vent port plug to vent the cask cavity."

---END---

Section	RAI	Change/Revision
1.1 (footnote)	Co-2	Changed issue of ANSI N14.5 from 1997 to 2014.
1.2.1.1	M-5	Removed option for cast material.
1.2.1.1	M-10	Added "(in any grade)" after "ASTM B29".
1.2.2	M-4	Added clarification to description of contents and added a schematic of contents configuration (Figure 1.2-6).
1.3.1	Co-2	Changed issue of ANSI N14.5 from 1997 to 2014.
1.3.2	M-5	Modified definitions to remove the word "forging".
Drawing 1916-02-02-SAR	M-5	List of Materials: remove cast material and revise the names of Items 14, 17, and 18
Drawing 1916-02-02-SAR	M-10	List of Materials: specify "any grade" of ASTM B29 lead for Items 16 and 28.
Drawing 1916-02-02-SAR	M-5	Delete Flag Note 20 (inspections of cast material).
Drawing 1916-02-02-SAR	M-5	Sheet 2, revise terminology in Flag Note 25 and General Note 35.
Drawing 1916-02-02-SAR	Co-1	Sheet 4, Zone C-1, revise dimension from 5.1 to 5.13.
Drawing 1916-02-02-SAR	M-16	Sheet 4, Zone B-4, add minimum gap size to lead cavity.
Drawing 1916-02-03-SAR	St-1	Sheet 3, Zone B-5, add dimensions of Item no. 3 to drawing.
Drawing 1916-02-03-SAR	---	Sheet 1, General Note 4, include intermittent and tack welds along with seal welds as not requiring liquid penetrant examination.
2.1.2.3.2.1	Th-2	Updated pressure fatigue analysis for changed fill gas temperature.
2.2	M-10	Added "(in any grade)" after "ASTM B29".
2.2	M-6	Added footnote 7 to Table 2.2-1 to include ASTM A276. Note: none of the material properties in the table have changed.
2.2	M-7	Table 2.2-1 and Table 2.2-2, Changed the heading of column 5 to "Design Stress Intensity".
2.2	M-8	Added a row to Table 2.2-3 showing properties at 800 °F. Note: none of the material properties in the table have changed, except for the added row at 800 °F.
2.2	---	Editorial change: placed reference to existing footnote 6 in title of Table 2.2-1, Table 2.2-2, and Table 2.2-3.
2.2	M-10	Added "(any grade)" to column 1 of Table 2.2-4. Note: none of the material properties in the table have changed.

Section	RAI	Change/Revision
2.2	M-11	Added properties to Table 2.2-5.
2.3.2	M-5	Removed inspections for cast material.
2.6.4	---	Corrected typographical error.
2.7.1.2, 2.7.1.3, 2.7.4.1 & 2.7.4.3	M-5	Clarified that the allowable strength is for forged material.
2.7.1.2, 2.7.1.3, & 2.7.8	St-2	Added margin of safety calculations for HAC stress evaluations and revised summary Table 2.7-2.
2.12.1	Co-2	Changed issue of ANSI N14.5 from 1997 to 2014.
2.12.1	M-11	Added references required by Chapter 2 text revisions.
2.12.2.2.1	Th-1	Revised average foam temperature for consistency with revised thermal results.
2.12.4.4	St-3	Clarified text regarding stress linearization.
2.12.4.4.4, 2.12.4.4.6, 2.12.4.4.8, & 2.12.4.6	St-2	Added margin of safety calculations for HAC stress evaluations, added summary Table 2.12.4-2, and Figure 2.12.4-44a, Figure 2.12.4-44b, & Figure 2.12.4-44c. Added information to Figure 2.12.4-47.
2.12.5.3.1 & 2.12.5.3.3.4	Th-1	Revised average foam temperature for consistency with revised thermal results.
2.12.5.6.1	St-4	Added text discussing benchmark and analysis comparisons, and revised Figures 2.12.5-24, 2.12.5-25, and 2.12.5-26.
3.1.1	M-5	Changed "forgings" to "structures".
3.1.1	M-10	Added "any grade of" before "ASTM B29".
3.1.2	M-4	Referenced new Figure 1.2-6.
3.1.2	Th-1	Added to discussion of first and second heat disposition scenarios.
3.1.2	Th-1, Th-2, Th-6	Revised Table 3.1-1 and Table 3.1-2 to update terminology, to add specific results for the closure bolts and vent port sealing washer, to update temperature results, and pressure results.
3.1.4	Th-2	Revised maximum pressure for revised gas temperature.
3.2.1	M-10	Added "any grade of" before "ASTM B29".
3.2.2	Th-6	Added bullet to discuss solar absorptivity after fire.
3.2.3	---	Added leak tight criteria of 430 °F for one hour to O-ring capability data.
3.2	M-10	Added "(any grade)" to column 1 of Table 3.2-1.
3.3.1.1	M-5	Changed "forging" to "end structure" and revised discussion of temperatures.

