UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 20, 2018

Mr. W. Scott Edwards
Director of Transportation
To the attention of: Glenn A. Mathues,
  Licensing Engineer
TN Americas LLC
7135 Minstrel Way, Ste. 300
Columbia, MD 21045

SUBJECT: REVISION NO. 16 OF CERTIFICATE OF COMPLIANCE NO. 9233 FOR THE MODEL NO. TN-RAM PACKAGE

Dear Mr. Edwards:

As requested by TN Americas LLC letter dated July 10, 2017, as supplemented September 26, 2017, October 19, 2017, and January 29, 2018, enclosed is Certificate of Compliance No. 9233, Revision No. 16, for the Model No. TN-RAM transportation package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's safety evaluation report is also enclosed.

TN Americas LLC is registered as the certificate holder for this package. The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of Title 49 of the *Code of Federal Regulations* (49 CFR) 173.471. Those on the attached list have been registered as users of the package under the general license provisions of 10 CFR 71.17 or 49 CFR 173.471.

Upon removal of Enclosure 3, this document is uncontrolled.

If you have any questions regarding this certificate, please contact me or John Vera of my staff at (301) 415-5790.

Sincerely,

/RA/

John McKirgan, Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9233
EPID No. L-2017-LLA-0116

Enclosures:
1. Certificate of Compliance
   No. 9233, Rev. No. 16
2. Safety Evaluation Report
3. Registered Users List

cc w/encls 1 & 2: R. Boyle, DOT
J. Shuler, DOE-SRNL c/o L. Gelder
Registered Users

SUBJECT: REVISION NO. 16 OF CERTIFICATE OF COMPLIANCE NO. 9233 FOR THE MODEL NO. TN-RAM PACKAGE, DOCUMENT DATE: April 20, 2018

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OFC:	DSFM	DSFM	DSFM	DSFM	DSFM
NAME:	JVera	SFigueroa *by email	SEverard *by email	Chang *by email	DTarantino *by email
DATE:	2/28/2018	3/20/2018	3/5/2018	3/3/2018	3/5/2018
OFC:	DSFM	DSFM	DSFM	DSFM	DSFM
NAME:	EGoldfeiz *by email	YDiaz-Sanabria *by email	HGonzalez *by email	TTate *by email	JMcKirgan
DATE:	3/5/2018	3/28/2018	3/26/2018	4/18/18	4/20/18

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT
Docket No. 71-9233
Model No. TN-RAM
Certificate of Compliance No. 9233
Revision No. 16

SUMMARY

By letter dated July 10, 2017, as supplemented September 26, 2017, October 19, 2017, and January 29, 2018, TN Americas LLC (the applicant) requested to amend the Certificate of Compliance (CoC) for the TN-RAM package (Docket No. 71-9233). The amendment requested approval of a new model of the TN-RAM with justification for the decreased lead thickness in the annulus with corresponding decreased allowed content, changes to the materials specifications of the impact limiter wood materials, a clarification regarding tie-downs and lifting lugs, and updated maintenance and acceptance testing. This safety evaluation report documents the staff's evaluations and findings on the proposed changes. The certificate has been updated to Revision No. 16 to reflect the changes.

EVALUATION

2.0 STRUCTURAL EVALUATION

2.1 Description of Structural Design

2.1.1 Discussion

No changes were made to the TN-RAM packaging that affected the structural effectiveness of the packaging. This amendment updated the tie-down analysis of the forward trunnions and provided justification for removing the density and perpendicular crush strength as conditions of approval for the wood used in the impact limiters.

2.2 Tie-Down Devices

In their application, the licensee stated that the previous safety analysis report (SAR) had described trunnion supports that moved in the direction of travel in relation to the transport frame in order to prevent constrained differential thermal expansion between the cask and transport frame. As a result, the front trunnions had not been analyzed for any portion of the required 10g load applied in the direction of travel. The licensee stated that TN-RAM transport trailer has fixed front trunnion supports that may react to part of the 10g load on the trunnions and updated the analysis accordingly.

In Section 2.5.2 of the SAR, the licensee used a bounding package weight to determine the resultant force acting on the package by combining the required 2g vertical and 10g longitudinal transportation forces. The licensee assumed that all four trunnions support the package against the vertical force and that only two trunnions (front or back) support the load in the longitudinal direction. The licensee stated that the 5g lateral force is applied directly to the trunnion flange and therefore, does not influence the trunnion shoulder stress.

