Orano TN
7160 Riverwood Drive
Suite 200
Columbia, MD 21046
USA
Tel: 410-910-6900
Fax: 434-260-8480

July 9, 2020
E-57025

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

Subject: Supplemental Information for Application for Revision 5 of Certificate of Compliance No. 9358 for the Model No. TN-LC, Docket No. 71-9358

Reference:
(1) NRC Certificate of Compliance for the Model No. TN-LC, USA/9358/B(U)F-96, Revision 4
(2) Packaging Safety Analysis Report for the Model TN-LC Package, Revision 6
(3) TN Americas letter dated April 23, 2020, Subject: Application for Revision of Certificate of Compliance No. 9358 for the Model No. TN-LC, Docket No. 71-9358
(4) NRC letter dated June 5, 2020, Subject: Amendment Request for the Model No. TN-LC Package – Request for Supplemental Information (EPID No. L-2020-LLA-0086)

In accordance with 10 CFR 71.38, TN Americas LLC (TN Americas) submitted an application to revise Certificate of Compliance (CoC) No. 9358 for the TN-LC packaging [3]. The current CoC 9358, Revision 4 [1], references the TN Americas consolidated application dated November 2012 [2], as supplemented. The NRC reviewed the application [3] and requested supplemental information to continue the acceptance review [4]. The supplemental information is provided as Enclosure 2.

Enclosure 3 provides the Safety Analysis Report (SAR) changed pages associated with Revision 9b. The Revision 9b changes are identified in the header with "Revision 9b, 04/20". Changes are indicated by italicized text and a revision bar in the right-hand margin. Enclosure 4 provides the public version of the Enclosure 3 pages. The new changes associated with this revision are further annotated with gray shading and an indication in the footer of the changed pages that the changes are associated with the discussion in this letter.

This submittal also includes an updated a Summary of Proposed Changes (Enclosure 5), which provides a description of the changes and justifications associated with the Revision 9 SAR. Changes in Enclosure 5 are tracked.

Additional changes have been submitted for Drawings 65200-71-01 Revision 9A and 65200-71-21 Revision 2A, and the description and justification for these changes have been added to the Enclosure 5 Summary of Changes as Items 1.5.1p

Enclosures transmitted herein contain SUNSI. When separated from enclosures, this transmittal document is decontrolled.

and 1.5.6, respectively. SAR drawing changes are shown as preliminary using the drawing revision number. These drawing changes will be submitted as final versions with the consolidated Revision 9 SAR after the NRC review is completed.

Certain portions of this submittal include proprietary information, which may not be used for any purpose other than to support the NRC staff's review of the application. In accordance with 10 CFR 2.390, TN Americas is providing an affidavit (Enclosure 1), specifically requesting that this proprietary information be withheld from public disclosure.

Should the NRC staff require additional information to support review of this application, please contact Peter Vescovi at 336-420-8325, or by email at peter.vescovi@orano.group.

Sincerely,

Don Shaw

Digitally signed by Don Shaw
Date: 2020.07.09 07:20:58 -04'00'

Don Shaw
Licensing Manager
TN Americas LLC

Electronic Information Exchange (EIE) Document Components:

001 NRC TN-LC RSI Response Transmittal Letter
002 Enclosure 1 Affidavit Pursuant to 10 CFR 2.390
003 Enclosure 2 RSI-OBS Responses
004 Enclosure 3 Changed Pages for SAR Revision 9b (Proprietary)
005 Enclosure 4 Changed Pages for SAR Revision 9b (Public)
006 Enclosure 5 Summary of Proposed Changes

cc: Pierre Saverot, Senior Project Manager, U.S. Nuclear Regulatory Commission
Peter Vescovi, Licensing Engineer, TN Americas LLC
Damien Sicard, Project Manager, TN Americas LLC

AFFIDAVIT PURSUANT
TO 10 CFR 2.390

TN Americas LLC)
State of Maryland) SS.
County of Howard)

I, Prakash Narayanan, depose and say that I am Chief Technical Officer of TN Americas LLC, duly authorized to execute this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.390 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is contained in Enclosure 3 and is listed below:

- Portions of certain chapters and appendices of the Safety Analysis Report (SAR) for Certificate of Compliance No. 9358 TN-LC, Revision 9b, Docket 71-9358 (Proprietary Version)

This document has been appropriately designated as proprietary.

I have personal knowledge of the criteria and procedures utilized by TN Americas LLC in designating information as a trade secret, privileged, or as confidential commercial or financial information.

Pursuant to the provisions of paragraph (b) (4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure involves certain design details associated with the SAR analyses, calculations, and SAR drawings for the TN-LC System, which are owned and have been held in confidence by TN Americas LLC.
2) The information is of a type customarily held in confidence by TN Americas LLC and not customarily disclosed to the public. TN Americas LLC has a rational basis for determining the types of information customarily held in confidence by it.
3) Public disclosure of the information is likely to cause substantial harm to the competitive position of TN Americas LLC because the information consists of descriptions of the design and analysis of a radioactive material transportation system, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with TN Americas LLC, take marketing or other actions to improve their product's position or impair the position of TN America LLC's product, and avoid developing similar data and analyses in support of their processes, methods or apparatus.

Further the deponent sayeth not.

A. Prakash

Prakash Narayanan
Chief Technical Officer, TN Americas LLC

Subscribed and sworn before me this 9th day of July, 2020.

Ronda Jones

Notary Public
My Commission Expires 10/16/2023

RONDA JONES
NOTARY PUBLIC
MONTGOMERY COUNTY
MARYLAND
MY COMMISSION EXPIRES OCT. 16, 2023

DOCKET NO. 71-9358

REQUEST FOR SUPPLEMENTAL INFORMATION (RSI) FOR THE MODEL NO. TN-LC PACKAGE

Containment Evaluation

Observations

Observation O-1:

Provide additional justification that the bounding fuel assembly as described in Section 4.6.1.1.2, "Parameters," of the application is the B&W 15x15 for the analysis in Appendix 4.6.1, "Containment Reference Leak Rate for 1FA Contents," of the application.

Section 4.6.1.1.2 of the application describes that the bounding fuel assembly is based on the maximum internal pressure for the TN-LC package during normal conditions of transport (NCT) and hypothetical accident conditions (HAC) based on the limiting fuel assembly type B&W 15x15 which has a maximum allowable heat load of 3 kW and a maximum burnup of 70,000 MWD/MTU.

However, for example, the bounding contents used for the analysis in Appendix 4.6.1 should also consider the radionuclides present, the releasable source term, initial enrichment, burnup, and minimum cooling time which could result in a numerically smaller NCT and HAC reference air leakage rate.

This is necessary to provide reasonable assurance that there would be no loss or dispersal of radioactive contents, as demonstrated to a sensitivity of 10^{-6} A_2 per hour during NCT, and that there would be no escape of krypton-85 exceeding 10 A_2 in 1 week, and no escape of other radioactive material exceeding a total amount A_2 in 1 week during HAC. Changing the bounding fuel assembly could change subsequent calculations in Appendix 4.6.1 of the application due to different input parameters.

This information is necessary to determine compliance with 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response to Observation O-1:

ORIGEN runs were performed to create a source term for the purpose of containment calculations. Radionuclides inventories resulting from various burnup, initial enrichment and cooling time combinations were created to determine a bounding inventory for use in the containment evaluation in Appendix 4.6.1. The revised criterion was incorporated in an update to chapter 8.

Impact:

Appendix 4.6.1 and Chapter 8 are revised as described in the response.

Observation O-2:

Provide justification that the NCT and HAC reference air leakage rate is acceptable for MOX contents, or alternatively describe the reference air leakage rate for the MOX contents to be leaktight.

Sections 4.2.3, “Containment Criterion,” and 4.3.3, “Containment Criterion,” of the application describe the containment criterion for NCT and HAC, respectively. Sections 4.2.3 and 4.3.3 of the application also describe that, for 1FA contents, a leak rate test criterion that is less restrictive may be used (as compared to leaktight in ANSI N14.5, “American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment.”

However, 1FA contents include MOX. Section 4.5.2,2, “Containment Criteria,” of NUREG-1617 Supplement 1, “Standard Review Plan for Transportation Packages for MOX Spent Nuclear Fuel,” describes that consideration should also be given to defaulting to the ANSI N14.5 leaktight criterion for the expected leakage test criterion for MOX spent nuclear fuel. See also Observation O-1.

This information is necessary to determine compliance with 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response to Observation O-2:

The containment evaluation presented in Appendix 4.6.1 applies to 1FA content at the exclusion of MOX fuel. For MOX fuel transportation (either fuel assembly or fuel pins), the leak-tight criterion applies.

Chapters 4 and 8 as well as Appendix 4.6.1 were updated to clarify this MOX fuel criterion.

Impact:

Chapters 4, 8 and Appendix 4.6.1 are revised as described in the response.

Observation O-3:

Provide more specific justification in Sections 4.6.1.1.2, “Source Activity Density Due to Release of Fines from Cladding Breaches,” and 4.6.1.1.3, “Source Activity Density Due to Release of Gaseous Fission Products and Volatiles from Cladding Breaches,” of the application, to demonstrate that the release of fines and volatiles can be neglected for the bounding content, or alternatively provide calculations in Appendix 4.6.1 of the application that include the release of fines and volatiles.

Sections 4.6.1.1.2 and 4.6.1.1.3 of the application describe that the contribution of fines and volatiles released as compared to the total source term are each less than 1% of the total; therefore, the release of fines and volatiles is neglected in this analysis. The application references NUREG/CR-6487, “Containment Analysis for Type B Packages Used to Transport Various Contents,” which describes sample containment analyses and examples of leakage rate calculations for Type B packages used to transport various radionuclide contents. However, the application does not provide a basis to justify that the releases of fines and volatiles can be neglected for the bounding content that is consistent with the guidance. If providing calculations, NUREG-1617, “Standard Review Plan for Transportation Packages for Spent Nuclear Fuel,” Agencywide Documents Access and Management System (ADAMS) No. ML003696262, provides guidance on release fractions and effective specific activities for the releasable source term contributors for spent nuclear fuel with an initial enrichment of 3.2%, a burnup of 33,000 MWd/MTIHM, and a cooling time of 5 years, and draft NUREG-2224, “Dry Storage and Transportation of High Burnup Spent Nuclear Fuel,” ADAMS No. ML18214A132, provides additional guidance on the release fractions for high burnup fuel. This is necessary to provide reasonable assurance that there would be no loss or dispersal of radioactive contents, as demonstrated to a sensitivity of 10^{-6} A_2 per hour during NCT, and that there would be no escape of krypton-85 exceeding 10 A_2 in 1 week, and no escape of other radioactive material exceeding a total amount A_2 in 1 week during HAC.

This information is necessary to determine compliance with 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response to Observation O-3:

Multiple detailed and dedicated ORIGEN runs were performed for the purpose of containment in order to evaluate various radionuclides inventories from various burnup, initial enrichment and cooling time combinations to come up with a bounding inventory to be used in the containment evaluation in Appendix 4.6.1, including fuel fines and volatiles in addition to fission gases.

The output of this inventory evaluation consists of a bounding number of A_2 for each of the fuel fines, volatiles and fission gases release forms. It is used as the input to the new revision of Appendix 4.6.1.

The guidance from NUREGs 1617, and 2224 in addition to 6487 was also used to develop the bounding release fractions for each release form for both NCT and HAC used in the new revision of Appendix 4.6.1. The revised criterion was incorporated in an update to Chapter 8.

Impact:

Appendix 4.6.1 and Chapter 8 are revised as described in the response.

Shielding Evaluation

RSI-1:

Provide an evaluation that demonstrates that the Unit 01 packaging loaded with the remaining currently approved contents (i.e., the contents besides the PWR UO_2 contents) for a package fabricated within the design specifications will meet the regulatory radiation level limits in 10 CFR Part 71.

The Unit 01 packaging has thinner lead radial shielding than the currently approved package design allows. Thus, the applicant has submitted some analyses to show the Unit 01 packaging meets regulatory requirements. However, the shielding analysis has only evaluated for the PWR (UO_2) assembly and PWR rods (UO_2) contents. There are other contents, including but not limited to BWR, EPR and MOX assemblies and rods, for which the package design has been approved, but for which nothing has been provided to show the Unit 01 packaging will meet the radiation level limits in 10 CFR Part 71.

Provide analyses for these other contents or a demonstration that PWR (UO_2) assembly and PWR rods (UO_2) contents bound the other contents in regards to meeting the radiation level limits in 10 CFR Part 71.

This information is necessary to determine compliance with 10 CFR 71.35(a), 71.47, and 71.51(a).

Response to RSI-1

The Certificate of Compliance (CoC 9358) Revision 5 for the as-built TN-LC Unit 01 includes only the 1FA PWR (UO_2) assembly and PWR rods (UO_2) contents. A condition for TN-LC Unit 01 should be added to the CoC that only allows 1FA PWR (UO_2) assembly and PWR rods (UO_2) contents. The approved contents for the TN-LC package design remains unchanged.

Impact:

No change as a result of this RSI.

RSI-2:

Provide the evaluation information described for proposed change ‘Item 1.5.3c’ (i.e., the addition of four optional slots in the 1FA Basket walls).

The justification for the proposed change (see pages 13 and 14 of 31 of the ‘Summary of Proposed Changes’) states that the shielding analysis has been updated to include the effects of this proposed change. However, the staff was unable to find information regarding this change in the shielding evaluation section of the application.

This information is necessary to determine compliance with 10 CFR 71.35(a), 71.47, and 71.51(a).

Response to RSI-2:

The optional slots of approximately 1/2” wide and up to 2” tall located on top of the basket are not expected to increase significantly the limiting dose rate, which is the 2 m from vehicle side; therefore, no further shielding sensitivity is needed for the proposed change.

Impact:

No change as a result of this RSI.

Shielding Observations

Observation O-1:

Confirm the minimum cooling times for the new Table 1.4.5-10a of the application.

This table provides minimum cooling times for UO_2 PWR fuel rods in the Unit 01 packaging, which has less radial lead shielding than the currently approved package design. The equivalent table for the approved package design is Table 1.4.5-10 of the application. With less radial shielding, minimum cooling times should increase in order to ensure radiation levels meet regulatory limits (i.e., the cooling times in Table 1.4.5-10a of the application should be longer than those in Table 1.4.5-10 of the application). However, the opposite is true in the currently provided tables (cooling times in Table 1.4.5-10a are less than those in Table 1.4.5-10). This would not appear to be correct. Also, decay heat limits for the fuel rods remaining unchanged from the currently approved values would also indicate that minimum cooling times should not decrease.

This information is necessary to determine compliance with 10 CFR 71.35(a), 71.47, and 71.51(a).

Response to Observation O-1:

As mentioned in Section 5.6.4.2.1 of Appendix 5.6.4, each Fuel Qualification Table (FQT) entry is developed to maintain external dose rates below the regulatory limit, which is the dose rate at 2 m from the side of the vehicle. For the 25-UO_2 rods can considered in the analysis, 7.69 mrem/hr was used as the design criteria to meet the regulatory limit at 2 m when developing FQTs for fuel rods.

Appendix 1.4.5 Table 1.4.5-10 showed the FQT for 21 PWR/EPR fuel rods (UO_2). Note that the dose rates for burnup of 10 GWd/MTU, across enrichments from 0.7 wt% to 5 wt% and associated cooling times rounded conservatively to 0.25 year cooling time (0.3 year cooling time for enrichment 0.7 wt% and 0.8 wt%), were actually in the range of 5.20 mrem/hr. The dose rates for burnup of 20 GWd/MTU, across enrichments from 0.7 wt% to 5 wt% and associated cooling time rounded conservatively to 0.25 year cooling time, were actually in the range of 6.50 mrem/hr. Actually, in many instances for burnup up 45 GWd/MTU, the cooling times were conservatively rounded to 0.25 year, which resulted in dose rates below or well below 7 mrem/hr. The cooling times in Table 1.4.5-10 also were rounded to the next 0.00 or the next 0.05 year.

Appendix 1.4.5 Table 1.4.5-10a shows the FQT for 21 PWR fuel rods (UO_2) for the TN-LC Unit 01 with a reduced lead thickness condition. The dose rates for the burnup/enrichment/cooling time combinations across Table 1.4.5-10a are all shy of 7.69 mrem/hr; for example the dose rate for 10 GWd/MTU, 0.9 wt%, 0.191 year cooling time is 7.65 mrem/hr as opposed to 5.04 mrem/hr for the 10 GWd/MTU, 0.9 wt%, 0.205 year cooling time (rounded to 0.25 year) combination shown in Appendix 1.4.5 Table 1.4.5-10. The effect of the reduced lead thickness is reflected in term sof dose rate.

Cooling times in Appendix 1.4.5 Table 1.4.5-10a have been revised to conservatively bound those in Appendix 1.4.5 Table 1.4.5-10 to prevent further confusion.

Impact:

Appendix 1.4.5, Table 1.4.5-10a has been revised as described in the response.

Observation O-2:

Ensure consistency of the characterization and description of the fuel pin can.