Section	RAI	Change/Revision
3.3.2	Th-2	Revised the calculation of MNOP using a conservative representation of bulk gas temperature.
3.3	Th-1, Th-2, Th-6	Revised Table 3.3-1 and Table 3.3-2 to update terminology, to add specific results for the closure bolts and vent port sealing washer, and to update temperature results.
3.3	Th-2	Revised Table 3.3-3 consistent with the revisions to Section 3.3.2.
3.3	Th-1, Th-2, Th-6	Revised Figures 3.3-1 through 3.3-8 consistent with the revised thermal analysis.
3.4.1 and 3.4.2	Th-6	Revised solar absorptivity after fire to 1.0.
3.4.3	Th-1, Th-2, Th-6	Revised the discussion of maximum temperatures.
3.4.3.1	Th-1, Th-2, Th-6	Revised the maximum pressure based on revised bulk gas temperature.
3.4.3.2	M-4	New section added to address non-metallic materials in the cask.
3.4	Th-1, Th-2, Th-6	Revised Table 3.4-1 to update terminology, to add specific results for the closure bolts and vent port sealing washer, and to update temperature results.
3.4	M-4	Added Table 3.4-2 in support of the new Section 3.4.3.2.
3.4	Th-1, Th-2, Th-6	Revised Figures 3.4-1 through 3.4-7 consistent with the revised thermal analysis.
3.5.1	Th-1, Th-2, Th-6	Updated Thermal Desktop and SINDA/FLUINT references.
3.5.1	M-4	Added references for behavior of non-metallic materials in support of new Section 3.4.3.2.
3.5.3.1	M-5	Changed “forgings” to “end structures”.
3.5.3.1	Th-1	Added discussion concerning the first and second heat disposition scenarios.
3.5.3.5	Th-6	Added bullet to discuss solar absorptivity after fire.
3.5.3.5	Th-4	Added clarifying text regarding the behavior of foam in the HAC fire.
3.5.3.6	Th-5	Added a discussion of the heat transfer coefficients under NCT and HAC.
3.5.3.7	Th-1, Th-2, Th-6	Added new section describing the closure lid thermal model mesh refinement.

Section	RAI	Change/Revision
3.5.3.7	Th-1, Th-2, Th-6	Added Table 3.5-2 supporting the mesh refinement.
3.5.4	Th-4	Added clarifying text regarding the behavior of foam in the HAC fire.
4.1.2	M-5	Changed "forging" to "end structure".
4.1.4	M-5	Changed "forging" to "structure".
4.4.3	Co-3	Added text to clarify the options regarding preshipment leakage rate testing.
4.5	Co-2	Changed issue of ANSI N14.5 from 1997 to 2014.
5.5.4	Co-1	Added text to clarify the volume of hydrogen.
5.5.4	---	Editorial: Changed all table numbers from 5-X to 5.5-X.
5.5.4	Co-1	Added footnote to Table 5.5-6.
7.1.2	---	A new note permits the required visual inspections to be done at any time in the loading sequence.
7.1.2	M-4	Step 11 requires the polyurethane foam to be closed-cell type.
7.1.2	M-4	Step 11.c. includes a requirement to maintain a minimum clearance between the contents and the cask.
7.1.2	---	A new option permits the slings used in the loading operation to be left inside the cask during transport.
7.1.2	---	Step 15 includes the new requirement to visually inspect the O-ring grooves if the seals are removed.
7.1.2	Co-3	Step 22 has been clarified regarding the options for preshipment leakage rate testing.
7.1.4	Th-1	A new requirement has been added to limit the specific payload heat generation.
7.2.2	---	A new step #1 has been added to vent the payload cavity when unloading the cask.
7.5.1	Co-2	Changed issue of ANSI N14.5 from 1997 to 2014.
8.1.5.1.2.3.2	M-15	The procedure for measuring the compressive stress of the impact limiter foam has been revised to include the use of ASTM D1621.
8.1.6.1	M-16	Revised the acceptance criteria for the gamma scan.
8.3.1	Co-2, M-15	Changed issue of ANSI N14.5 from 1997 to 2014, and added a reference to ASTM D1621.