The licensee combined the maximum bending and shear stress in the shoulder of the trunnion to obtain the maximum stress intensity within the material. Based on the allowable yield stress of the material, the licensee computed a margin of safety of 0.84. The licensee used the following equation for margin of safety:

$$MS = \frac{allowable\ yield\ stress}{calculated\ stress\ intensity} - 1$$

The licensee analyzed the front trunnion bae plate in the same manner by determining the stress intensity in the material due to the load and comparing it with the allowable yield stress. The licensee obtained a margin of safety of 1.91 for the front trunnion base plate.

The staff reviewed the stress calculations for the front trunnion and notes that the margins of safety are conservative, because the maximum axial stress due to bending and the maximum shear stress do not occur simultaneously in the trunnion; therefore, the actual stress will be less than that calculated by the applicant. Because the margins of safety are greater than zero, the staff concludes that the front trunnions satisfy the standards of 10 CFR 71.45(b) for tie-down.

2.3 Materials

The applicant requested to revise CoC No. 9233 for the Model No. TN-RAM, Docket No. 71-9233. This materials evaluation documents the details of the requested changes and the staff's evaluations and findings on the proposed changes. The proposed material change(s) for modification of the package design are as follows:

- Removed the detailed specification for impact limiter wood from DWG 990-708 and replaced with SPEC 990-1. Impact Limiter wood specification is maintained and controlled, in specification 990-1 (E-10536) as a quality assurance document in the document management system

- Deleted Appendix 2.10.6, "Impact Limiter Wood Specification"

- Deleted Appendix 2.10.7, "Lead Pour Procedure"

- Added Appendix 2.10.10, "Evaluation of Impact Limiters" to demonstrate the sensitivity of performance to wood properties

The applicant stated that density and perpendicular crush strength are removed as a condition of approval for wood used in the impact limiters. Density and perpendicular crush strength do not need to be specified as critical characteristics for the package design to ensure compliant package design requirements. The critical characteristics to be used for the wood (Balsa and Redwood) in the impact limiters and specified as conditions of approval on the SAR drawings are parallel compressive strength, locking strain, and moisture content. These critical characteristics are verified by acceptance testing during fabrication. Additional specifications typical of the wood and useful in the selection of wood for impact limiters are maintained as a controlled specification document under the TN Americas LLC Quality Assurance program. The specification document may be referenced in the SAR, but is not intended to be included as a condition of approval in the CoC.

The staff notes that applicant is requesting to control only the most critical design properties for the wood, used in the impact limiters, within the CoC. Crush strength, locking strain and moisture properties continue to be specified on design drawing 990-708. All other wood properties for evaluating the TN-RAM transportation package under normal conditions of transport (NCT) and hypothetical accident conditions (HAC) remain unchanged and controlled within the SAR and/or design drawings.

The staff reviewed the SAR (e.g., Table 2.3-3, Table 2.10.2-2, Appendix 2.10.10), which incorporates the specified properties of impact limiter wood and finds the changes to be acceptable based on the discussion above. The staff reviewed the material properties provided against various technical publications, handbooks, and scientific articles and determined that they provide reasonable assurance for safety of the package. The Model TN-RAM transportation package impact limiter material properties have been previously evaluated, accepted and used, without incident.

The amendment request also deleted the lead pour procedure previously included as Appendix 2.10.7, “Lead Pour Procedure.” Deletion of this procedure does not change the design basis of the package. Its retention as a quality assurance document is appropriate as a fabrication procedure, therefore the staff finds this change acceptable.

On the basis of the discussion above, the staff determined that the materials used in the TN-RAM transportation package continue to meet the regulatory requirements of 10 CFR Part 71.

2.4 Impact limiter Material Specification

According to the licensee, the density and perpendicular crush strength of the wood used in the impact limiter do not need to be specified as critical characteristics for the package design to ensure compliant package design requirements. The licensee asserted that the critical characteristics (parallel compress strength, locking strain, and moisture content) for the wood are specified as conditions of approval on the SAR drawings and that these characteristics are verified by acceptance testing during fabrication. In Section 2.10.10 of the SAR, the licensee justifies the removal of density and perpendicular crush strength as conditions of approval from the SAR drawings.