The application is inconsistent regarding the description of the fuel pin can. In addition to the changes in the provided change pages, additional places within the application still refer to the pin can as containing 25 fuel pins or being the 25 pin fuel can. However, with the modifications to the can design, it can no longer contain 25 rods. Thus, all places in the application describing the fuel pin can should remove the '25' from the description as has been done in some of the submitted change pages. Even in the provided change pages, it is not clear that the change to the fuel pin can description has been done in all locations where it is needed.

This information is necessary to determine compliance with 10 CFR 71.33, 71.35(a), 71.47, and 71.51(a).

Response to Observation O-2:

The original design of the pin can permitted loading of 25 individual fuel pins. A design change during fabrication modified the four corner fuel pin tubes to accommodate lid fastening bolts, which resulted in the capacity of the pin can being reduced to 21 fuel pins. However, previous evaluations done considering 25 pins bound the new pin can design and, therefore, these evaluations were kept. Since the pin can was previously referred to throughout the SAR as "25 pin can", efforts were made to correct this in the SAR by replacing most instances with simply "pin can", except for those instances referring to evaluations of the original pin can performed using 25 pins, which were not changed from "25 pin can" to "pin can" in an attempt to clearly identify evaluations where 25 pins were conservatively considered. However, the changes are not consistent throughout the SAR. Instead of making these changes consistent throughout the SAR, the following statement is added to Appendix 1.4.5, to clarify the use of either "25 pin can" or "pin can" to mean the new pin can design that holds only 21 fuel pins:

> "25 pin can" or "pin can" refers to the 1FA basket pin can that is designed to hold 21 fuel pins.
>
> Evaluations done with the "25 pin can" bound the pin can design.

Impact:

Appendix 1.4.5, Section 1.4.5.1 has been revised as described in the response.

Observation O-3:

Provide the acceptance criterion for the proposed alternative gamma shielding acceptance test described in Section 8.1.6.1 of the application, and provide justification that this method is adequate to identify localized areas where the lead gamma shielding is inadequate.

The applicant has proposed a dimensional and weight check to confirm the average density of each part of the package. No acceptance criterion appears to be provided. Also, it is not clear how this test will be adequate to identify localized areas of inadequate gamma shielding. Using an average density, particularly for sufficiently large 'parts' of the packaging would not be as effective as a gamma scan because the presence of areas of inadequate shielding could be masked by the presence of areas with more than adequate gamma shielding.

Further, it is not clear that the method would provide a means for identifying where the areas of inadequate shielding are located within the packaging 'part'. It is also not clear how the term 'part' would be defined for the purpose of the test. Appropriate detail should be added to the description of the test in the application to ensure it is adequate to identify areas of localized inadequate gamma shielding, or the application should be revised to remove this proposed alternative.

This information is needed to confirm that the packaging acceptance tests are sufficient to ensure the as-fabricated package will perform as designed to meet the requirements of 10 CFR 71 Subpart E, particularly 10 CFR 71.47 and 71.51(a) for shielding, consistent with 10 CFR 71.85(a).Re-evaluate the closure lid and cask top flange interface design and perform the necessary numerical simulation analysis to substantiate the statement, "The maximum separation between the lid and cask body during the impact is 0.047 in. This gap occurs for a short duration, and the gap is closed subsequently." See Appendix 2.13.7, Page No. 2.13.7-8.

Considering the maximum calculated separation or bolt elongation of 0.047", the twenty (20) 4-inch long by 1-inch diameter SA-540 Graded B23 Class 1 bolts shown in Drawing 65200-71-01 appear to have undergone inelastic deformation during the 30-ft cask free end-drop hypothetical accident condition. Evidence of the inelastic deformation is shown by a permanent lid separation of more than 0.02" between the lid and cask body, as displayed in Figures 2.13.7-14 and -21. The calculated permanent lid separation of the 30-ft cask end-drop accident, per 10 CFR 71.73(c)(1), does not meet the regulations because "inelastic deformation of the containment closure system (e.g., bolts and flanges) is unacceptable for the containment evaluation."

This information is necessary to determine compliance with 10 CFR 71.73(c)(1).

Response to Observation O-3:

The acceptance test described in Section 8.1.6.1 has been revised to reflect more correctly that the specification for all lead shielding is a gamma scan. Lead shielding is either poured in place or fabricated from precast block of lead.

The following is a list of lead in the TN-LC cask and TN-LC-1FA 25 pin can basket. All lead shielding in the packaging parts was verified by gamma scan.

The main cask body radial gamma shield that was poured in place and verified by gamma scanning:

- Drawing 65200-71-01

  Item 9 Gamma Shielding – Cask body annulus

The following parts were machined from a precast block of lead that were also verified by main cask body radial gamma scanning:

- Drawing 65200-71-01

  Item 3D Gamma Shielding – Lid
  Item 5C Gamma Shielding – Bottom Flange
  Item 8D Gamma Shielding – Bottom Plug

- Drawing 65200-71-102

  Item 15 Top Gamma Shield
  Item 17 Bottom Gamma Shield

Impact:

Section 8.1.6.1 has been revised as described in the response.

Enclosure 3

Proprietary Document

Changed Pages for SAR Revision 9b

Withheld Pursuant to 10 CFR 2.390

Enclosure 4 to E-57025

Changed Pages for SAR Revision 9b

(Public Version)

Proprietary and Security Related Information
for Drawing 65200-71-01, Rev. 9A
Withheld Pursuant to 10 CFR 2.390

Proprietary and Security Related Information
for Drawing 65200-71-21, Rev. 2A
Withheld Pursuant to 10 CFR 2.390

Appendix 1.4.5
TN-LC-1FA Basket

NOTE: References in this Appendix are shown as [1], [2], etc. and refer to the reference list in Section 1.4.5.3.

1.4.5.1 TN-LC-1FA Basket Description

The TN-LC cask is designed to contain the TN-LC-1FA basket assembly, with either (a) one fuel assembly (PWR or BWR) or (b) one pin can with up to *21* fuel rods (and spacers) while remaining completely supported by the transport cask *"25 pin can" or "pin can" refers to the 1FA basket pin can that is designed to hold 21 fuel pins. Evaluations done with the "25 pin can" bound the pin can design.*

The basket structure is designed, fabricated and inspected in accordance with ASME B&PV Code Subsection NG [1]. Alternatives to the code are provided in Chapter 2. The overall length of the basket is 181.5 in. and has a diameter of 17.5 in. The details of the TN-LC-1FA basket are shown on drawing 65200-71-90, 65200-71-96 and 65200-71-102 in Chapter 1, Appendix 1.4.1.

The PWR basket structure consists of a thick square-shaped welded *or bolted* tube assembly which is attached to the solid aluminum support rails. The poison plate is sandwiched between each rail and frame on all four sides of the compartment. The BWR compartment, which slides inside the PWR compartment (to accommodate the smaller cross section of a BWR assembly), is comprised of a 17.5 inch long hold-down ring and a 164 inch long BWR sleeve. The hold-down ring is designed for BWR fuel assembly loading to provide lateral clearance for a fuel grapple, if necessary. After fuel loading, the hold-down ring is installed to provide continuous transfer of basket loads to the cask.

The minimum B-10 areal density of the poison plate is 16.7 mg/cm^2 if boron aluminum alloy or metal matrix composite (MMC) is used. The minimum B-10 areal density of the poison plate is 20.0 mg/cm^2 if Boral® is used.

The basket structure is open at each end. Therefore, longitudinal fuel assembly or fuel pin can loads are applied directly to the cask body and not the fuel basket structure. The fuel assembly or fuel pin can is supported laterally by the stainless steel tube assembly. The basket is supported laterally by the basket rails and the cask shell. The solid aluminum basket rails are oriented parallel to the axis of the cask and are attached to the periphery of the basket to provide support and to establish and maintain basket orientation.

The pin can is a welded 5x5 square array of stainless steel 1 in. tubes which are wrapped in a stainless steel plate and slides inside the BWR basket. The top of the pin can has a bolted closure lid*, and the four corner tubes are shortened at the top to install four solid rods: two with threads for the lid bolts and two with locating pins to facilitate installation of the lid underwater*. The closure lid has *threads to attach a* lifting handle to allow handling of the pin can.

A shear key, welded to the inner wall of the cask, mates with a notch in a basket support rail to prevent the basket from rotating during normal operations.

All Indicated Changes are in response to Shielding O-2

Table 1.4.5-10a
Fuel Qualification Table for 21 PWR Fuel Rods (UO_2) - 3.10" Lead Thickness

(Minimum required years of cooling time after reactor core discharge)

Burn-up, GWd/MTU	Initial Assembly Averaged 235-U Enrichment, wt.%.																																					
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
10	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
20	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
30			0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
39					0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
40												0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
45												0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
50												0.35	0.35	0.35	0.35	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
55												0.37	0.37	0.37	0.36	0.36	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
60												0.50	0.49	0.48	0.47	0.47	0.46	0.45	0.45	0.44	0.44	0.43	0.43	0.42	0.42	0.41	0.41	0.41	0.40	0.40	0.40	0.39	0.39	0.39	0.38	0.38
61												0.53	0.52	0.51	0.5	0.5	0.49	0.48	0.47	0.47	0.46	0.46	0.45	0.44	0.44	0.44	0.43	0.43	0.42	0.42	0.42	0.41	0.41	0.41	0.40	0.40
62												0.56	0.55	0.54	0.53	0.53	0.52	0.51	0.5	0.49	0.49	0.48	0.48	0.47	0.46	0.46	0.45	0.45	0.44	0.44	0.44	0.43	0.43	0.43	0.42	0.42
65																							0.56	0.55	0.55	0.54	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.49	0.49	0.49
70																							0.71	0.70	0.69	0.68	0.67	0.67	0.66	0.65	0.65	0.64	0.63	0.62	0.62	0.61
75																							0.87	0.86	0.85	0.84	0.83	0.82	0.8	0.79	0.79	0.78	0.77	0.76	0.75	0.75
80																							1.04	1.03	1.01	1.00	0.99	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89
85																							1.24	1.22	1.20	1.18	1.16	1.15	1.13	1.12	1.10	1.09	1.08	1.06	1.05	1.04
90																							1.47	1.44	1.41	1.39	1.37	1.34	1.32	1.3	1.29	1.27	1.25	1.23	1.22	1.20
Enr. wt.%	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0

Note:

1. Explanatory notes and limitations regarding the use of this table follow Table 1.4.5-14.

All Indicated Changes are in response to Shielding O-1

Chapter 4
Containment

TABLE OF CONTENTS

4.1 Description of Containment System *4-1*
4.1.1 Containment Boundary *4-1*
4.2 Containment under Normal Conditions of Transport (Type B Packages) *4-4*
4.2.1 Containment of Radioactive Material *4-4*
4.2.2 Pressurization of Containment Vessel *4-4*
4.2.3 Containment Criterion *4-4*
4.3 Containment under Hypothetical Accident Conditions (Type B Packages) *4-5*
4.3.1 Source Term *4-5*
4.3.2 Containment of Radioactive Material *4-5*
4.3.3 Containment Criterion *4-5*
4.4 Special Requirements *4-6*
4.5 References *4-7*
4.6 Appendices *4-7*
4.6.1 Containment Reference Leak Rate for 1FA Contents (Excluding MOX) *4-7*

LIST OF FIGURES

Figure 4-1 TN-LC Cask Containment *4-8*

The containment vessel is hydrostatically tested in accordance with the requirements of the ASME B&PV Code, Section III, Article NB-6200.

Even though the Code is not strictly applicable to transport casks, it is the intent to follow Section III, Subsection NB of the Code as closely as possible for design and construction of the containment vessel. The casks may, however, be fabricated by other than N-stamp holders and materials may be supplied by other than ASME Certificate Holders. Thus the requirements of NCA are not imposed. TN's quality assurance requirements, which are based on 10CFR71 Subpart H and NQA-1, are imposed in lieu of the requirements of NCA-3850. This SAR is prepared in place of the ASME design and stress reports. Surveillances are performed by TN and other personnel rather than by an Authorized Nuclear Inspector (ANI).

The materials of the TN-LC packaging will not result in any significant chemical, galvanic or other reaction as discussed in Chapter 2.

4.1.1.2 Containment Penetrations

The only penetrations through the containment boundary are the drain and vent ports, bottom plug plate and the top closure plate (lid). Each penetration is designed to *be able to* maintain a leak rate not to exceed 1.0×10^{-7} ref cm^3/s, defined as "leak tight" per ANSI N14.5 [4]*, but depending on the contents being shipped, this leak rate criterion may be relaxed to a value greater than* $1.0 X 10^{-7}$ *ref* cm^3/s. To obtain these seal requirements, each penetration has an O-ring face seal type closure. Additionally, the lid and bottom plug penetrations have double O-ring configurations.

4.1.1.3 Seals and Welds

All containment boundary welds are full penetration bevel or groove welds to ensure structural and sealing integrity. These full penetration welds are designed per ASME III Subsection NB and are fully examined by *radiographic* or ultrasonic methods in accordance with Subsection NB.

Additionally, a liquid penetrant examination is performed on these welds.

Containment seals are located at the bottom plug plate, lid, the drain plug and the vent plug. The inner seal, when two seals are provided, is the primary containment seal. The outer, secondary seals, facilitate leak testing of the inner containment seal of the bottom plug and the lid. There are also test ports provided for these two closures. The test ports are not part of the containment boundary.

All the seals used in the TN-LC cask containment boundary are static face seals. The seal areas are designed such that no significant plastic deformation occurs under normal and accident loads as shown in Chapter 2. The bolts are torqued to maintain seal compression during all load conditions as shown in Appendix 2.13.2. The seals used for all of the penetrations are fluorocarbon elastomer O-rings. All seal contact surfaces are stainless steel and are machined to a 32 RMS or finer surface finish. The dovetail grooves in the cask lid and the bottom end plug cover plate are intended to retain the seals during installation. The volume of the grooves is controlled to allow the mating metal surfaces to contact under bolt loads, thereby providing uniform seal deformation in the final installation condition.

All Indicated Changes are in response to Containment O-3

A fluorocarbon elastomeric seal was chosen for use on the TN-LC package because it has acceptable characteristics over a wide range of parameters. The fluorocarbon compound specified is V1289-75 or equivalent. The V1289-75 compound as described by the Parker Technical Bulletin ORD 5743 [8] is specially formulated for use at temperatures as low as -55°F while maintaining the upper temperature limit of 400°F. The selected seals remain leak tight (leak rate not exceeding 1.0×10^{-7} ref cm^3/s) at 482°F for accident conditions as shown in Parker O-Ring Handbook [7].

4.1.1.4 Closure

The containment vessel contains an integrally-welded bottom closure and a bolted and flanged top closure forging (lid). The lid forging is attached to the cask body with twenty (20), SA-540, Grade B23 *or B24*, Class 1, 1.0 inch diameter bolts and stainless steel washers. Closure of the bottom plug is accomplished by eight (8), SA-540, Grade B23 *or B24*, Class 1, 0.5 inch diameter cap screws and stainless steel washers. The bolt torque required for the top lid and bottom plug are provided in Drawing 65200-71-01 in Chapter 1, Appendix 1.4.1. The closure bolt analysis is presented in Appendix 2.13.2.

Closure of each of the vent and drain ports is accomplished by a single 0.5 inch brass or ASTM A193, Grade B8 bolt with an elastomer seal under the head of the bolt.

All Indicated Changes are in response to Containment O-3

4.2 Containment under Normal Conditions of Transport (Type B Packages)

4.2.1 Containment of Radioactive Material

As described earlier, the TN-LC cask is designed and tested for a leak rate of 1.0×10^{-7} ref cm^3/s, defined as "leak tight" per ANSI N14.5 *[4] although a higher leak rate criterion is authorized in the case of PWR or BWR fuel assembly or pins (not including MOX) transported in the 1FA basket, see Appendix 4.6.1*. Additionally, the structural and thermal analyses presented in Chapters 2 and 3, respectively, verify that there is no release of radioactive materials under any of the normal or accident conditions of transport.

4.2.2 Pressurization of Containment Vessel

The TN-LC cask contains one of four basket designs holding dry irradiated fuel and helium gas which is used to backfill the cask after drying. Therefore, the pressure in the TN-LC cask when loaded with fuel is from helium that has been backfilled into an evacuated cask cavity to a pressure of 2.5 ± 1 psig at the end of loading. If the TN-LC cask contains design basis fuel at thermal equilibrium, the cask cavity helium temperature with 100°F ambient air and maximum insolation is 282°F. The maximum normal operating pressure (MNOP) is calculated in Chapter 3 to be 16.9 psig. The analyses in Chapters 2 and 3 demonstrate that the TN-LC cask effectively maintains containment integrity with a cavity pressure of 30 psig.