2.4.1 Finite Element Model

The licensee developed a full scale half symmetry model in LS-DYNA to determine the structural response of the TN-RAM package to the regulatory 30-foot side, end and corner drops onto an unyielding surface. The model was comprised of 3-D solid elements for the cask, cask lid, and wood sections of the impact limiter. The sheet metal that encapsulates the wood was modeled using shell elements. The licensee used the modified honeycomb material (Material Type 126) to simulate the impact limiter wood. The stress-strain curves were input for all three orthogonal directions corresponding to the orientation of the grain. The crush region of the stress-strain curve had a small increase in slope to accommodate software data input requirements, and then rapidly increases at the appropriate lock-up strain for both species of wood.

The licensee benchmarked the LS-DYNA model of the TN-RAM using the impact limiter analysis that was used as the design basis for accelerations used in the structural evaluation of the cask body and impact limiters. This was accomplished by simulating the static testing of the one-third-scale model of the TN-BRP impact limiters presented in appendix 2.10.3.4 of the SAR.

The licensee performed a sensitivity analysis on the wood properties perpendicular to the grain by conducting three analyses for each of the drop orientations (side, end, and corner). For each orientation, the crush strength perpendicular to the grain was nominal strength, +50% of nominal and -50% of nominal. The acceleration and displacement results were compared to determine the effect of varying the crush strength perpendicular to the grain. They also compared the LS-DYNA results with the results from the ADOC (Acceleration Due to Drop On Covers) computer code that was as the original licensing basis. The ADOC analysis assumed that 80% of the wood was backed by the cask structure.

The licensee presented the peak accelerations of the analyses in Table 2.10.10-2 of the SAR. The acceleration values were within 4.2% for the end drop, 10.2% for the side drop and 0.6% for the corner drop. The maximum acceleration for each of the drop orientations were less than the licensing basis accelerations of 70g for end drop, 128g for side drop, and 68.5g for corner drop. Although the side drop values varied by more than 10%, the acceleration values were well below the licensing basis values.

In Section 2.10.5 of the SAR, the licensee stated that the LS-DYNA model analysis was used for the sensitivity analysis due to varying the crush strength of the wood perpendicular to the grain only. The staff reviewed the LS-DYNA model and the material models and determines that they are acceptable, because they are consistent with the guidance in Interim Staff Guidance – 21 “Use of Computational Modeling Software.” The staff further finds that the sensitivity results indicate that the crush strength of the wood perpendicular to the grain has little effect on the performance of the impact limiters for the various drop orientations based on the configuration of the wood in the impact limiter. Eliminating the crush strength perpendicular to the grain and density (density varies with crush strength) as conditions of approval is acceptable. Additionally, the staff reiterates that the LS-DYNA analysis was only used to conduct a sensitivity analysis and that the ADOC dynamic analysis remains as the design basis to demonstrate compliance with the regulatory requirements for package approval. As a result, the staff concludes the packaging continues to have adequate structural integrity to satisfy the subcriticality, containment, and shielding requirements of 10 CFR 71.51(a)(2) for a Type B package and 10 CFR 71.55(e) for a fissile material package.

Based on review of the statements and representations in the application, the NRC staff concludes that the structural design has been adequately described and evaluated and that the package has adequate structural integrity to meet the requirements of 10 CFR Part 71.

3.0 THERMAL EVALUATION

3.1 Review Objectives

The thermal review evaluated the proposed change of “as-fabricated non-conformance with respect to the lead thickness in the annulus for the TN-RAM package.” The applicant evaluated impact of the reduced lead thickness and stated that there is no significant impact on thermal performance.

The staff reviewed the applicant’s evaluations provided in SAR Chapter 3, “Thermal Evaluations,” and finds that an “as-fabricated” reduced lead thickness in the annulus of the package will reduce thermal resistance across the lead shield and will transfer more heat to the ambient under NCT. The staff concludes that the proposed change has no impact on the design basis thermal evaluation for NCT.

The staff reviewed the applicant’s evaluation under HAC that the package component temperatures and their temperature gradient across the lead shield are mainly dependent on the heat flow into the package from the fire. A thickness reduction in lead shield can increase the peak temperature of the inner shell, as reported in Table 3-7 of the application. However, increase of the peak inner shell temperature is very limited and the maximum package component temperatures still remain below their required limits under HAC.

The staff also reviewed Section 2.7.3.3 of the application and finds that the peak inner shell temperature for a reduced as-fabricated lead thickness is still much below 600°F used for thermal stress evaluation under HAC. Therefore, the staff concludes that the proposed change of the as-fabricated non-conformance with respect to lead thickness in package annulus has no significant effect on the design basis thermal performance and the thermal stress evaluation for HAC.

3.3 Evaluation Findings

The staff also confirmed that the proposed changes of specification of material properties regarding the impact limiters, operations and maintenance and acceptance testing, and tie-down and lifting standards have no impact on thermal performance of TM-RAM package under NCT and HAC. Based on review of the statements and representations in the application, the NRC staff concludes that the thermal design continues to meet the regulatory requirements of 10 CFR Part 71.

5.0 SHIELDING EVALUATION

During the manufacturing process of TN-RAM No. 02, the licensee discovered that the acceptance test gamma scan of as-fabricated annulus lead shielding indicated an effective thickness of 5.56 inches instead of the 5.75 inches minimum annulus lead required for the TN-RAM package design. This effective lead shielding thickness discrepancy was not in conformance with respect to the previously approved TN-RAM package design.

The purpose of the shielding evaluation is to verify that the Model No. TN-RAM-02 package shielding design, and according reduction in allowed content as compared to the previously approved quantities, provides adequate protection against radiation from its contents to ensure that the package design meets the external dose rate limit requirements of 10 CFR Part 71 under NCT and HAC.

5.1 Description of Shielding Design

5.1.1 Design Features

The shielding design features of the TN-RAM include a steel/lead/steel cask body with steel/lead/steel lids. Wood impact limiters are attached at both ends of the cask. The general arrangement of the TN-RAM Package is in Figure 1-1 of the applicant's safety analysis report (SAR, Reference 5-3). The applicant specified detailed dimensions of the shielding features of the package in licensing Drawings 990-701, 990-702, 990-705, 909-707, and 990-710. The revised Drawing 990-702 includes a note that states a reduced minimum radial thickness of 5.56 inches for the annulus lead shielding of the TN-RAM-02 package, which is exception to 5.75 inches annulus lead shielding of the TN-RAM package. The staff reviewed general information in the Chapter 1 as well as drawings in the SAR and the information on the shielding design in Chapter 5 of the SAR and determined consistency of the text, sketches and modeled representation of the package throughout the SAR.

The overall dimensions of the TN-RAM-02 are the same as TN-RAM. The packaging is 178 inches long and 92 inches in diameter with the impact limiters installed. The TN-RAM-02 cask contains steel and lead in the radial and axial directions for shielding. The inner shell has 0.75 inches of steel radially and 0.5 inches of steel at the bottom and the outer shell has 1.5 inches of steel radially and 2.5 inches of steel at the bottom as other TN-RAM packaging. Lead is poured between the shells with a minimum of 5.56 inches radially and 5.69 inches at the bottom.

The TN-RAM-02 requires use of a secondary container as shoring which is the same as the TN-RAM packing.

The staff finds that the figures, certificate drawings, shielding calculations and discussion describing the shielding features are sufficiently detailed to support an in-depth evaluation of the TN-RAM-02.

The content of the TN-RAM-02 is 18,000 Ci equivalent Co-60 activity which is reduced from 30,000 Ci previously approved for TN-RAM to compensate the reduced annular lead thickness. The shielding analysis is done for the reduced content.

5.2 Summary Table of Maximum Radiation Levels

The package is designed as exclusive use and will be transported in an open vehicle. Table 5.18 and Table 5.19 of the SAR provides the maximum dose rates of the package under NCT and HAC respectively.

The applicant performed an analysis of the normally occupied space to meet the requirement in 10 CFR 71.47(b)(4). The applicant discusses this analysis in Section 5.4.4.6 of the application. The applicant states that the TN-RAM is always transported horizontally with the lid end first on a specially designed three-axle semi-trailer. The applicant evaluated the normally occupied space as 152 inches from the top of the package and did not credit any shielding from the vehicle. The occupied space dose rates for TN-RAM-02 is bounded by TN-RAM since the TN-RAM has a higher activity limit and the shielding in direction normally occupied space is the same as TN-RAM.