4.2.3 Containment *Criterion*

The TN-LC cask is designed to be "leak tight*," except for PWR or BWR fuel assembly or pins (not including MOX) transported in the 1FA basket, see Appendix 4.6.1.* The acceptance criterion for fabrication*, maintenance,* periodic *and pre-shipment* leak tests of the TN-LC cask containment boundary shall be 1.0×10^{-7} ref cm^3/s. The test must have a sensitivity of at least one half the acceptance criterion, or 5.0×10^{-8} ref cm^3/s. The testing of the containment boundary is described in Chapter 8.

For shipment of 1FA contents (PWR, BWR or pin can not including MOX) in the TN-LC, a leak rate test criterion that is less restrictive than the leak-tight criterion may be used for periodic maintenance and pre-shipment testing. The leak rate criterion for these contents is established in Appendix 4.6.1.

All Indicated Changes are in response to Containment O-3

4.3 Containment under Hypothetical Accident Conditions (Type B Packages)

4.3.1 *Source Term*

There is no need to explicitly determine the source term available for release *when using the leak-tight criterion*. As described earlier, the TN-LC cask is designed and tested for a leakage rate of 1.0×10^{-7} ref cm^3/s, defined as "leak tight" per ANSI N14.5 *[4] for most contents. For the PWR and BWR assembly or fuel pins (not including MOX) transported in the 1FA basket, this source term determination is analyzed in Appendix 4.6.1.*

4.3.2 Containment of Radioactive Material

The TN-LC cask is designed and tested to be "leak tight*," except for PWR or BWR fuel assembly or pins (not including MOX) transported in the 1FA basket, see Appendix 4.6.1.* The results of the structural and thermal analyses presented in Chapters 2 and 3, respectively, verify the package will meet the leakage criteria of 10CFR71.51 for the hypothetical accident scenario.

4.3.3 Containment Criterion

This package has been designed and is verified by leakage testing to meet the "leak-tight" criteria of ANSI N14.5 *[4], except for PWR or BWR fuel assembly or pins (not including MOX) transported in the 1FA basket, see Appendix 4.6.1*.

For shipment of 1FA contents (PWR, BWR or pin can not including MOX) in the TN-LC, a leak rate test criterion that is less restrictive than the leak-tight criterion may be used for periodic maintenance and pre-shipment testing. The leak rate criterion for these contents is established in Appendix 4.6.1.

All Indicated Changes are in response to Containment O-3

4.5 References

1. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Division 1 – Subsection NB, 2004 edition including 2006 Addenda.

2. USNRC Regulatory Guide 7.6, "Design Criteria for the Structural Analysis of Shipping Cask Containment Vessel," Rev. 1, March 1978.

3. USNRC Regulatory Guide 7.8, "Load Combinations for the Structural Analysis of Shipping Cask," Rev. 1, March 1989.

4. ANSI N14.5-*2014*, "American National Standard for Radioactive Material – Leakage Tests on Packages for Shipment," *June 2014*.

5. United States Air Force Military Specification MIL-R-83485, "Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures," December 8, 1976.

6. Society of Automotive Engineers (SAE) Aerospace Material Specification (AMS) AMS-R-83485, "Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures", May 1, 1998.

7. "Parker O-Ring Handbook," Publication No. ORD-5700, 2007 Edition, Parker Seals www.parkerorings.com.

8. "Low Temperature FKM V1289-75," Parker Technical Bulletin ORD5743, Parker Seals www.parkerorings.com.

4.6 Appendices

4.6.1 Containment Reference Leak Rate for 1FA Contents (Excluding MOX)

All Indicated Changes are in response to Containment O-3

Appendix 4.6.1
Containment Reference Leak Rate for 1FA Contents *(Excluding MOX)*

TABLE OF CONTENTS

4.6.1 Containment Reference Leak Rate for 1FA Contents (Excluding MOX) 4.6.1-1
4.6.1.1 Criteria, Parameters and Assumptions 4.6.1-1
4.6.1.2 Source Activities and Source Activity Densities 4.6.1-4
4.6.1.3 Determination of the Allowable Leakage Rates 4.6.1-8
4.6.1.4 Results 4.6.1-10
4.6.1.5 Conclusions 4.6.1-10
4.6.1.6 References 4.6.1-10

LIST OF TABLES

Table 4.6.1-1 10 CFR 71 Containment Criteria for Type B Transportation Packages 4.6.1-1
Table 4.6.1-2 Bounding A_2 Values for Fission Gases, Volatiles and Fines 4.6.1-2
Table 4.6.1-3 Bounding Release Fractions 4.6.1-2
Table 4.6.1-4 TN-LC Cavity Gas Temperatures, Pressures and Properties 4.6.1-3
Table 4.6.1-5 Activities and Activity Densities per Release Type – PWR 4.6.1-7
Table 4.6.1-6 Activities and Activity Densities per Release Type - BWR 4.6.1-7

Appendix 4.6.1 is newly added in SAR Revision 9a.

4.6.1 Containment Reference Leak Rate for 1FA Contents *(Excluding MOX)*

4.6.1.1 *Criteria*, Parameters and Assumptions

4.6.1.1.1 *Criteria*

There are two release rates calculated corresponding to the requirements for NCT and HAC in 10 CFR 71.51 [1]. The smallest value of these is determined to be the bounding release rate, although NCT and HAC values are both reported. *Table 4.6.1-1* provides the containment criteria for the TN-LC transportation cask.

Table 4.6.1-1
10 CFR 71 Containment *Criteria* for Type B Transportation Packages

Radioactive Release Rate	
Transport Condition	**Value**
Normal Conditions of Transport (NCT)	Less than $A_2 \times 10^{-6}$ per hour
Hypothetical Accident Conditions (HAC)	Less than A_2 per week (excluding ^{85}Kr) Less than $10A_2$ per week (^{85}Kr) *A limit of 1 A_2/week is conservatively considered (including ^{85}Kr)*

4.6.1.1.2 Parameters

The TN-LC equipped with the 1FA basket is designed to transport the following:

- PWR irradiated fuel assemblies;
- BWR irradiated fuel assemblies loaded in the BWR sleeve fitted in the 1FA basket;
- Irradiated pins (UO_2, MOX, and EPR) loaded in the 1FA pin can, which is itself loaded in the BWR sleeve fitted in the 1FA basket.
- *MOX fuel is not in the scope of this evaluation.*

The following contributions are considered in determining the releasable source term for packages designed to transport irradiated fuel assemblies or rods: (1) the radionuclides comprising the fuel *(further broken down into three categories: fuel fines, volatiles and fission gases)*, (2) the radionuclides on the surface of the fuel rods/assemblies *(crud)*, and (3) the residual contamination on the inside surfaces of the containment vessel. However, studies have indicated that the contamination due to residual activity on the cask interior surfaces is negligible as compared to crud deposits on the fuel rods or assemblies [5]. This is helped by the fact that the TN-LC cask interior surfaces are cleaned before each loading operations. Therefore, this residual contamination on the interior surfaces of the cask is neglected in the following analysis and the following source terms are considered.

Based on Chapter 3 section 3.3.3, the bounding fuel assembly for *internal pressure* is the B&W 15×15, which has 208 fuel rods per assembly.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

For the PWR crud evaluation, this analysis conservatively considers 264 fuel rods per assembly with a Ø0.440 in rod O.D. (per Table 1.4.5-2), and the rod length is conservatively taken equal to 168 in. For the BWR crud evaluation, this analysis conservatively considers 100 fuel rods per assembly with a Ø0.394 in rod O.D. (per Table 1.4.5-7, 10x10 Allis Chalmer assembly), and the rod length is also conservatively taken equal to 168 in.

The ORIGEN-ARP module of SCALE 6.0 is used to compute radionuclide activities for each 1FA content (i.e., PWR fuel assembly, BWR fuel assembly, and PWR/BWR pins; MOX fuel is excluded). Each content is examined over the range of burnup, enrichment, and cooling time combinations defined in the respective fuel qualification table (FQT). The resulting bounding inventory for fission gases, volatiles and fines is summarized in Table 4.6.1-2 below.

Table 4.6.1-2
Bounding A_2 Values for Fission Gases, Volatiles and Fines

Release Form	*Fission Gases*	*Volatiles*	*Fuel Fines*
Maximum A_2 Value Available For Release – PWR	*21*	*16,000*	*500,000*
Maximum A_2 Value Available For Release – BWR	*12*	*18,000*	*250,000*

Per NUREGs [5], [7] and [8], the following bounding release fractions listed in Table 4.6.1-3 are applicable.

Table 4.6.1-3
Bounding Release Fractions

Conditions	*Crud*	*Fission Gases*	*Volatiles*	*Fuel Fines*
NCT	*0.15*	*0.3*	*2×10^{-4}*	*3×10^{-5}*
HAC	*1.00*	*0.3*	*2×10^{-4}*	*3×10^{-3}*

The cask cavity free volume is equal to 11,429 in^3 = 187,288 cm^3 (see Chapter 3 section 3.3.3).

The calculation methodology is based on NUREG/CR-6487 [5]. ANSI N14.5 [3] provides the basis and methods for determining the maximum allowable reference air leakage rate for leak testing purposes.

Table 4.6.1-4 shows cavity pressures and gas temperatures relevant to TN-LC transport during NCT and HAC from Chapter 3 Tables 3-8 & 3-11. The temperatures used are the average cavity gas temperatures for the bounding FA with spent fuel contents. The table also lists the gas properties relevant to the analysis.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

Table 4.6.1-*4*
TN-LC Cavity Gas Temperatures, Pressures and Properties

Parameter	NCT	HAC	Ref. Air In-Leakage at STP
Pressure (equal to fluid upstream pressure, P_u)	2.48 atm abs (16.9 psig)	13.35 atm abs (90.9 psig)	1 atm abs
Fluid Temperature (T)	483.1K (410°F)	578K (581°F)	298K
Fluid type	Helium	Helium	Air
Fluid molecular weight	4 g/mol	4 g/mol	29 g/mol
Fluid downstream pressure[1], P_d	0.25 atm abs	0.25 atm abs	0.01 atm abs
Fluid viscosity[2] μ(T)	0.0285 [6]	0.0322 [6]	0.0185 cP [4]
Average stream pressure Pa =(P_u + P_d)/2	1.37	6.80	0.51

The calculation is performed in several steps that are described below:

- Step 1: Determine the source terms for the containment evaluation *and evaluate the maximum activity available for release in terms of numbers of A_2 for each release form*.
- Step 2: *Calculate the number of A_2 that can be potentially released for each release form for NCT and HAC for BWR and PWR considering the release fractions listed in Table 4.6.1-3 and a conservative fuel cladding failure rate*.
- Step 3: Using the *total number of* A_2 *that can be potentially released* and the *resulting* source concentrations (source activity *density* available for release in the cask), calculate the permissible leakage rate to satisfy 10 CFR 71 [1].
- Step 4: Using ANSI N14.5 [3], calculate the reference air leakage rates.

4.6.1.1.3 Assumptions *and Conservatisms*

Although the possibility of forming and releasing a crud-aerosol is minimal, a leakage rate can be calculated for this phenomenon. It is most probable that the crud particles will plug the small holes through which gas leakage usually occurs. However, it is conservatively assumed that the particulate leakage rate is the same as the gas leakage rate.

As a conservative approach and to simplify calculations, it is assumed that crud spallation and cladding breaches occur instantaneously after fuel loading and container closure operations. Therefore, the source term becomes time-independent, and all the radioactivity in the fill gas that is available for release from the containment vessel (should a leak occur) is available initially. This assumption ensures the maximum amount of radioactive inventory is available should a leak occur just after closure.

[1] See Assumptions, Section 4.6.1.1.3.

[2] *Viscosities for helium at NCT and HAC temperatures were extrapolated from the outputs of [6] at various lower temperatures using a second order polynomial.*

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

The length of the leakage hole for *the* calculation of the permissible leak rates is *conservatively* assumed to be *1/16 in (0.159 cm)*, which is the diameter of the *smallest* seal cross-section.

The downstream pressure is conservatively taken as 0.25 atm abs for both the NCT and the HAC analyses.

It is conservatively assumed that the fuel pins experience cladding failure during NCT and HAC at rates of 5% and 100%, respectively. *These cladding failure fractions are applicable to fuel fines, volatiles and fission gases only, and are applied in addition to the release fractions listed in Table 4.6.1-3.*

4.6.1.2 Source Activities and Source Activity Densities

4.6.1.2.1 Crud Spallation From Fuel Rods

When fuel rods are subject to the radioactive and corrosive environment of a PWR or BWR reactor, radioactive flaky material is formed on the outside surface of the fuel rods. Some of this material is loosely bound to the fuel rod surface and can be dislodged in some circumstances and possibly form an aerosol in the cavity atmosphere. Vibration and flowing gases for example have been shown to dislodge some of the particles, forming a powder aerosol in the surrounding gas, which could present a potential dispersion situation, although studies [2] show the crud to be very stable and adherent.

The typical chemical composition of materials in this aerosol would be primarily oxides of the constituents of reactor hardware metals including radionuclides such as Co-60. If there was any failed fuel in the reactor or storage pool along with the hardware, there might also be minute traces of fission products.

Measurements [5] have shown that the bounding values for crud surface activity for PWR and BWR rods are 140 $\mu Ci/cm^2$ = 5.18 × 10^6 Bq/cm^2 and 1,254 $\mu Ci/cm^2$ = 4.64 × 10^7 Bq/cm^2, respectively, at discharge. Since ^{60}Co dominates the crud activity [5], the A_2 of ^{60}Co (0.4 TBq) is used for the crud.

The surface area per rod is calculated based on the rod dimensions and the surface area associated with the assembly hardware is neglected [5].

The total surface area per PWR rod is:

$$S_{AR} = 168 \times \pi \times 0.440 = 232.2\ in^2 = 1{,}498.2\ cm^2.$$

The total surface area per BWR rod is:

$$S_{AR} = 168 \times \pi \times 0.394 = 207.9 in^2 = 1{,}341.6\ cm^2.$$

Measurements have also shown that 15% is a reasonable value for crud spallation for both PWR and BWR fuel rods under normal transport conditions. For hypothetical accident conditions, 100% crud spallation is assumed (see Table 4.6.1-3).

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

Therefore, the total activity released from crud spallation under NCT for PWR is equal to: $5.18 \times 10^6 \times 264 \times 1{,}498.2 \times 0.15 = 3.07 \times 10^{11}$ *Bq* $= 0.77\ A_2$.

The total activity released from crud spallation under HAC for PWR is equal to: $5.18 \times 10^6 \times 264 \times 1{,}498.2 \times 1 = 2.05 \times 10^{12}$ *Bq* $= 5.12\ A_2$.

Therefore, the total activity released from crud spallation under NCT for BWR is equal to: $4.64 \times 10^7 \times 100 \times 1{,}341.6 \times 0.15 = 9.34 \times 10^{11}$ *Bq* $= 2.33\ A_2$.

The total activity released from crud spallation under HAC for BWR is equal to: $4.64 \times 10^7 \times 100 \times 1{,}341.6 \times 1 = 6.22 \times 10^{12}$ *Bq* $= 15.56\ A_2$.

Expressed in A_2/cm^3*, the activity density for PWR crud inside the containment vessel is therefore:*

$$NCT: 0.77 / 187{,}288 = 4.102 \times 10^{-6}\ A_2/cm^3.$$

$$HAC: 5.12 / 187{,}288 = 2.735 \times 10^{-5}\ A_2/cm^3.$$

Expressed in A_2/cm^3*, the activity density for BWR crud inside the containment vessel is therefore:*

$$NCT: 2.33 / 187{,}288 = 1.246 \times 10^{-5}\ A_2/cm^3.$$

$$HAC: 15.56 / 187{,}288 = 8.309 \times 10^{-5}\ A_2/cm^3.$$

4.6.1.2.2 Release of *Fuel* Fines from Cladding Breaches

PWR:

Per Table 4.6.1-2 and Table 4.6.1-3, the total activity released from cladding breaches due to fuel fines under NCT is equal to: $0.05 \times 3 \times 10^{-5} \times 500{,}000 = 0.75\ A_2$.

The total activity released from cladding breaches due to fuel fines under HAC is equal to: $1.00 \times 3 \times 10^{-3} \times 500{,}000 = 1{,}500.00\ A_2$.

Expressed in A_2/cm^3*, the activity density inside the containment vessel is therefore:*

$$NCT: 0.75 / 187{,}288 = 4.005 \times 10^{-6}\ A_2/cm^3.$$

$$HAC: 1{,}500 / 187{,}288 = 8.009 \times 10^{-3}\ A_2/cm^3.$$

BWR:

Per Table 4.6.1-2 and Table 4.6.1-3, the total activity released from cladding breaches due to fuel fines under NCT is equal to: $0.05 \times 3 \times 10^{-5} \times 250{,}000 = 0.38\ A_2$.

The total activity released from cladding breaches due to fuel fines under HAC is equal to: $1.00 \times 3 \times 10^{-3} \times 250{,}000 = 750.00\ A_2$.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

Expressed in A_2/cm^3, the activity density inside the containment vessel is therefore:

NCT: 0.38 / 187,288 = 2.002 x 10^{-6} A_2/cm^3.