The staff found that the maximum dose rates in the summary table shows that the package meets the regulatory dose rate limits in 10 CFR 71.47 for exclusive use shipments and the dose rate limits for HAC specified in the 10 CFR 71.51(a)(2)

5.3 Radiation Source

The applicant describes the allowable contents of the TN-RAM in Section 1.2.3 of the SAR as "9,500 lbs of dry irradiated and contaminated, non-fuel-bearing solid materials (with only trace quantities of fissile materials present as contamination) in secondary containers." The content limit for all radionuclides is 3,000 A_2, where A_2 is specified in Table A-1 of Appendix A of 10 CFR Part 71.

5.3.1 Gamma Radiation

The primary content for the TN-RAM is activated steel. The nuclide of concern from activated steel is Cobalt-60 (^{60}Co), therefore the applicant assumed ^{60}Co as the source of gamma radiation. The TN-RAM has a limit of 18,000 Curies (Ci) of ^{60}Co or equivalent, with equivalency determined by evaluating the limiting source geometry at a range of energies. Approximately 99% of the activity is a result of two gammas with energy of 1.1732 and 1.3325 MeV. Section 5.5.3 of the application includes the details of this analysis. The applicant evaluated the maximum activity limit (in gammas per second) that produces a dose rate of 8.90 mrem/hr at 2 meters for discrete energies ranging from 1 to 16 MeV. Table 5-14 of the application includes the results of this evaluation. Conditions of the CoC requires the user to conservatively use the next highest gamma in the table to estimate the sum of the activity (gammas per second) fractions of all gammas emitted. For example, the activity limit for a 2.1 MeV gamma would be the 2.5 MeV limit from Table 5-14.

The staff finds this an acceptable method for determining maximum allowable gamma contents using continues energy cross section for determining flux by using the ANSI/ANS 6.1.1-1977 flux-to-dose-rate conversion factors for gamma rays and neutrons.

5.3.2 Neutron Radiation

The applicant conservatively evaluated a small neutron source using the watt fission spectrum for Cm-244 at 1×10^6 neutrons/second even though the TN-RAM is not allowed to ship any neutron sources beyond a negligible amount as a result of surface contamination that has been transported. This neutron source produced a negligible dose rate at the package surface. The staff found that this was adequate to represent the possible neutron source term including spontaneous fission, gamma-neutron and alpha-neutron reactions.

5.3.3 Beta Radiation

The beta radiation is easily stopped by the package materials but can induce bremsstrahlung radiation when hits high Z materials such as steel and lead that are used as shielding materials. The bremsstrahlung radiation will occur when the beta emitters attenuated through high Z materials. The applicant evaluates a source of 3,000 A2 of phosphorus-32 with maximum energy of 1.71Mev in the TN-RAM to determine the impact of bremsstrahlung radiation on the dose rates of the package. The results indicate the impact is negligible. The staff finds this conclusion reasonable because the stainless steel layer(s) inside the lead layer will reduce the beta radiations and their energy significantly before the beta particles reach the lead layer to produce significant secondary gammas resulting from bremsstrahlung reactions.

5.4 Shielding Model

The staff reviewed the shielding model for NCT and HAC and found the NCT and HAC conditions consistent with the structural and thermal sections of the SAR as discussed in the following subsections.

5.4.1 Source and Shielding Configuration

The staff verified that the applicant used dimensions consistent with those in the drawings of the TN-RAM-02 package in their model of the package to calculate external dose rates. The applicant used nominal package dimensions to model the TN-RAM-02 package body with the exception of the lead shield, which was modeled at its minimum thickness. The staff verified the conservative assumptions within the evaluation such as not crediting for the shielding materials within the liner, self-shielding, using higher energy limits and 5% margin to the regulatory limit.

5.5 Shielding Evaluation

5.5.1 Methods

The applicant performed shielding calculations with Monte Carlo N-Particle (MCNP), version 5. MCNP is a three dimensional transport code. The code's capabilities include modeling of and determining dose rates from package design features where radiation streaming may be a concern. The applicant modeled the package under NCT and HAC conditions, as prescribed in 10 CFR 71.71 and 71.73 respectively. The code is widely used in the shielding calculations and is consistent with the guidance provided in NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

5.5.2 Input and Output Data

The applicant provided input and output files for the MCNP calculations used to determine the external dose rate of the TN-RAM-02 package. The staff reviewed input files for all scenarios and found that the information regarding material properties and dimensions used in the calculations is consistent with descriptions of TN-RAM and drawings given in the application. The staff reviewed all output files for all scenarios and found the calculated dose rates agree with those reported in the SAR.

5.5.3 Flux-to-Dose-Rate Conversion

The applicant used conversion factors that were derived from the ANSI/ANS 6.1.1-1977 standard. The staff found this acceptable because these are the recommended factors per the guidance in NUREG-1609.

5.5.4 Normal Condition Dose Rates

The applicant modeled 1,800 kg of stainless steel with the Co-60 gamma source with specific activity ≤ 10Ci/kg spread throughout the steel. The content mass could be greater than 1,800 kg, the applicant has restricted the contents to less than or equal to 10 Ci/kg of Co-60 or 18000 Ci. The applicant modeled various source geometries to determine a limiting geometry for evaluating external dose rates for TN-RAM-02. Based on the geometry of the contents as shown in Table 5-20 of the SAR, the contents could fill the volume but with voids in random places that are not practical to model. Therefore, for simplicity the applicant modeled the cavity with steel filling the volume, but artificially reduced the density so that it would not exceed 1,800 kg. This model is referred to as the homogenized case and was the limiting case. The applicant also modeled various source geometry scenarios to determine a limiting geometry for evaluating external dose rates.

In the first scenario the applicant modeled the 1,800 kg as a disk source assuming that the content were shifted to the top and bottom of cavity. The stainless disk can fit inside the cavity at full density and radius. In the second scenario the source is assumed in the top of cavity; and, in the third case the source is assumed in the bottom of cavity as shown in Table 5-21 of the SAR. In the fourth case scenario the source is assumed as an annulus of 1,800 kg of the full density steel around the periphery of the cavity that span the axial length of the cavity as shown in Table 5-22 of the SAR. This assumes that there are no voids within the content and is conservative as it concentrates the source closer to the detector in the radial direction. A summary of dose rate for NCT for all four scenarios is shown in Table 5.23 of the SAR.

The maximum radial dose rate at 2 meters is 9.13 mrem/hr for the homogeneous case which is below 10 mrem/hr with relative uncertainty of 0.4% or 0.037 mrem/hr. This dose rate is conservatively determined without taking credit for the shielding material within the liner, or self-shielding of any materials less dense than steel, and using higher energy limits for mixed energy gamma sources. The dose rate is below the 10 CFR 71.47(b)(3) regulatory limit.

The disk top source configuration has the maximum radial surface dose of 127 mrem/hr that is below limit of 200 mrem/hr of the requirement of 10CFR71.47 (b)(1)

The applicant assumed that external surface of the TN-RAM-02 is coincident with the external surface of the vehicle, which satisfies both requirements of 10 CFR 71.47(b)(1) and 10 CFR 71.47(b)(2).

5.5.5 Normally Occupied Space

The applicant performed an analysis of the normally occupied space to meet the requirements in 10 CFR 71.47(b)(4). The applicant discussed this analysis in Section 5.4.4.6 of the SAR. The shielding in the direction of the normally occupied space for TN-RAM-02 is the same as TN-RAM but TN-RAM-02 has a lower source activity, therefore the normally occupied space for TN-RAM-02 is bounded by normally occupied space of the TN-RAM.

5.5.6 Hypothetical Accident Conditions

The HAC modeling assumptions are discussed in 5.4.4.12 of the SAR. The applicant evaluates external dose at 1 meter from surface of the cask under the regulatory requirements of 10 CFR 71.51 9a)(2). The applicant evaluates a few source geometries under the HAC. The limiting geometry has the source homogeneously distributed in a volume that fills the entire diameter of the cavity and 1/3 of the cavity height placed at the top of the cavity where there is potential for streaming over the lead shield. The applicant models no self-shielding material, as stated in the SAR and since no self-shielding is a conservative assumption as the self-shielding material provides significant attenuation of the source. Table 5.-19 shows the summary of HAC dose rates.