HAC: 750 / 187,288 = 4.005 x 10^{-3} A_2/cm^3.

4.6.1.2.3 Release of Gaseous Volatiles from Cladding Breaches

PWR:

Per Table 4.6.1-2 and Table 4.6.1-3, the total activity released from cladding breaches due to volatiles under NCT is equal to: 0.05 × 2 × 10^{-4} × 16,000 = 0.16 A_2.

The total activity released from cladding breaches due to volatiles under HAC is equal to: 1.00 × 2 × 10^{-4} × 16,000 = 3.20 A_2.

Expressed in A_2/cm^3, the activity density inside the containment vessel is therefore:

NCT: 0.16 / 187,288 = 8.543 x 10^{-7} A_2/cm^3.

HAC: 3.20 / 187,288 = 1.709 x 10^{-5} A_2/cm^3.

BWR:

Per Table 4.6.1-2 and Table 4.6.1-3, the total activity released from cladding breaches due to volatiles under NCT is equal to: 0.05 × 2 × 10^{-4} × 18,000 = 0.18 A_2.

The total activity released from cladding breaches due to volatiles under HAC is equal to: 1.00 × 2 × 10^{-4} × 18,000 = 3.60 A_2.

Expressed in A_2/cm^3, the activity density inside the containment vessel is therefore:

NCT: 0.18 / 187,288 = 9.611 x 10^{-7} A_2/cm^3.

HAC: 3.60 / 187,288 = 1.922 x 10^{-5} A_2/cm^3.

4.6.1.2.3a Release of Gaseous Fission Products from Cladding Breaches

PWR:

Per Table 4.6.1-2 and Table 4.6.1-3, the total activity released from cladding breaches due to fission gases under NCT is equal to: 0.05 × 0.3 × 21 = 0.32 A_2.

The total activity released from cladding breaches due to fission gases under HAC is equal to: 1.00 × 0.3 × 21 = 6.30 A_2.

Expressed in A_2/cm^3, the activity density inside the containment vessel is therefore:

NCT: 0.32 / 187,288 = 1.682 x 10^{-6} A_2/cm^3.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

HAC: 6.30 / 187,288 = 3.364 x 10^{-5} A_2/cm^3.

BWR:

Per Table 4.6.1-2 and Table 4.6.1-3, the total activity released from cladding breaches due to fission gases under NCT is equal to: 0.05 × 0.3 × 12 = 0.18 A_2.

The total activity released from cladding breaches due to fission gases under HAC is equal to: 1.00 × 0.3 × 12 = 3.60 A_2.

Expressed in A_2/cm^3, the activity density inside the containment vessel is therefore:

NCT: 0.18 / 187,288 = 9.611 x 10^{-7} A_2/cm^3.

HAC: 3.60 / 187,288 = 1.922 x 10^{-5} A_2/cm^3.

4.6.1.2.4 Summary of Activities and Activity Densities

Table 4.6.1-*5*
Activities and Activity Densities per Release Type – *PWR*

Release Type	***NCT***		***HAC***	
	A_2	***A_2/cm^3***	***A_2***	***A_2/cm^3***
Crud	*0.77*	*4.102×10^{-6}*	*5.12*	*2.735×10^{-5}*
Fuel Fines	*0.75*	*4.005×10^{-6}*	*1,500.00*	*8.009×10^{-3}*
Volatiles	*0.16*	*8.543×10^{-7}*	*3.20*	*1.709×10^{-5}*
Fission Gases	*0.32*	*1.682×10^{-6}*	*6.30*	*3.364×10^{-5}*
Total	*1.99*	*$C_{N\,PWR} = 1.064 \times 10^{-5}$*	*1,514.62*	*$C_{A\,PWR} = 8.087 \times 10^{-3}$*

Table 4.6.1-6
Activities and Activity Densities per Release Type - BWR

Release Type	***NCT***		***HAC***	
	A_2	***A_2/cm^3***	***A_2***	***A_2/cm^3***
Crud	*2.33*	*1.246×10^{-5}*	*15.56*	*8.309×10^{-5}*
Fuel Fines	*0.38*	*2.002×10^{-6}*	*750.00*	*4.005×10^{-3}*
Volatiles	*0.18*	*9.611×10^{-7}*	*3.60*	*1.922×10^{-5}*
Fission Gases	*0.18*	*9.611×10^{-7}*	*3.60*	*1.922×10^{-5}*
Total	*3.07*	*$C_{N\,BWR} = 1.639 \times 10^{-5}$*	*772.76*	*$C_{A\,BWR} = 4.126 \times 10^{-3}$*

The maximum possible values of C_N and C_A are considered for the rest of the evaluation. Therefore:

- *$C_N = max(C_{N\,PWR}, C_{N\,BWR}) = 1.639 \times 10^{-5}$ A_2/cm^3;*
- *$C_A = max(C_{A\,PWR}, C_{A\,BWR}) = 8.087 \times 10^{-3}$ A_2/cm^3.*

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

4.6.1.3 Determination of *the* Allowable Leakage Rates

4.6.1.3.1 *Determination of* the Allowable Release *Rates* for NCT and HAC

The allowable release rate for NCT, R_N, is calculated as:

$$R_N = 10^{-6} A_2 \; per \; hour = 2.778 \times 10^{-10} A_2 \; / \; sec.$$

The allowable release rate for HAC, R_A, is calculated as:

$$R_A = A_2 \; per \; week = 1.653 \times 10^{-6} A_2 / sec.$$

4.6.1.3.1.1 NCT Allowable Leak Rate, L_N

The following equation from ANSI N14.5 [3] is used to calculate the permissible volumetric gas release rate at cask conditions:

$$L_N = \frac{R_N}{C_N}.$$

Where C_N is the average activity concentration of the gas available for release inside the cask previously calculated (in A_2/cm^3) and R_N is the allowable release rate set above.

The maximum allowable leakage rate during normal condition of transport is:

$$L_N = \frac{R_N}{C_N} = \frac{2.778 \times 10^{-10}}{1.639 \times 10^{-5}} = 1.695 \times 10^{-5} cm^3/sec.$$

4.6.1.3.1.2 HAC Allowable Leak Rate, L_A

The maximum allowable leakage rate during HAC is:

$$L_A = \frac{R_A}{C_A} = \frac{1.653 \times 10^{-5}}{8.087 \times 10^{-3}} = 2.045 \times 10^{-4} \; cm^3/sec.$$

4.6.1.3.2 Determine the reference air leakage rates

4.6.1.3.2.1 NCT Reference Air Leakage Rate, L_{RN}

The air leakage rate at standard conditions that is equivalent to L_N is determined following the example 21 in ANSI N14.5 [3]. The following formula is used for calculating the reference air leakage rate, where L_u is the upstream volumetric leakage rate in cm^3/sec L_N calculated above:

$$L_u = (F_c + F_m)(P_u - P_d) \times \frac{P_a}{P_u} \qquad (5.1)$$

F_c is the coefficient of continuum flow conductance per unit pressure (cm^3/atm-sec):

$$F_c = \frac{2.49 \times 10^6 \cdot D^4}{a\mu} \qquad (5.2)$$

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

F_m is the coefficient of free molecular flow conductance per unit pressure (cm^3/atm-sec):

$$F_m = \frac{3.81\times10^3 \cdot D^3 \cdot \left(\frac{T}{M}\right)^{0.5}}{aP_a} \quad (5.3)$$

Where:

- D is the leakage hole diameter (cm),
- a is the leakage hole length (cm),
- μ is the fluid viscosity (cP),
- T is the fluid absolute temperature,
- M is the molecular weight (g/mol),
- P_u is the upstream fluid pressure (atm abs),
- P_d is the downstream fluid pressure (atm abs), and
- P_a is the average stream pressure (atm abs).

The value for L_N calculated in Section 4.6.1.3.1.1 is taken equal to the maximum leakage rate L_U in equation (5.1). All the parameters are known except the leakage hole diameter D. The diameter is found by iteratively solving the equation (5.1).

For NCT, $L_U = L_N =$ *1.695 x 10^{-5}* cm^3/sec. Using the values given for NCT, the resulting leakage hole diameter D is equal to *3.324 × 10^{-4}* cm.

The F_c and F_m values using this diameter are calculated for helium using equations (5.2) and (5.3) as equal to *6.716 x 10^{-6}* and *7.094 x 10^{-6}* respectively, and *the value of* L_N is verified using the value for D in equation (5.1).

Using this value of D, the resulting standard air leakage rate is calculated using the same equation (5.1), but with parameters corresponding to air at standard conditions of temperature and pressure. The resulting NCT reference air leakage rate L_{RN} is calculated as:

$$F_c = 1.035 \times 10^{-5};$$
$$F_m = 5.593 \times 10^{-6};$$
$$L_{RN} = 7.97 \times 10^{-6}\ cm^3/sec.$$

4.6.1.3.2.2 HAC Reference Air Leakage Rate, L_{RA}

Similar to what was done in the previous section, the value for L_A calculated in Section 4.6.1.3.1.2 is now taken equal to the maximum leakage rate L_U in equation (5.1). All the parameters are known except the leakage hole diameter. The diameter is found by iteratively solving equation (5.1).

For HAC, $L_U = L_A =$ *2.045 x 10^{-4}* cm^3/sec.

Using the same iterative calculation method as above for HAC, the resulting leakage hole diameter D is equal to *4.804 × 10^{-4}* cm.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

The value of L_A is verified using the value for D in equation 5.1.

Using this value of D, the resulting standard air leakage rate is calculated using the same equation (5.1), but with parameters corresponding to air at standard conditions of temperature and pressure. The resulting HAC reference leakage rate L_{RA} is calculated as:

$$F_c = 4.515 \times 10^{-5};$$
$$F_m = 1.689 \times 10^{-5};$$
$$L_{RA} = 3.10 \times 10^{-5}\ cm^3/sec.$$

4.6.1.4 Results

The NCT reference air leakage rate L_{RN} is the most restrictive of the values determined for NCT and HAC, therefore, $L_R = L_{RN} = 7.97 \times 10^{-6}$ ref cm^3/sec.

4.6.1.5 Conclusions

The following leak rates are specified for the TN-LC transportation package tests in accordance with ANSI N14.5, Section 7 [3], *for the transportation of PWR and BWR fuel assembly or pins in the 1FA basket (not including MOX)*:

*M*aintenance and periodic verification tests shall determine that the leak rate for the cask is no greater than $L_R = 8.0 \times 10^{-6}$ ref cm^3/sec with a test sensitivity better than 4.0×10^{-6} ref cm^3/sec.

Pre-shipment verification tests shall demonstrate no detectable leakage when tested to a sensitivity of at least 10^{-3} ref cm^3/sec per Section 7 [3]

4.6.1.6 References

1. 10 CFR 71, “Packaging and Transportation of Radioactive Material”.

2. Hazelton, R.F., “Characteristics of Fuel Crud and its Impact On Storage, Handling and Shipment of Spent Fuel”, PNL-6273 Pacific Northwest Laboratories, September 1987.

3. ANSI N14.5-2014,”American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment”, June 2014.

4. Engineering ToolBox – Resources, Tools and Basic Information for Engineering and Design of Technical Applications !, Air – Dynamic and Kinematic Viscosity https://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html?vA=298&units=K#

5. NUREG/CR-6487, “Containment Analysis for Type B Packages Used to Transport Various Contents,” LLNL, November 1996.

6. Fluid Properties Calculator, http://www.mhtl.uwaterloo.ca/old/onlinetools/airprop/airprop.html.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

7. NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel", March 2000.

8. NUREG-2224, "Dry Storage and Transportation of High Burnup Spent Nuclear Fuel", July 2018.

Appendix 4.6.1 is newly added in SAR Revision 9a.

All Indicated Changes are in response to Containment O-1 and O-3

Each impact limiter container will be pressurized to a pressure between 2.0 and 3.0 psig. All the weld seams and penetrations will be tested for leakage using a soap bubble test. If bubbles are detected, the weld will be repaired and the test re-performed.

8.1.5.4 Functional Tests

The following functional tests will be performed prior to the first use of the TN-LC package. Generally these tests will be performed at the fabrication facility.

(a) Installation and removal of the lid, bottom plug, vent and drain port plugs, and other fittings will be observed. Each component will be checked for difficulties in installation and removal. After removal, each component will be visually examined for damage. Any defects will be corrected prior to the acceptance of the cask.

(b) Each TN-LC-1FA basket as well as each TN-LC-MTR, TN-LC-TRIGA and TN-LC-NRUX fuel assembly/element compartment will be checked by gauge to demonstrate that the fuel assemblies or elements, as applicable, will fit in the basket.

8.1.6 Shielding Tests

Chapter 5 presents the analyses performed to ensure that the TN-LC package shielding design is adequate.

8.1.6.1 Gamma Shield Test

The TN-LC cask poured lead gamma shielding shall be inspected via gamma scanning at the intersections of a grid no larger than 6 x 6 inches on the outside of the shell prior to installation of the neutron shield.

The acceptance criterion for the gamma scan is based on dose rate measurements of a test block constructed to replicate the layers of stainless steel, lead, and stainless steel in the TN-LC cask. The thickness of each stainless steel layer in the test block shall be no less than the minimum specified thickness of the corresponding cask shell, and the thickness of the lead layer in the test block shall be no less than *the minimum* thickness of lead specified for the cask. The dose rate measured using the test block shall be the maximum acceptable reading for the inspected cask.

The source/detector distance used in the cask inspection shall be the same as that used in establishing the maximum dose rate limit. Inspection results which exceed this limit will be evaluated to ensure that the regulatory dose rate limits will not be exceeded.

The TN-LC cask precast lead gamma shielding, which is installed as parts machined from a precast lead block, shall be inspected either via gamma scanning, using the same acceptance criteria as for the poured lead gamma shielding.

All Indicated Changes are in response to Shielding O-3

8.2 Maintenance Program

8.2.1 Structural and Pressure Tests

Within 14 months prior to any lift of a TN-LC package, the trunnions shall be subject to either of the following:

- A test load equal to 300% of the maximum service load per ANSI N14.6 [3], paragraph 7.3.1(a) for single failure proof trunnions.
- Dimensional testing, visual inspection and nondestructive examination of accessible critical areas of the trunnions including the bearing surfaces in accordance with Paragraph 6.3.1(b) of ANSI N14.6 [3].

8.2.2 Leakage Tests

The following containment boundary components shall be subject to periodic maintenance, and preshipment leakage testing in accordance with ANSI N14.5 [4]:

- Lid and seals
- Bottom Plug and seals
- Vent Port Plug Seal
- Drain Port Plug Seal

Leakage Tests for NRUX, TRIGA, MTR and MOX fuel (assembly or pins) in 1FA basket

Test	Frequency	Acceptance Criteria	Typical Method (ANSI N14.5 TABLE A.1 [4])
Periodic	Within 12 months prior to shipment	Each component individually ≤ 1×10^{-7} ref cm^3/s	(He) A.5.3 A.5.4
Pre-shipment	Before each shipment, after the contents are loaded and the package is closed	No detected leakage, sensitivity of 10^{-3} ref cm^3/s or better, unless seal is replaced.	A.5.1 A.5.2 A.5.8 A.5.9
Maintenance	After maintenance, repair, or replacement of containment components, including inner seals	Each component individually ≤ 1×10^{-7} ref cm^3/s	(He) A.5.3 A.5.4

All Indicated Changes are in response to Shielding O-3

Leakage Tests for 1FA Shipments

Test	***Frequency***	***Acceptance Criteria***	***Typical Method (ANSI N14.5 TABLE A.1 [4])***
Periodic	*Within 12 months prior to shipment*	*Sum of leak rates ≤ $8.0x10^{-6}$ ref cm^3/s with a test sensitivity of $4.0x10^{-6}$ ref cm^3/s*	*A.5.1* *A.5.2*
Pre-shipment	*Before each shipment, after the contents are loaded and the package is closed*	*No detected leakage, sensitivity of 10^{-3} ref cm^3/s or better, unless seal is replaced.*	*A.5.1* *A.5.2*
Maintenance	*After maintenance, repair, or replacement of containment components, including inner seals*	*Sum of leak rates ≤ $8.0x10^{-6}$ ref cm^3/s with a test sensitivity of $4.0x10^{-6}$ ref cm^3/s*	*A.5.1* *A.5.2*

No leakage tests are required prior to shipment of an empty TN-LC packaging.

8.2.3 Component and Material Tests

The TN-LC cask shall be inspected in accordance with the requirements of 10 CFR Part 71.87, *Routine determinations*, part (b) prior to each shipment. Any defects or signs of degradation discovered by these inspections for any component (including accessible welds and fasteners) or feature would be repaired and brought into compliance with the licensing drawings prior to shipment of the loaded package.

All Indicated Changes are in response to Shielding O-3

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

This enclosure provides a summary of the proposed changes to assist in reviewing the affected sections of the safety analysis report (SAR). The changes affect the SAR as described in the following summary and more detailed description and justification of the changes that follows.

Contents Specification

WE 16x16 was added to the list of fuel classes to be transported in the TN-LC-1FA Basket. Fuel designations were added for WE 17x17, WE 14x14, CE 16x16, WE 16x16 fuel classes.

Appendix 1.4.5, Table 1.4.5-1, Table 1.4.5-2, Table 1.4.5-4, and Figure 1.4.5-6, Appendix 6.10.4, Section 6.10.4.2, Section 6.10.4.4.1, Table 6.10.4-2, Table 6.10.4-26, were revised or added for this change.

Engineering Drawings

The revisions to the SAR drawings include changes as recommended in NRC SFST ISG-20 (i.e., material specifications, dimensions, details, optional parts) that provide flexibility to make design changes without requiring prior NRC approval. Improvements are made to the design features based on experience with similar cask fabrication, operation, and maintenance. In addition, some non-conforming conditions that were dispositioned during fabrication require adding options to the SAR drawings to allow use as-fabricated.

Shielding Evaluation

The TN-LC Unit 01 as-fabricated cask body has a reduction in its shielding capability due to localized areas where the lead thickness is less than the acceptance criterion, and may be as low as 3.10 inches. As a result of the reduced lead thickness condition for TN-LC Unit 01, Section 5.6.4.5 was added to SAR Appendix 5.6.4 for assessing the impacts of the non-conforming thickness conditions with respect to the limiting dose rates for TN-LC-1FA PWR fuel assembly and PWR fuel rods contents loaded in TN-LC transport cask. Chapter 5, Section 5.4.4, Appendix 5.6.4, Section 5.6.4.4.5 were revised or added for this change.

Containment Evaluation

The *TN-LC* transport cask is designed and tested for a leak rate of $1x10^{-7}$ ref cm^3/s, defined as "leak-tight" per ANSI N14.5. Some contents do require the cask to be leak-tight for containment. A reference air leak rate that allows *periodic and maintenance* testing to less than leak-tight is established that satisfies containment requirements *for the 1FA PWR and BWR contents (assemblies and rods, MOX excluded)*. A new Appendix 4.6.1, Containment Reference Leak Rate for 1FA, is added to determine an allowable leak rate for the 1FA contents *excluding MOX fuel*.

Operating Instructions, and Acceptance Criteria and Maintenance

The allowable leak rate provides flexibility for performing leak tests using methods less sensitive than the helium leak test that is required to demonstrate leak-tightness required for other contents.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Affected sections of the SAR are revised to allow less sensitive leak rate measurement methods and take into account NRC IN-2016-04, ANSI N14.5-2014 Revision and Leakage Rate Testing Considerations.

Editorial Corrections

Changes as noted in table of detailed description of changes.

Each item in the table below corresponds to a description of change that affects one or more sections in the SAR. Each "Description of Change" is itemized and may be associated with one or more affected sections in the SAR. Each affected section associated with an item may have a separate justification, or a single justification is provided at the end of the item that applies to all the affected sections. Affected sections that require changes may include an excerpt from the SAR, in addition to the change pages that are provided in Enclosure 2. A SAR page number is provided to assist in finding the affected section in the SAR or within the change pages provided after the table.

Design changes made to package design are subject to design control commensurate with original design as previously approved. An LR Number (e.g. LR719358-XXXX) is a reference to the review process implemented by the QA program that reviews design changes for impact on the SAR.

Item	Chapter/Appendix/ Section	Description and Justification
	Chapter 1	**General Information**
1.1	1.2.1.1 TN-LC Cask Body Page 1-1 Page 1-2 Page 1-3 Page 1-5, Page 1-5a, Page 1-6	<u>Description of Change</u> a) Add option to transport on flat rack, deleted description to transport single package, changed "21 pin can" to "*pin can*", added "*boat*" mode for transport, changed "carrier" to "*carriers*" b) Added word "*fuel*" before "cladding", and added word "*that*" before "the fuel cladding" c) Added word "*the*" before "criticality analysis" d) Changes to inner cavity length, and shielding lead thickness due to nonconforming conditions during fabrication for TN-LC Unit 01. e) Modified o-ring seals cross-section diameter. f) Removed description of cask orientation for transportation. <u>SAR</u> a) See changed page(s) b) See changed pages c) See changed pages d) See changed pages e) See changed pages

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		f) Trunnions, attached to the cask body, are provided for lifting and handling operations, including rotation of the packaging between the horizontal and vertical orientations. The TN-LC transport package is transported in the horizontal orientation on a specially designed shipping frame. ~~with the lid end facing the direction of travel.~~ Justification a) Editorial for clarification and add options for transport. b) Editorial c) Editorial d) Evaluations done to accept the non-conforming conditions. e) Editorial. Change to correct value. f) Structural evaluation makes no assumption for cask orientation during routine and normal conditions for transport.
1.2	1.2.1.3 Impact Limiters Page 1-7	Description of change: a) Added B24 material class for impact limiter bolts, and b) Specified number of fusible plugs. SAR Each impact limiter is attached to the TN-LC transport cask by eight 1-8 UNC bolts made from SA-540 grade B23 or *B24* class 1 material. The attachment bolts are designed to keep the impact limiters attached to the cask body during all NCT and HAC. Each impact limiter is provided with ~~four~~ *five* fusible plugs that are designed to melt during a fire accident, thereby relieving excessive internal pressure. Each impact limiter has four hoist rings for handling and two support angles for supporting the impact limiter in a vertical position during storage. The hoist rings are threaded into the reinforcement blocks which are welded to the impact limiter gusset plates, while the support angles are welded to the outer shell. Prior to transport, the impact limiter hoist rings are removed and replaced with bolts. Justification a) See Item 2.3 b) Conforms to package design specification and as-built.
1.3	1.2.2 Contents Page 1-8	Description of Change Refer to ” pin can” instead of “25 pin can” SAR See changed pages. Justification Original design of pin can permitted loading of 25 individual fuel pins. A design change during fabrication modified the four corner fuel pin tubes to accommodate lid fastening bolts.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
1.4	Table 1-2 Basket Configurations in the TN-LC Packaging Page 1-12	Description of change: a) Changed "Subbasket Type" names to be consistent with other sections of SAR and drawings. b) Add max decay heat for pin can SAR See changed page Justification a) Editorial b) Adjusted decay heat for reduced number of fuel rods in pin can.
1.5	Appendix 1.4.1 TN-LC Transport Package Drawings Drawing	1.5.1 Drawing 65200-71-01 Revision *7 and 8* TN-LC Cask Assembly (11 sheets) 1.5.2 Drawing 65200-71-20 Revision *5* TN-LC Impact Limiter Assembly (*2* sheets) 1.5.3 Drawing 65200-71-90 Revision *4 and 5* TN-LC-1FA Basket (5 sheets) 1.5.4 Drawing 65200-71-96 Revision *5* TN-LC-1FA BWR Sleeve and Hold-Down Ring (2 sheets) 1.5.5 Drawing 65200-71-102 Revision *5 and 6* TN-LC-1FA 25 Pin Can Basket (4 sheets) *1.5.6 Drawing 65200-71-21 Revision 2 TN-LC Transport Package Transport Configuration (1 sheet)* Updated page 1.4.1-1 to show most current revision. Note: Drawings 65200-71-01, 65200-71-20, 65200-71-90 and 65200-71-102 were revised twice since last approved. Both revisions are provided.
1.5.1	Drawing 65200-71-01 Revision 7 and 8 TN-LC Cask Assembly (11 sheets)	LR719358-0008 Item(s) a) LR719358-0014 Item(s) b) through i) LR719358-0016 Item(s) j) LR719358-0019 Item(s) k) LR719358-0027 Item(s) l) LR719358-0028 Item(s) m) LR719358-0030 Item(s) n) LR719358-0031 Item(s) o) *TLC719358-0001 Item(s) p)* Description of change: a) Items 3B, 7C, and 10A, code criteria changed to "NB W/ EXCEPTIONS", "NF W/ EXCEPTIONS", AND "NB W/ EXCEPTIONS", respectively Add note 47 as follows, "ASME CODE MATERIAL SPECIFICATION NOT REQUIRED FOR HELI- COIL THREAD INSERTS (Sheet 1 of 11) b) Revise Item material description for Item 3J and 3N to "ASTM B36 or ASTM A193 B8". See Figure 1 on Page 2 .(Sheet 1 of 11) c) Revise Item description and pictorial representation for Items 3J and 3N to "SHCS, Port Plug". See Figures 1 on Pages 2. (Sheet 1 of 11)

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		d) Revise Note 45 to allow an optional Vent/Drain/Test port plug configuration. (Sheet 1 of 11) e) Create a new Item 3P with a quantity of 2 to replace two of Item 3J. Make 3P a NITS item. Reduce quantity of 3J to 1 (Sheet 1 of 11) f) Revise part of Note 16 to "SST Vent/Drain/Test Port Plugs" and add "Brass Vent/Drain/Test Port Plugs – 130-168 in-lb" Torque requirement per revised calculation TN-LC-0203". (Sheet 2 of 11) g) Revise the edge of the two machined pocket trunnions on the bottom of the bottom flange to incorporate transport frame pivot pins lead-in chamfers. (Sheet 8 of 11) h) Revise the 90° and 270° orientation (Sheet 1 of 11) i) Revise the torque values specified for the vent/drain/test port plugs. torque specified for the SST vent/drain/test port plug and optional brass vent/drain/test port plugs to 130-140 in-lb. (Sheet 1 of 11) j) Recess Item 24 (check valve) within neutron shielding using new Item (25) (Sheet 1 of 11) k) Include ASME SA-193 B8 as an acceptable material for Items 3J ("SHCS, PORT PLUG"), 3N ("SHCS, PORT PLUG, W/ EXTENSION"), and 3P ("SHCS, PORT PLUG") of SAR Drawing 65200-71-01 ("TN-LC CASK ASSEMBLY"). (Sheet 1 of 11) l) As-fabricated TN-LC Ser. No. 01 shielding non-conformance resulted in a minimum lead thickness as verified by gamma scan that is less than the specified 3.38 minimum lead thickness. (Sheet 1 of 11) m) As-fabricated TN-LC Ser. No. 01 non-conformance resulted in a minimum cask cavity length less than 182.50 inches. The as-fabricated measured cavity length is 182.12 inches. (Sheet 2 of 11) Add Note 46 – AS-FABRICATED CAVITY LENGTH OF 182.12 INCHES IS ALLOWED FOR TN-LC NO. 01 FOR USE ONLY WITH 1FA BASKET AND TRIGA BASKET WITH HEIGHT OF TOP SPACER REDUCED BY 0.50 INCHES. (Sheet 1 of 11) Call out note 46 at the minimum cavity length dimension on the drawing (Sheet 4 of 11) n) Add a groove between the TN-LC lid and bottom plugs O-ring grooves, (Sheet 7 and 11 of 11) o) Remove the bottom lead plug and its attachment hardware (Items 5, 6, 7A, 7B, 12, 13 and 14) from Drawing 65200-71-102 and Item 8J from Drawing 65200-71-01. *p) Update the material of items 3J, 3N and 3P to add ASTM B16 as an authorized material specification.* <u>SAR</u>

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		See change page(s)
		Justification a) The material specified in the BOM is non-code material; however, the code criteria are specified as NB, NF, and NB for Items 3B, 7C, and 10A, respectively. This change adds clarification that although the design criteria are code-based, exception is taken to the material used. These Heli-Coil thread inserts are tested to confirm identified critical characteristics and dedicated to comply with the ASME code design and NAQ-1 program safety basis. b) The addition of ASTM B36 is for clarification purposes only. The current revision of the drawing allows brass with no clarity on the applicable material specification. ASTM B36 has been reviewed and found to be an acceptable material for this application. c) The primary reason for the vent/drain/test port plugs is for flooding, draining and leak testing of the confinement boundary and seals prior to transportation of the packaging. The only design function credited to the vent/drain port plug is the confinement design function with a leak-tight criterion of 1 x E-7 std atm cc/s. The only purpose for the test port plug is to facilitate helium leak testing of the top Lid and Bottom Plug seals. Although, the test port plug is not considered part of the confinement boundary, the same material requirements and changes implemented for the vent/drain port plug (Item 3J) are also being implemented for the test port plug (Item 3N) to maintain consistency throughout. Refer to Item 1.5.1 e) for discussion on the quality classification change for the test port plugs. The reason for the change to the vent/drain/test port plug fastener from a hex head to a socket head is for compatibility with the Helium Leak test tool that will be used during operations for cask cavity evacuation, helium filling and leak testing. The helium leak test tool will utilize a hex key (in lieu of a hex head socket) to perform various stages of tightening and loosening of the vent/drain/test port plugs during leak testing. The thread size, length engagement, and required torque during tightening are unaffected by this change d) The TN-LC Cask along with the port plug/washer/o-ring combination seal with a 1 x E-7 std atm cc/s Helium leak acceptance criterion was a first of a kind. During fabrication, testing of the original design using the Port Plug (Item 3J), washer, and Parker O-ring 2-015 configuration did not work during helium leak testing. It was therefore, concluded that the acceptance criterion as specified in the SAR was unachievable when the current washer/o- ring configuration was used. Consequently, Note 45 is revised to implement the new port plug design that was tested and proven successful. e) The only purpose for the test port plug (Item 3J) is to facilitate helium leak testing of the top Lid and Bottom Plug inner O-ring seals. The test port plug is not considered part of the confinement boundary, as the confinement design function is performed by the inner o-ring (Items 3E and 8E) seals the test port plug is intended to test. Additionally, making the new Item 3P a NITS item, removes unnecessary restrictions and controls on the material simplifying the procurement process, should there ever be a need to procure material for a replacement plug during operations or maintenance.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		f) Provides clarification on the applicable torque requirements when a Brass vent/drain/test port plug is used and when a SST vent/drain/test port plug is used. A 60-70 FT-LB torque requirement has been demonstrated to work well for a SST port plug but lower torque values specified on the drawing are sufficient. The vent/drain port plugs are part of the confinement boundary as they allow a direct path to the cask cavity when the plugs are removed. The calculated torque requirements shall be such that the bolt maintains its confinement integrity and leak-tightness acceptance criterion while installed and does not become loose during transportation of the cask. No other design function is credited to the vent/drain port plugs. g) In most cases, the addition of lead chamfers is good practice as it provides the field operator with improved lead-in and alignment capabilities during operations. The worst case clearance between the pocket trunnion and the TN-LC Cask Transport Frame Pivot Pin is .020 inch (3.90 - 3.88). The lead-in chamfer will provide for better alignment control while lowering of the cask onto the Pivot Pins. The periphery of the bottom flange where the relatively small amount of material will be removed is not stressed during down-ending of the cask. The effective wall thickness is also not reduced; therefore, there is no adverse impact to the structural, thermal, shielding, or confinement design function of the TN-LC. h) This change is a correction of an orientation oversight. The orientation shown at the bottom flange at the component level (Sheet 8, Section H-H) does not agree with the orientation of the bottom flange shown at the assembly level (Sheet 5, View D-D). i) This proposed activity is essentially identical to Item 1.5.1 f) discussed above; except that clarification is provided in the Operations Sections 7.1.2.1 and 7.4.1 of the SAR in addition to the transportation drawings. j) Avoid interference of check valve with impact limiter. k) The proposed activity will add ASTM A193 B8 as an acceptable material for Items 3J 3N, and 3P on sheet 1 of design Drawing 65200-71-01. Although ASME SA-193 and ASTM A193 are identical specifications, ASTM A193 B8 material is not specifically identified as an acceptable material for Items 3J, 3N, and 3P on sheet 1 of SAR Drawing 65200-71-01. l) Engineering drawings for the approval of the package design as provided in SAR Chapter 1.0 – General Information, specify a 3.50-inch nominal thickness for the lead component of the radial shielding, and a 3.38-inch minimum thickness for the lead. No change is made to design specification for the 3.50-inch nominal radial thickness, or 3.38-inch minimal thickness. A minimum thickness of 3.10-inch is specified for TN-LC No. 01 based on the evaluation of as-built gamma scan results. A minimum lead thickness of at least 3.12 inches was verified by gamma scan of a reworked calibration block. m) Design specification for TN-LC minimum cavity length remains unchanged. The non-conformance is dispositioned for TN-LC No. 01 by reconciling the shorter cavity length with the technical evaluations, operations, and maintenance and acceptance requirements.