The maximum dose rate of 612 mrem/hr is above the lead shielding below the lid which is below the 10 CFR 71.51(a)(2) limit of 1,000 mrem/h.

The maximum top HAC dose rate is 177 mrem/h, which is below the limit of 1,000 mrem/h. This occurs when the source is compressed towards the top of the cask.

The maximum bottom HAC dose rate is 246 mrem/h, which is below the limit of 1,000 mrem/h. This occurs when the source is compressed towards the bottom of the cas*k.*

The staff finds these locations appropriate for evaluating HAC dose rates per the specifications in 10 CFR 71.51(a)(2). The maximum HAC dose rate was at the side (radial direction) of the package, toward the axial center of the package and was 246 mrem/hr.

All calculated dose rate limits are below those of the regulatory limits in 10 CFR 71.47 and 10 CFR 71.51(a)(2) for NCT and HAC, respectively.

5.6 Staff Calculations

The staff performed independent calculations of the TN-RAM-02 using the MCNP 6.1 Code. The staff used the MCNP 6.1 which supports continuous energy source distribution and the gamma lines of Co-60 can be modeled explicitly. The staff was able to confirm the applicant's results by modeling the package independently using the design information contained within the drawings and the SAR. The staff also modeled all other possibly limiting source geometries and found that they produced statistically equivalent results. The staff found that this helps to demonstrate that the package meets the external dose rate requirements in 10 CFR Part 71.

5.7 Evaluation Findings

The staff reviewed the description of the package design features related to shielding, the source terms, and the method and instructions for determining the contents. The staff reviewed also the shielding analyses, the assumptions and approximations used in the analyses as presented in the shielding safety analysis, and the results of the analysis, presented in the application, and the maximum dose rates for NCT and HAC to determine that the reported values were below the regulatory limits in 10 CFR 71.47 and 71.51 for an exclusive use package. Based on review of the statements and representations in the application, the NRC staff concludes that there is a reasonable assurance that the TN-RAM package continues to meet the regulatory requirements of radiation dose rate limits as prescribed by 10 CFR 71.47 and 71.51.

7.0 OPERATING PROCEDURES EVALUATION

Chapter 7 of the SAR, "Operating Procedures," is incorporated as a requirement in Condition No. 8(b) of the CoC. In the amendment request, the applicant added a note to the operating procedures requiring verification of the allowed contents for each particular model of the TN-RAM. This is because the TN-RAM Model No. 02 has a lower allowed content of 18,000 Ci Co-60 equivalent than the TN RAM Model No. 01 which is limited at 30,000 Ci Co-60 equivalent. The verification prior to release for shipment is appropriate given the allowed content difference. Therefore, the staff finds the change acceptable.

The applicant also added notes stating that impact limiter lifting lugs may not be used to lift the cask and that they must be rendered inoperable with a bolt or similar means once the impact limiters are attached. This change was implemented as part of corrective action for shipments where conditions of the approval were not observed. Specifically, the applicant realized that routinely during shipments, the impact limiter lifting lugs were not rendered inoperable in the manner prescribed by 10 CFR 71.87(h). The new notes incorporated in the operating procedures for installing impact limiters corrects this issue, therefore the staff finds the change acceptable.

The applicant added notes throughout the operating procedures directing compliance with appropriate Department of Transportation regulations. The regulations at 10 CFR 71.5, "Transportation of licensed material" require licensees to comply "…with the applicable requirements of the DOT regulations…" and these changes aid in accomplishing that objective. Therefore, the staff finds these changes acceptable.

CONDITIONS

The following changes have been made to the certificate of compliance:

Condition No. 5(a)(2) has been updated to reflect that there now are two models of the TN-RAM.

Condition No. 5(a)(3) has been updated to reflect updated drawings.

Condition No. 5(b)(2)(ii) has been updated to incorporate the maximum quantity limits for the second model of the TN-RAM.

Condition No. 10 now allows use of Revision No. 15 of the certificate until April 30, 2019.

The References section has been updated to reference the TN-RAM consolidated safety analysis report, Revision No. 17.

CONCLUSION

Based on the statements and representations in the amendment request, the staff finds that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9233, Revision No. 16, on