Item	Chapter/Appendix/ Section	Description and Justification
		Structural The impact of an under length cavity is interference with the basket (or basket stack) in the hot condition (insufficient hot gap). Each of the basket designs were evaluated. The NRUX, MTR, and TRIGA basket heights resulted in a hot gap interference with the inner cavity. A modification to the TRIGA top spacer eliminate the interference, and 1FA baskets did not have a hot gap interference. Neither the NRUX or MTR baskets was fabricated. A note is added to DWG 65200-71-01 to allow an exception to the minimum cavity length for TN-LC No. 01 and use of only the 1FA basket and TRIGA basket with modified top spacer. Appendix 2.13.10 was updated accordingly. Thermal / Containment The heat flux is simulated in the thermal model over the active fuel length that is less than the cavity length. No axial gaps are assume between the cavity and lid or bottom of the inner shell. A reduction in inner cavity length of 0.38 inches has no effect on the thermal evaluation temperatures. A reduction in length of 0.38 inches (182.50 inches minimum – 182.12 inches as-fabricated) results in approximately 0.2% reduction in the free volume. The MNOP and maximum pressure calculated using the reduced free volume would increase by approximately 0.2%. MNOP pressure is calculated as 16.9 pisg, but a pressure of 30 psig is used for structural evaluation. The result is an increase in the maximum pressure from 90.9 psig to 91.1 psig. The estimated increase in pressure is offset by the reduce quantity of helium fill gas that contributes about 30% total amount of gas in the TN-LC cask cavity. Shielding A reduction in the cavity length below the specified minimum has no effect on radial or axial shielding. The TRIGA top spacer is not modeled; therefore, any change to the height of the spacer has no effect on the shielding evaluation. Criticality Criticality control is provided primarily by the MTR, NRUX, TRIGA, and 1FA basket materials and dimensions. The cask body is modeled with nominal dimensions because the tolerances on the cask body dimensions have little effect on the system reactivity. A 0.38-inch reduction in cavity length below the minimum specified 182.50 inches has no significant effect on the criticality evaluations. Operations Package Operations do not specify the cavity length or basket spacer lengths. Acceptance Tests and Maintenance Acceptance Tests and Maintenance do not specify the cavity length or basket spacer lengths. (LR 719358-0028) n) Minimizes the conductance time for a leak to reach the test port and to ensure that the time is repeatable. Without these grooves, a leak will need migrate up to 180° around the circumference of the sealing surface through a metal to metal interface (hence higher conductance time). (LR 719358-0030)

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		o) In the current design, the plug (at the bottom of the pin can) can move in one direction and it may not engage with the hole at the bottom of the cask. Locating it is difficult because the plug diameter is very close to the diameter of the cask bottom opening. Also, the two #10 screws are not strong enough to withstand the pulling loads with the pin can, which can weigh approximately 1,000 lbs fully loaded. Overall it makes the design and operations simpler if there is no plug at the bottom of the pin can, and if the bottom cover with the lead plug is used on the cask to maintain the same amount of shielding. Therefore, this pin can bottom plug is removed from the design as well as the plug-less cover from the cask drawing (Item 8J). (LR 719358-0031) *p) Any grade of ASTM B36 is acceptable to make the port plugs, the weakest grade was used in the determination of the torque applied to the port plugs. It is acceptable to use ASTM B16 instead, because the weakest B16 grade is stronger than B36.* *Using B16 makes fabrication easier as it is a rod specification whereas B36 is a plate specification and it is easier to manufacture these bolts from rod-shaped raw material.*
1.5.2	Drawing 65200-71-20 Revision 4 and 5 TN-LC Impact Limiter Assembly (2 sheets)	LR719358-0004 Item(s) a) LR719358-0023 Item(s) b) LR719358-0029 Item(s) c) through gg) <u>Description of change:</u> a) Change material of Item 8B to ASTM A240 TYPE 304. b) Change lower limit Balsa density tfrom 10 to 7 lb/ft^3, moisture content range from 6-10% to 6-12%. c) Update note 2. d) Update note 3 and delete note 15. e) Update note 5 On sheet 2 area F4 change the "(Ø30.50 I.D.)" inner diameter of the impact limiter to "Ø30.38 I.D." f) Update note 8 and change to note 6. g) Note 11: clarify that the length is the length of the bolt taper on the second sentence. On detail 1 make sure note points to actual taper. h) Correct note 13, Item 22 is also plug-welded to Item 2. i) Correct note 14, change Item 8 to Item 22. j) Note 16 (welding code): remove edition and add ASME code section IX. k) In parts list, add metric equivalent to the ASTM material specifications where applicable (see markups) and specify metric thicknesses for all the impact limiter plates. l) Clarify "STAINLESS STEEL" material for Items 14, 15, 19, 20, 21A, 24 and 25. m) Add material specification to Items 7, 8 and 8A like on 65200-30-20 latest revision. n) Fusible plug (Item 16) material: replace "equivalent" with "nylon". o) Update part # and material for Item 17.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		p) Add Gr. B24 as an authorized material for Item 21. q) Make Item 10 in one piece and shorten gussets (Items 11) accordingly. r) Correct the length of impact limiter bolt. s) Update Item 8B like on latest 65200-30-20.
		t) Add a note to clarify that the bolts Items 24 will be swapped for the hoist rings Items 18 during transportation. u) Sheet 2 views B-B and C-C: remove tolerance on bolt circle diameter reference dimensions. v) In detail 1 (sheet 2), remove weld callout of Item 8A to 10. Add a not to clarify that the bolts (item 24) will be swapped for the hoist rings (item 18) for transportation. w) Sheet 2 section A-A: update tolerances per the markup and update 5.63 dimension. Add missing dimension of Item 23 and wood orientation + callout of one Item 22. x) Sheet 2 section A-A: add depth of impact limiter. y) Sheet 2, Detail 2B: update to clarify callouts of bolts tunnels welds (see markups), change to just detail 2 (no detail 2A). z) Sheet 3, bolt tunnel weld assembly: change weld of Item 8 to 9 to a groove weld. Add allowance for weld face to be ground or machined flush at locations where there will be contact with Item 2 (at a minimum). aa) Specify intermittent 1/8" fillet welds between each Item 11 and Items 1, 2 and 10. Same thing between each Item 12 and Items 2, 3 and 13. Add/remove details as required. bb) Add a new diamond note to specify that the wood in the middle section of the impact limiter is split into four pie-shaped regions, with each having a grain orientation in the radial direction. cc) Insert in new note 8 that Items 8 and 8A may be procured with a smaller inner diameter, and their inner diameter machined by the fabricator after full impact limiter assembly). dd) Add another fusible plug on Item 6 and add holes on Item 2. ee) Add in note 7 (sheet 1) the allowance to make each wood block from multiple pieces glued together. ff) In detail 1 (sheet 2), change weld location of Item 2 to 3 to the other side of plate Item 3 (inside the impact limiter recess). gg) Sheet 3 detail bolt tunnel assembly: change the length of Item 7 to 15.65. <u>SAR</u> See change page(s)

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		Justification a) The current specification for Item 8B is ASTM A511, which is a tube specification. However, this Item is fabricated from a plate an cannot be fabricated from a tube. b) See change previously approved for similar package design (Reference NRC Safety Evaluation Report , Docket No. 71-9302, Certificate of Compliance No. 9302, Revision No. 9, April 17, 2019, ADAMS Accession No.: ML19112A168)) c) Lessons learned from MP197HB impact limiter fabrication: a more specific description of the gaps allowed (and between which components) is needed. d) Clarification of the drilling instructions for the tamper-indicating device. Note 15 was an operational note with no package safety implications.The minimum radial gap is not important to the safety of the package, only the maximum radial gap is important and therefore only the maximum radial gap is mentioned in the note. The previous 30.50 (reference) nominal diameter was wrong and did not match the required bolt circle diameter of 32.50 considering material thicknesses and dimensions. The maximum possible radial gap based on fabrication tolerances is .2875", which is bounded by the .38" value; also, this corrects the impact limiter inner diameter nominal value, which was wrong. e) Other items than Item 1 (2, 3, 10 and 13) could benefit from the allowance to be built in several pieces. The requirement to use full penetration welds was missing. Inversely, fabricating the bolt tunnels from one piece of bar material could make the design easier to fabricate. Clarifies how the items should be made and allows other items to be made from more than one piece, or from a single piece in the case of the bolts tunnels. f) Clarification. g) Correction. h) Correction. i) Some shops are ASME-certified instead of AWS, so this change makes fabrication easier. Editions to be specified in fabrication specification. j) Makes fabrication easier in the event the impact limiter is fabricated in a country that follows the metric standard. k) "SST" is not always understood (for example if the impact limiters are fabricated in a non-English speaking country). Specifying "300 series" is not necessary for a NITS item, "stainless steel" is enough. This is an editorial change. l) These specifications have been used for the MP197HB impact limiters and they are easier to procure for tubes. m) Editorial and generic nylon has been shown to be an acceptable alternate to Rilsan.

Item	Chapter/Appendix/ Section	Description and Justification
		n) The currently specified item, Parker 600-01 02-1/2, is a ½" Stat-O-Seal with a zinc-plated carbon steel washer and a nitrile rubber seal. The nitrile rubber seal would perform adequately but is not consistent with the materials used for the seals in the rest of the cask design, and there is a chance of rusting with the zinc-plated steel washer portion. The new part number has a stainless steel washer and a fluorocarbon seal. The seal material is consistent with the other elastomer O-rings/seals used elsewhere in the cask design, and changing the washer material to stainless steel will eliminate the possibility of rusting (also see DCR 1001190, change #35). o) Adds flexibility for fabrication. Specifying either Gr. B23 or B24 allows suppliers more flexibility in meeting material requirements including fracture toughness tests. (See Item 2.3) p) Current design with multiple plates is difficult to fabricate: lots of welding, lots of distortion, it will be hard for the fabricator to meet the required dimensions. This change aligns this design with the MP197HB impact limiters design. Simplifies the design and makes it easier to fabricate, reduces amount of welding required, which means less distortion, which allows the fabricator to better control the dimensions. Updated calculation TNLC-0242 accordingly. Length of gussets is below the level of detail (not shown) q) 17" seems too long: based on 3D model, length should be 16.25", TBD after model check. Improvement, bolt may be too long to perform its function and some important dimensions might be missing. r) Part can be machined very accurately and will vastly improve tubes alignment. s) Not clear on the drawings where bolts (Item 24) are supposed to go. t) No reason to tolerance a reference dimension. u) It's already shown on detail 2B. v) Tolerances are updated per lessons learned on the MP197HB to specify tolerances that the fabricator can achieve. Dimension is updated to reflect actual impact limiter geometry. Corrected missing information. w) Dimension is missing. x) Add clarity to the details, prevent the creation of unnecessary paperwork for later. y) Prevent interference of this fillet weld with Item 2 (see markup and sketches). z) These welds are not defined on the drawing. aa) This note was missing (see MP197HB impact limiter Drawing MP197HB-30-8, note 14) and is required to ensure the impact limiter is built as intended in the design. bb) Incorporation of lessons learned from fabrication of the MP197HB impact limiters. During their fabrication, the welding of the impact limiter plates resulted in alignment problems in the bolts tunnels on the cask side and the necessity to machine the IDs to a larger value. This change should eliminate this potential problem. cc) This is so that the intermediate wood compartments communicate with the outer wood compartments. The center and intermediate compartments have no over-pressure relief system in case of a fire. dd) Clarification, and simplifies the fabrication of the impact limiter.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		ee) Welding from this side is easier, since Item 9 is not in the way like it was on the other side. ff) Actual length from the design Drawing 65200-30-20. This dimension is not important to safety and may be adjusted to fit the overall length of bolt tunnel needed, therefore it is given as a reference dimension.
1.5.3	Drawing 65200-71-90 Revision 3 and 4 TN-LC-1FA Basket (5 sheets)	LR719358-0022 Item(s) a) LR719358-0032 Item(s) b), c), and d) <u>Description of change:</u> a) Remove note 11 and the mention 'flat' in the BOM for Item 6. b) Add an optional 3" long, 1/4" max deep recess at the top of the basket cavity. c) Add 4 optional slots roughly 1/2" wide, up to 2" tall (enough to remove the threaded holes at the top of the walls and allow the insertion of a tool to lift the failed fuel can) through the thickness of the walls, see sketch below and markups (final dimensions per final Drawing 65200-30-90). d) Add optional small drain holes at the bottom of the threaded holes in the top of the rails and basket plates. e) Remove "STK" from the basket plates (Items 1 and 2) thicknesses on sheet 2 view D-D and sheet 5. f) 1) slot width update to .55-.70 and 2) add missing dimensions and radii: As a result of this change, the slot width on the SAR drawing changes from .55 to .70 max and optional radii are explicitly allowed in the cutout/recess. g) Apply note 10 (diamond) to the weld of Item 8 to Items 1 or 2 on sheet 3. h) Change 8.875 basket opening (sheet 2) and 8.875 and 10.875 basket plates widths (sheet 5) to reference dimensions (8.875) and (10.875). <u>SAR</u> See change page(s) <u>Justification</u> a) There is no formal analysis for these nuts and their torque; these studs/nuts are NITS and only serve to hold the rails on the basket during fabrication. There is no reason for the washer to be flat, Belleville washers could be used instead. Washers, studs and nuts have no function during transportation and they are not needed for the basket to perform its structural, thermal, shielding and criticality functions. b) Some room is needed at the top of the basket to fit the increased thickness at the top of the failed fuel can (FFC) so that the FFC can be lifted without deformations. The introduction of the use of an FFC for a PWR FA shall be the subject of a further application. No impact to the design structural-wise: the recess is not tall enough to reach the first welded studs, and the short depth and length of the recess means it does not have any impact on the structural behavior of the basket. *The recess is not expected to increase significantly the limiting dose rate which is the dose rate 2 m from vehicle side.* c) Some room is needed at the top of the basket for a tool to lift an FFC if one is used. The slots height is increased to 2" because the lifting slots are typically ½" tall and located 1" from the top of the failed fuel can.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
1.5.3		No impact to the design structural-wise: the slots are not tall enough to reach the first welded studs, and the short width and height of the slots means they do not have any impact on the structural behavior of the basket. *The optional slots of approximately 1/2" wide and up to 2" tall located on top of the basket are not expected to increase significantly the limiting dose rate which is the dose rate 2 m from vehicle side.* d) Any water trapped in the threaded holes will make drying of the cavity very difficult during operations. e) The mention "STK" implies a negative tolerance of -.01" to the nominal value, which is unnecessarily restrictive for fabrication. The usual practice is to not provide fabrication tolerances on the licensing drawings, and therefore this unnecessary restrictive fabrication tolerance is removed. f) 1) Extra clearance might be needed for the FFC lifting tool. Only the max is needed as the min slot width would have less of an effect, and 2) Fabrication processes might require radii in these areas. g) Editorial change for clarification. h) The basket opening (and therefore basket plates widths) is controlled by note 2. Therefore, these dimensions can be provided as reference dimensions (for information only) on the drawing.
1.5.4	Drawing 65200-71-96 Revision *5* TN-LC-1FA BWR Sleeve and Hold-Down Ring (2 sheets)	LR719358-0033 <u>Description of change:</u> Add a new note to state "Optional drain holes may be drilled at the base of all lifting holes on both BWR sleeve and hold-down ring (Items 1 through 4)" <u>SAR</u> See change page(s) <u>Justification</u> Without a drain hole, water pools inside each hole during operations in the pool and this makes the cask cavity very difficult to dry.
1.5.5	Drawing 65200-71-102 Revision *5 and 6* TN-LC-1FA 25 Pin Can Basket (4 sheets)	LR719358-0020 Item(s) d) LR719358-0031 Item(s) a), b), and c) <u>Description of change:</u> *a) Replace small 6-32 UNX hex* head screws with larger bolts and add alignment pins to facilitate underwater alignment pins are placed at the inside corners of the pin can tube. b) Update the various design lengths (see markups) to reflect the as-built dimensions of the first fabricated pin can and TN- LC cask (Drawing 65200-71- 102). Update 2.13.10 accordingly. c) Downgrade the quality categories of various item (Drawing 65200-71-102). d) Remove mention of "25 pin can", replace with simply "pin can", including in the title (Drawing 65200-71-102). <u>SAR</u> See change page(s)

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		Justification *a)* Revise Pin Can Basket lid design to improve remote underwater operation *b) The as-built cask cavity is shorter than it was supposed to be by roughly 3/8". Even though the as-built pin can is also slightly shorter than it was supposed to be, with the current dimensions, the design gap of ¼" is now down to 0.03". These changes are meant to restore this ¼" design gap, reflect the as-built final pin can dimensions (especially cavity length and overall length) and ensuring in the future will fit into the* cask. *c) A lot of items that have been classified quality category A should be B or even* NITS. Downgrading these items is a future cost-saving opportunity. d) *The quantity of rods that can be transported inside the pin can was decreased from 25 to 21 to make way for str is needs to be* reflected throughout the drawing.
1.5.6	*Drawing 65200-71-21 Revision 2 TN-LC Transport Package Transport Configuration (1 sheet)*	*TLC719358-0003* *Description of change:* *A note is added to TN-LC SAR drawing 65200-71-21 to allow indicated that the drawing is a general representation to show the tie-down interface between the cask and transport skid.* *SAR* *See changed page(s)* *Justification* *The transport skid drawing is shown in TN-LC SAR drawing 65200-71-21 with the intent to specify the tie-down interface for the transport skid to the TN-LC cask. The note added to the drawing allows flexibility to make changes to the transport skid without prior NRC approval.*
1.6	Appendix 1.4.5 TN-LC-1FA Basket Page 1.4.5-I and ii	Description of change: Updated Table of Contents, List of Tables, and List of Figures. SAR See changed page(s) Justification Editorial
1.7	Pages 1.4.5-1,2,3,8,9,14,16,18, 19 Table 1.4.5-5 Specification for the MOX Fuel Rods to be Transported in the TN-LC-1FA Basket Table 1.4.5-6 Fuel Specification for the BWR Fuel to be Transported in the in the TN-LC-1FA Bask Table 1.4.5-10 Fuel Qualification Table for 21	Description of Change Changes to describe modifications to pin can. SAR See changed page(s) Justification Pin can design changed to improve underwater operation of lid.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
	PWR/EPR Fuel Rods (UO2) Table 1.4.5-12 Fuel Qualification Table for *21* BWR Fuel Rods (UO2) Table 1.4.5-14 Fuel Qualification Table for MOX PWR/BWR *21* Rods and MOX PWR/BWR 9 Rods	
1.8	*Table 1.4.5-1 PWR Fuel Specification for the* Fuel to be Transported in the TN-LC-1FA Basket *Page 1.4.5-5*	Description of Change Add WE 16x16 to Fuel Class, and revised Notes SAR See changed page(s) Justification See Change Item 6.3.
1.9	Table 1.4.5-2 PWR Fuel Assembly Design Characteristics for Transportation in the TN-LC-1FA Basket *Page 1.4.5-6*	Description of Change Added fuel designations for WE 17x17, W 14x14, CE 16x16, and WE 16x16 SAR See changed page(s) Justification See Items 6.1 through 6.4.
1.10	Table 1.4.5-4 Summary of PRA Requirements for PWR Fuel Assembly Classes Page 1.4.5-7	Description of Change Added PRA requirements for WE 16x16. SAR See changed page(s) Justification See Change Item 6.1.
1.11	Figure 1.4.5-6 PRA Insertion Locations for WE 16x16 Class Assemblies Page 1.4.5-25	Description of Change Added PRA insertion locations for WE 16x16 SAR See changed page(s) Justification See Change Item 6.4.
	Chapter 2	**Structural Evaluation**
2.1	Appendix 2.13.8 TN-LC Basket Structural Evaluation Page 2.13.8-i thru iii	Description of change: Updated Table of Contents, List of Tables, and List of Figures. SAR

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
		See changed page Justification Editorial
2.2	Chapter 2 TN-LC Transport Package Structural Evaluation Pages 2-3, 4, 5, and 49 Appendix 2.13.8 TN-LC Basket Structural Evaluation Pages 2.13.8-1, 5, 8, 9, 11, 12, 13, 48, 58, 59, 60, 65, 66, 67, 68 Appendix 2.13.10 TN-LC Transport Package Thermal Expansion Evaluation Pages 2.13.10-12, 15, and 17	Description of Change Refer to " pin can" instead of "25 pin can" SAR See affected changed pages. Justification Original design of pin can permitted loading of 25 individual fuel pins. A design change during fabrication modified the four corner fuel pin tubes to accommodate lid fastening bolts.
2.3	Appendix 2.13.12 TN-LC Transport Package Impact Limiter Page 2-13.12-1, 8d, 14	Description of Change Add flexibility to SAR to allow B23 or B24 for the grade of material allowed for lid bolts, ram access cover bolts, and trunnion bolts for TN-LC. All references to SA-540 Gr. B23 Cl.1 are revised to add Gr. B24 Cl.1 SAR SA-540 GR. B23 *or B24* CL. 1 Justification Design stress values for bolting materials for ASME BPVC Subsection NB (Section III, Class 1) are found in Section II, Part D, Table 4 for SA-540, B23 and B24, Class 1. Table 3 provides stress values for Subsection NF (Section III, Class 3). The design stress values are the same for Type/Grade B23 and B24, and are the same values in Table 3 and Table 4. Excerpts from Table 4 as follows show that the stress intensity values are the same for Grade B23 and B24. The technical evaluations specify SA-540 Gr B24 Cl. 1 steel for bolts used on the trunnions, lid, and ram access cover. Specifying B23 or B24 allows suppliers more flexibility in meeting material requirements including tests for fracture toughness at -40 °F. The difference in composition may affect the fracture toughness.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
2.3		

Table 4 2004 SECTION II

TABLE 4 (CONT'D)
SECTION III, CLASS 1 AND SECTION VIII, DIVISION 2*
DESIGN STRESS INTENSITY VALUES S_m FOR BOLTING MATERIALS
(*Use With Appendices 4, 5, and 6 of Section VIII, Division 2)

Line No.	Nominal Composition	Spec No.	Type/ Grade	Alloy Designation/ UNS No.	Class/ Condition/ Temper	Size/ Thickness, in.
	Ferrous Materials (Cont'd)					
1	2¼Ni–¾Cr–¼Mo	SA-540	B23	H43400	4	$\le 9\frac{1}{2}$
2	2¼Ni–¾Cr–¼Mo	SA-540	B23	H43400	3	$\le 9\frac{1}{2}$
3	2¼Ni–¾Cr–¼Mo	SA-540	B23	H43400	2	$\le 9\frac{1}{2}$
4	2¼Ni–¾Cr–¼Mo	SA-540	B23	H43400	1	≤ 8
5	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	5	$6 < t \le 9\frac{1}{2}$
6	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	5	$6 < t \le 9\frac{1}{2}$
7	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	5	≤ 6
8	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	4	$\le 9\frac{1}{2}$
9	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	3	$\le 9\frac{1}{2}$
10	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	2	$\le 9\frac{1}{2}$
11	2¼Ni–⅔Cr–⅓Mo	SA-540	B24	K24064	1	≤ 8

PART D — PROPERTIES (CUSTOMARY) Table 4

TABLE 4 (CONT'D)
SECTION III, CLASS 1 AND SECTION VIII, DIVISION 2*
DESIGN STRESS INTENSITY VALUES S_m FOR BOLTING MATERIALS
(*Use With Appendices 4, 5, and 6 of Section VIII, Division 2)

Line No.	Min. Tensile Strength, ksi	Min. Yield Strength, ksi	Applicability and Max. Temperature Limits (NP — Not Permitted) III	VIII-2	Notes
					Ferrous Materials (Cont'd)
1	135	120	700	700	G5
2	145	130	700	700	G4
3	155	140	700	700	G4
4	165	150	600	600	G2
5	115	100	700	NP	G5
6	115	100	NP	700	G5
7	120	105	700	700	G5
8	135	120	700	700	G5
9	145	130	700	700	G4, G5
10	155	140	700	700	G4
11	165	150	600	600	G2

Table 4 2004 SECTION II

TABLE 4 (CONT'D)
SECTION III, CLASS 1 AND SECTION VIII, DIVISION 2*
DESIGN STRESS INTENSITY VALUES S_m FOR BOLTING MATERIALS
(Use with Appendices 4, 5, and 6 of Section VIII, Division 2)

Line No.	Design Stress Intensity, ksi (Multiply by 1000 to Obtain psi), for Metal Temperature, °F, Not Exceeding: –20 to 100	200	300	400	500	600	650	700	750	800
	Ferrous Materials (Cont'd)									
1	40.0	38.2	36.9	35.9	34.7	33.1	...	31.1	...	...
2	43.3	41.4	40.2	38.8	37.6	35.9	...	33.7	...	...
3	46.7	44.6	43.1	41.8	40.5	38.7	...	36.3	...	...
4	50.0	47.8	46.2	44.8	43.4	41.4	...	...	...	...
5	33.3	31.8	30.9	29.8	28.9	27.6	...	25.9	...	...
6	33.3	31.8	30.7	29.8	28.9	27.6	...	25.9	...	...
7	35.0	33.4	32.4	31.3	30.3	29.0	...	27.2	...	...
8	40.0	38.2	36.9	35.9	34.7	33.1	...	31.1	...	...
9	43.3	41.4	40.2	38.8	37.6	35.9	...	33.7	...	...
10	46.7	44.6	43.1	41.8	40.5	38.7	...	36.3	...	...
11	50.0	47.8	46.2	44.8	43.4	41.4	...	...	...	...

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
	Chapter 3	**Thermal Evaluation**
3.1	Page 3-1	Description of change: Reduced heat load value for PWR/BWR/EPR/MOX Fuel Pins. SAR See changed page(s) Justification Pin can capacity reduced from 21 to 25 fuel rods.
3.2	Page 3-4, 3-5, 3-15, 3-30, 3-31, 3-32, 3-36, 3-43, 3-46, 3-51, 3-52, 3-53, 3-68, 3-74, 3-76, 3-77, 3-79, 3-79a, 3-79b, 3-79c, 3-79e, 3-79f, 3-79g, 3-79h, 3-82, 3-88 thru 91, ,	Description of Change Pin can design change to reduce capacity from 25 to 21.. SAR See changed page(s) Justification Editorial and clarification that thermal evaluation for 25 fuel rods bounds 21 fuel rods
	Chapter 4	**Containment Evaluation**
4.1	Chapter 4 Containment TABLE OF CONTENTS Page 4-i	Description of change: Updated Table of Contents, List of Tables, and List of Figures. SAR See changed page(s) Justification Editorial
4.2	4.1.1 Page 4-2	Description of Change Corrected spelling of radiographic as an allowed weld inspection method. SAR 4.1.1.3 Seals and Welds All containment boundary welds are full penetration bevel or groove welds to ensure structural and sealing integrity. These full penetration welds are designed per ASME III Subsection NB and are fully examined by *radiographic* or ultrasonic methods in accordance with Subsection NB. Justification Editorial

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
4.3	4.1.1 Page 4-3	Description of Change See Item 2.3 SAR 4.1.1.4 Closure The containment vessel contains an integrally-welded bottom closure and a bolted and flanged top closure forging (lid). The lid forging is attached to the cask body with twenty (20), SA-540, Grade B23 *or B24*, Class 1, 1.0-inch diameter bolts and stainless steel washers. Closure of the bottom plug (with or without gamma shielding) is accomplished by eight (8), SA-540, Grade B23 *or B24*, Class 1, 0.5-inch diameter cap screws and stainless steel washers. The bolt torque required for the top lid and bottom plug are provided in Drawing 65200-71-01 in Chapter 1, Appendix 1.4.1. The closure bolt analysis is presented in Appendix 2.13.2. Justification See Item 2.3
4.4	4.2 Containment under Normal Conditions of Transport Page 4-4 4.3 Containment under Hypothetical Accident Conditions Page 4-5 4.5 References Page 4-7 **Appendix 4.6.1** Containment Reference Leak Rate for 1FA Pages 4.6.1-i, and 4.6.1-1 thru 4.6.1-9	Description of Change Add containment criteria for 1FA contents and a calculation to specify a leak rate criteria for the 1FA contents *(at the exclusion of MOX)* to allow test methods less sensitive than the helium leak test *(or at least relax the leak test criterion)*. SAR See changed page(s) Justification Allows flexibility for performing leak tests using methods less sensitive than the helium leak test required to demonstrate leak-tightness required for other contents *(or at least relax the leak test criterion for 1FA contents at the exclusion of MOX)*.
	Chapter 5	**Shielding Evaluation**
5.1	Chapter 5 Shielding Evaluation Page 5-1,5-2, and 5-3	Description of Change As-built lead shielding thickness for TN-LC Unit 01 is non-conforming to specification. SAR *The TN-LC Unit 01 as-fabricated cask body has a reduction in its shielding capability due to localized areas where the radial lead thickness may be as low as 3.10 inches. See Appendices 1.4.1 and 5.6.4 for further details.* Justification See Item 5.8

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
5.2	5.2.1 Crud Evaluation for Shielding Page 5-3a	Description of Change Containment criteria allows leak rate for 1FA contents. SAR Since the TN-LC is designed to be leak-tight, no release calculations are performed *except for the 1FA contents (see Appendix 4.6.1) in order to relax the pre-shipment leak- tightness criterion when shipping LWR fuel assemblies or rods.* Justification See Item 4.4
5.3	5.4.4 External Radiation Levels Page 5-9	Description of Change Added word "*chapter*" and "*its*" SAR The cask pay load with 1 LWR fuel assembly, referred to as 1 FA throughout this *chapter* and *its* appendices, results in 2 meters from side of the cask radial dose rates that are bounding for those due to other payloads of the cask. Justification Editorial
5.4	5.4.4 External Radiation Levels Page 5-10	Description of Change As-built lead shielding thickness for TN-LC Unit 01 is non-conforming to specification. SAR *The TN-LC Unit 01 is the same as the TN-LC with the exception of localized reduced lead thickness on the side of the cask body. The shielding assessment of the TN-LC with a uniformly reduced lead thickness of 3.10 in. is performed in Appendix A.5.4.4.4.5.* Justification See Item 5.8
5.5	Appendix 5.6.4 TN-LC-1FA Basket Shielding Evaluation Pages 5.6.4-i through iv	Description of change: Updated Table of Contents, List of Tables, and List of Figures. SAR See changed page(s) Justification Editorial

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
5.6	5.6.4.4.4.1 NCT, PWR Fuel Assembly Package surface: Page 5.6.4-16	Description of Change Changed ratios for scaling factors. SAR To estimate the dose rate at the shear key using the HAC source, the neutron scaling factor is the ratio of the HAC to NCT neutron source magnitudes, or 2.256E+09/2.078E *+09*= 1.1. The gamma scaling factor is estimated by using the PWR fuel assembly response function to compute dose rates for the two in-core gamma sources and taking the ratio, or *2.12/2.58* = 0.82. Using the shear key results for the NCT source from Table 5.6.4-33, the dose rate using the HAC source is estimated as 0.82*23.2 + 1.1*(446+4.79) = 508 mrem/hr. Justification Editorial to correct typos to existing analysis.
5.7	5.6.4.4.5 Reduced Lead Thickness Assessment 5.6.4-18a thru 18d	Description of Change Add assessment for reduced lead thickness in TN-LC unit 01. SAR *5.6.4.4.5 Reduced Lead Thickness Assessment* *The gamma shield minimal lead thickness is 3.38 inches; during fabrication, and prior to the installation of the neutron shield, gamma scanning is used to verify the integrity of the poured lead shielding and a minimum thickness is confirmed by comparison of gamma scan results to a calibration block consisting of a known thickness of lead between steel plates of nominal thickness the same as used in the cask fabrication.* *This section provides a comprehensive shielding evaluation for a reduced lead thickness, i.e. lead thickness below the minimal lead thickness of 3.38 inches, for the 1FA basket with 1 PWR fuel assembly and 25 PWR rods in 1 pin can. The assumed lead thickness is 3.10 inches.* *The shielding evaluation is consistent with the shielding evaluation performed in Section 5.6.4.4.4 for a minimal lead thickness is 3.38 inches. The shielding evaluation for the reduced lead thickness consists of updated response functions, FQTs, bounding NCT and HAC sources for the 1 PWR fuel assembly and 25 PWR rods contents and shielding analysis of the 1 PWR fuel assembly and 25 PWR rods contents (more)* See changed page(s) Justification *See Item 5.8*

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
5.8	Table 5.6.4-59 thru 66 Page 5.6.4-89a thru 89h	Description of Change Added response functions, Fuel qualification tables, Design Basis Gamma Source Terms, Design Basis Neutron Sources, and Dose Rate Summary tables for TN-LC No. 1 with reduced lead shielding thickness for 1FA contents. SAR See changed page(s) Justification The evaluation assesses the impact on shielding analysis for the 1-FA PWR fuel assembly and PWR fuel rods contents due to reduced lead thickness condition. The evaluation includes updated response functions, fuel qualification tables, design basis radiation gamma and neutron sources and dose rates for the contents above and an assumed uniformly distributed lead thickness of 3.10 in. The dose rates results demonstrate the shielding performance of the TN-LC, with a uniformly distributed lead thickness of 3.10 in., is not affected for the authorized 1-FA PWR fuel assembly and PWR fuel rods contents when loaded under the fuel qualification tables requirements developed in Table 5.6.4-61 and Table 5.6.4-62.
	Chapter 6	**Criticality Evaluation**
6.1	6.10.4.2 Fissile Material Contents Page 6.10.4-4	Description of Change Added WE 16x16 Class Assemblies SAR The PWR fuel assemblies and their parameters are provided in Table 6.10.4-2. The KENO model fuel assemblies are constructed using these parameters. *Note that WE 16x16 fuel class is not specifically analyzed as this fuel class is similar to WE 17x17 fuel class. WE 16x16 fuel class is a 235 fuel rods design (16x16 – 21 guide/instrument tubes) with fuel characteristics (pellet OD, clad thickness and clad OD) similar to those of WE 17x17 LOPAR. WE 17x17 fuel class is expected to bound WE 16x16 fuel class.* Justification WE 16x16 fuel class is bounded by WE 17x17 fuel class by virtue of similar fuel rods characteristics (pellet OD, clad thickness and clad OD), slightly smaller pitch (0.485” for WE 16x16 as opposed to 0.496” for WE 17x17) in a 16x16 lattice with 21 guide/instrument tubes (235 fuel rods for WE 16x6 fuel class as opposed to 264 fuel rods for WE 17x17 fuel class).
6.2	6.10.4.4 Single Package Evaluation 6.10.4.4.1 Configuration Page 6.10.4-12a	Description of Change Added WE 16x16 Class Assemblies SAR

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
6.2		WE 17x17 Class Assemblies: The most reactive WE 17x17 assembly evaluated is the WE 17x17 OFA fuel assembly, as shown in Table 6.10.4-8. These class of assemblies will remain subcritical and below the USL with the PRA configuration as shown in Figure 6.10.4-15. The number of PRAs required is 8, each at a minimum diameter of 0.88 cm. The maximum allowable U-235 enrichment is 5.00 weight percent. All rotationally symmetric configurations of the absorber rods are also acceptable. *Results for WE 17x17 class assembly are applicable to WE 16x16 class assembly.* Justification WE 16x16 fuel class is bounded by WE 17x17 fuel class by virtue of similar fuel rods characteristics (pellet OD, clad thickness and clad OD), slightly smaller pitch (0.485" for WE 16x16 as opposed to 0.496" for WE 17x17) in a 16x16 lattice with 21 guide/instrument tubes (235 fuel rods for WE 16x6 fuel class as opposed to 264 fuel rods for WE 17x17 fuel class).
6.3	Table 6.10.4-2 PWR Fuel Assembly Parameters Page 6.10.4-26	Description of Change Add WE 16x16 fuel types to parameters SAR See changed page(s). Justification Design changes to contents, add WE 16x16 fuel class parameters in Table 6.10.4-2.
6.4	Table 6.10.4-26 Summary of PRA Requirements Under all Conditions of Transport for PWR Fuel Assembly Classes Page 6.10.4-44	Description of Change Added WE 16x16 Assembly Class. SAR See changed page(s). Justification WE 16x16 fuel class is bounded by WE 17x17 fuel class by virtue of similar fuel rods characteristics (pellet OD, clad thickness and clad OD), slightly smaller pitch (0.485" for WE 16x16 as opposed to 0.496" for WE 17x17) in a 16x16 lattice with 21 guide/instrument tubes (235 fuel rods for WE 16x6 fuel class as opposed to 264 fuel rods for WE 17x17 fuel class). WE 17x17 PRAs requirements (PRAs number, locations, minimum B4C content for enrichment up to 5.00 wt% U-235) are applicable to the WE 16x16 fuel class.
	Chapter 7	**Package Operations**
7.1	Chapter 7 Package Operations TABLE OF CONTENTS Pages 7-i	Description of change: Updated Table of Contents, List of Tables, and List of Figures. SAR See changed page(s) Justification Editorial

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
7.2	7.1.1 TN-LC Cask Preparation for Loading page 7-2	Description of Change Changes described below in excepts from SAR. Reference to Justification shown in brackets, for example [1] refers to Justification below for corresponding number in brackets. SAR 5. Prior to removing the lid, sample the cask cavity atmosphere. *If removing the lid at this stage, inspect the lid seals and sealing surfaces and verify that the O-ring seals have been replaced within the last 12 months.*[1] 8. The lid, bottom plug and all drain/vent/test ports incorporate O-ring seals. O-ring seals may be reused. Prior to installation, the seals and sealing surfaces shall be inspected. Verify that the seals have been replaced within the last 12 months.[1] 10. Install the two lifting trunnions in place of the front trunnions plugs. Install the trunnion bolts and torque them to the torque specified on drawing 65200-71-01, Appendix 1.4.1, following the torquing sequence shown in Figure 7-1. [2] 14. Remove the bottom plug assembly, inspect the *seals and* sealing surfaces, *verify that the O-ring seals have been replaced within the last 12 months,* lubricate and reinstall the bottom plug assembly, torquing the bolts to *the torque specified on drawing 65200-71-01, Appendix 1.4.1.*[1] *15. Remove the two test ports, the drain port and the vent port, inspect the seals and sealing surfaces, verify that the O-ring seals have been replaced within the last 12 months, lubricate and reinstall each port (hand tight). The vent port on the lid may be left partially threaded to facilitate draining operations in step 14. The ports covers may be reinstalled over the two test ports at this time.*[1]
	page 7-3	19. If the cask lid has not already been removed, remove the bolts from the lid and lift the lid from the cask. *Inspect the seals and sealing surfaces and verify that the O-ring seals have been replaced within the last 12 months,*[1] **Notes:** If loading fuel rods in a TN-LC-1FA basket, place a pin can inside the BWR sleeve with a hold down ring in the basket as shown in drawing 65200-71-102. [3]
	7.1.2 TN-LC Cask Wet Loading Page 7-4	7.1.2.1 Preparing the TN-LC Cask for Downending 1. Torque the drain port plug to *the torque specified on drawing 65200-71-01, Appendix 1.4.1. The* drain port plug cover *may be installed at this time*. *2.* ~~Verify the lid O-ring seals are new.~~ *Not used*. 3. Install the cask lid *remaining bolts*. Follow the torquing sequence shown in Figure 7-1, torque the lid bolts to ~~400-450 ft-lbs~~. *the torque specified on drawing 65200-71-01, Appendix 1.4.1*. [4] [2] *4.* ~~Discard cavity test port seal, and install new cavity test port seal.~~ *Not used.* 6. Backfill with helium to 2.5 ± 1.0 psig. [4]
	Page 7-5	2. If the cask lid has not already been removed, remove the bolts from the lid and, using appropriate slings and/or the cask yoke with appropriate slings, lift the lid from the cask. *Inspect the seals and sealing surfaces and verify that the O-ring seals have been replaced within the last 12 months,* [1] 6. Install and torque the lid bolts to the torque specified on drawing 65200-71-01, Appendix 1.4.1, following the torquing sequence shown in Figure 7-1.[2]

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
7.2	Page 7-6	The cask is now ready to be *ba k-filled with helium and down-ended* as described *starting from step 6* in section 7.1.2.1 above.[4]
	7.1.4 TN-LC Cask Preparation for Transport 7.1.4.1 Placing the TN-LC Cask onto the Conveyance Page 7-6	4. Install the impact limiters on the cask, torqueing the attachment bolts to ~~330-375 ft-lbs~~ *the torque specified on drawing 65200-71-01, Appendix 1.4.1*. [2].
	Page 7-7	10. Install the two trunnions in place of the trunnion plugs, torquing the trunnion bolts to ~~400-450 ft-lbs~~. *the torque specified on drawing 65200-71-01, Appendix 1.4.1,* in the sequence shown in Figure 7-1. [2]
	7.2.2 Removal of Contents from TN-LC Cask 7.2.2.1 Unloading the TN-LC Cask in a Fuel Pool Page 7-8	3. Remove the drain port plug and install an appropriate fitting in the drain port. Alternatively, *a* cask port tool may be used to perform flooding and draining activities. [4]
	7.2.2.2 Unloading the TN-LC Cask to a Hot Cell Page 7-9	**NOTE:** See Section 7.2.2.3 for dry unloading of a ~~25~~ pin can. [3] 7.2.2.3 Horizontal Unloading of a ~~25~~ Pin Can from the TN-LC Cask This procedure is for handling a TN-LC cask with a ~~25~~ pin can [3]
	7.4 Other Operations	Make port plug cover removal conditional on having been previously installed. 2. Add a allowable leakage rate to permit flexibility for leak rate measurement method when replacing elastomeric seals, and require maintenance leak test when any o-ring is replaced. 3. Provide torque requirements when a Brass vent/drain/test port plug is used and when a SST vent/drain/test port plug is used. A 60-70 FT-LB torque requirement has demonstrated to work well for a SST port plug but may exceed material strength for a Brass vent/drain/test port plug.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
7.2	7.4 Other Operations 7.4.1 Assembly Verification Leakage Testing of the Containment Boundary Page 7-11	The acceptance criterion for pre-shipment leakage rate testing shall be either (a) a leakage rate of not more than the reference air leakage rate, or (b) no detected leakage when tested to a sensitivity of at least 10^{-3} ref-cm^3/s. [1] The following steps present one method of performing the pre-shipment verification leakage testing. Alternate methods and order of testing are acceptable as long as the above criteria is satisfied for the TN-LC containment boundary seals.[4] <u>Vent Port Plug Seal Leakage Test</u> 1. Remove the vent port plug cover *if previously installed*. Install the cask port tool in the vent port.[4] 6. Close the vent port plug, torquing it to ~~60-70 ft-lb~~. the torque specified on drawing 65200-71-01, Appendix 1.4.1. [2] 8. Connect a ~~mass spectrometer~~ leak detector to the cask port tool. [4] 10. Perform the~~ leakage test~~ pre-shipment leak test in accordance with Section 8.2.2. If either O-ring was replaced, the maintenance leak test in Section 8.2.2 shall be performed. ~~If the leakage rate is greater than 1x10-7 ref cm3/s, repair or replace the vent port seal as required and retest.~~ [1]
	Page 7-12	<u>Lid O-ring Leakage Test</u> 13. Remove the lid test port plug cover *if previously installed*. [4] 17. Connect the leak~~age~~ detector to the cask port tool. [4] 18. Evacuate the lid test port until the vacuum is sufficient to operate the leakage detection equipment per the manufacturer's recommendations. ~~Perform a pressure rise leakage test to confirm leakage rate past the outer seal is less than $7x10^{-7}$ ref cm^3~~ [1] 19. Perform the pre-shipment leak test in accordance with Section 8.2.2. If either O-ring was replaced, the maintenance leak test in Section 8.2.2 shall be performed. ~~Perform the helium leakage test. If the leakage rate is greater than 1x10-7 ref cm3/s, repair r replace the cask lid or the cask lid O-ring seals as required and retest.~~ [1] 20. Remove the leak~~age~~ detection equipment. [4] 21. Close lid test port plug and tighten it to the torque specified on drawing 65200-71-01, Appendix 1.4.1. Remove the cask port tool from the lid test port and replace the lid test port plug cover. [1] <u>Drain Port Plug Seal Leakage Test</u> 22. Remove the cask drain port plug cover *if previously installed*. [4] 23. Verify that the cask drain port is closed and torqued to ~~60-70 ft-lbs~~. *the torque specified on drawing 65200-71-01, Appendix 1.4.1*.[2] 26. Connect the leak~~age~~ detector to the cask port tool. [4] 29. Remove the leak~~age~~ detection equipment.[4]

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
7.2	Page 7-13	Bottom Plug O-ring Leakage Test 31. Remove the bottom test port plug cover *if previously installed*.[4] 35. Connect the leak~~age~~ detector to the cask port tool.[4] 36. Evacuate the bottom test port until the vacuum is sufficient to operate the leakage detection equipment per the manufacturer's recommendations. ~~Perform a pressure rise leakage test to confirm leakage rate past the outer seal is less than $7x10^{-7}$ ref cm^3~~[1] 37. Perform the ~~helium leakage test. If the leakage rate is greater than 1x10-7 ref cm3/s, repair or replace the bottom plug or the bottom plug O-ring seals as required and retest.~~ *pre-shipment leak test in accordance with Section 8.2.2. If either O-ring was replaced, the maintenance leak test in Section 8.2.2 shall be performed.* [1] 38. Remove the leak~~age~~ detection equipment.[4] 39. Close bottom test port plug *and tighten it to the torque specified on drawing 65200-71-01, Appendix 1.4.1.* Remove the cask port tool from the bottom test port and replace the bottom test port plug cover. [2]
		Justification 1. Remove the requirement to replace the seal before every transport. Such a requirement is not necessary because elastomer O-rings can be reused, and doing so allows the user to perform a leak-test prior to shipment that does not need to be a helium leak test and greatly simplifies pre-shipment operations. This is supported by the new release evaluation appendix which calculated allowable release rates. Also updated the applicable standard for leak-testing to the latest version to stay up-to-date with current, applicable standards. 2. In order to avoid listing the torque values in two places in the SAR (in this chapter and on the drawings), all the torque values are replaced with a reference to the drawing where these torques are specified instead. 3. Original design of pin can permitted loading of 25 inividual fuel pins. The capacity of the pin can was decreased from 25 to 21 in its new design, any mention of the actual capacity is removed. A design change during fabrication modified the four corner fuel pin tubes to accommodate lid fastening bolts 4. Optimization of the wording/sequence of operations/correction of eventual typos, etc.; general chapters improvements. Includes renumbering steps as required.
7.3	7.5 References Page 7-14	Description of Change Change ANSI-N14 edition from 1997 to 2014 SAR 1. ANSI N14.5-*2014*, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, *2014*. Justification NRC Information Notice 2016-04, ANSI 14.5-2014 Revision and Leakage Rate Testing Considerations

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
7.4	7.6 Glossary Page 7-15 Table 7-2 Appendices Containing Loading Procedures for Various TN-LC Baskets Page 7-17 Appendix 7.7.4 TN-LC-1FA Basket Wet and Dry Loading and Unloading 7.7.4.1 TN-LC-1FA Basket Wet Loading Page 7.7.4-1, 2 7.7.4.2 TN-LC-1FA Basket Dry Loading Page 7.7.4-3, 4 7.7.4.3 TN-LC-1FA Basket Wet Unloading Page 7.7.4-5, 6	Description of Change Refer to ” pin can” instead of “25 pin can” SAR See change page(s). Justification Original design of pin can permitted loading of 25 individual fuel pins. A design change during fabrication modified the four corner fuel pin tubes to accommodate lid fastening bolts.
7.5	Figure 7-1 TN-LC Packaging Torquing Patterns Page 7-18 Figure 7-2 Assembly Verification Leakage Test Page 7-19	Description of Change Page numbers changed SAR See change page(s). Justification Editorial
	Chapter 8	**Acceptance Tests and Maintenance**
8.1	8.1.2 Weld Examinations Page 8-1a	Description of change: (LR 719358-0023) Added weld specifications SAR The TN-LC impact limiter welds are designed, fabricated, and inspected in accordance with the AWS Structural Welding Code – Stainless Steel [17] *or the ASME Code, Section III Subsection NF [1], and Section IX [5].* Justification Consistent with guidance in NUREG-3854, Fabrication Criteria for Shipping Containers.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
8.2	8.1.3 Structural and Pressure Tests *8.1.4.1* TN-LC Cask Leakage Tests Page 8-2 8.1.4.1.2 Fabrication Verification Leakage Tests Page 8-3 8.2.2 Leakage Tests Page 8-14	Description of change: Eliminated options for bottom plug. SAR See changed page(s) Justification Option 2 of the bottom plug was removed from the design due to operational considerations.
8.3	8.1.6.1 Gamma Shield Test Page 8-4	Description of change: Added alternative way to inspect gamma shield, and specify the acceptance criteria for gamma scan as minimum specified lead thickness. SAR *See changed page(s)*. Justification Fabrication specifications required use of alternate verification method.
8.4	*8.1.9 Impact Limiter Wood Test* Page 8-13 and 13a	Description of change: Change lower limit Balsa density from 10 to 7 lb/ft^3, moisture content range from 6-10% to 6-12%, and redwood crush stress upper limit from 7500 to 7000 psi. SAR See changed page(s) Justification See change previously approved for similar package design (Reference NRC Safety Evaluation Report , Docket No. 71-9302, Certificate of Compliance No. 9302, Revision No. 9, April 17, 2019, ADAMS Accession No. ML19112A168))
8.5	8.2.2 Leakage Tests Page 8-14, 14a	Description of change: Added a table for leakage test requirements for 1FA contents. SAR See changed page(s) Justification See Item 4.4.

Summary of Proposed Changes
(Safety Analysis Report, TN-LC, Revision 9a *and 9b*)

Item	Chapter/Appendix/ Section	Description and Justification
8.6	8.2.3.3 Valves, Rupture Discs, and Gaskets on Containment Vessel Page 8-15	Description of change: Changed criterial for replacing o-ring seals. SAR If the bottom plug or the lid is removed, the seals ~~are replaced~~ *shall be inspected* prior to transport of a loaded TN-LC package. The seals will be leakage tested after retorquing the bolts in accordance with Chapter 7, Section 7.4. O-ring seals may be reused for transport of an empty TN-LC packaging. O-ring seals shall be ~~replaced~~ *inspected* prior to each shipment of a loaded TN-LC package *and replaced at least every twelve months*. ~~For shipments with a loaded TN-LC-1FA basket the O-ring seals shall be replaced within six months of the shipping date or prior to the next shipment, whichever comes first.~~ Justification These changes because it is now acceptable to reuse the seals, which is OK because they are elastomer seals and meant to be reused.
8.7	8.3 References Page 8-17	Description of change: a) Change ANSI-N14 edition from 1997 to 2014 b) Add ASME BPVC, Section IX c) Delete 2007 from AWS code specification SAR 4. ANSI N14.5-~~1997~~ *2014*, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials." *5. ASME Boiler and Pressure Vessel Code, Section IX, 2004 Edition including 2006 addenda.* 17. AWS D1.6/D1.6M-~~2007~~, "Structural Welding Code – Stainless Steel." Justification a) NRC Information Notice 2016-04, ANSI 14.5-2014 Revision and Leakage Rate Testing Considerations b) See Item 8.1 c) See Item 8.1