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

Mr. Richard W. Boyle
Radioactive Materials Branch
U.S. Department of Transportation
400 Seventh Street, S.W.
Washington, D.C. 20590

SUBJECT: REVALIDATION RECOMMENDATION FOR THE FRENCH CERTIFICATE OF APPROVAL NO. F/381/AF-96, REVISION Dk, MODEL NO. TNF-XI PACKAGE (DOCKET NO. 71-3092)

Dear Mr. Boyle:

By letter dated June 13, 2018 [Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML18169A098], and as supplemented on August 21, 2018 (ADAMS Package Accession No. ML18250A059), October 24, 2018 (ADAMS Package Accession No. ML18313A063), February 26, 2016 (ADAMS Package Accession No. ML19071A143), and July 2, 2019 (ADAMS Package Accession No. ML19210D199), the United States (U.S.) Department of Transportation (DOT) requested our assistance in the revalidation review of the Model No. TNF-XI package for transporting Content No. 8, as authorized by the French Certificate of Approval No. F/381/AF-96, Revision Dk.

Based upon our review, the statements and representations contained in the application and its supplements, and for the reasons stated in the enclosed safety evaluation report, we recommend revalidation of the French Certificate of Approval No. F/381/AF-96, Revision Dk, for the Model No. TNF-XI package, with the following additional conditions:

1) In addition to the requirements of IAEA SSR-6, 2012 Edition:

   a. The package design must be in agreement with Chapter 0, “Description of the TNF-XI Packaging Model,” Document No. DOE-06-00370218-004, Revision 5;

   b. The package must be prepared for shipment and operated in accordance with Chapter 6A, “Operating Instructions of the Packaging,” Document No. DOS-06-00037028-600, Revision 5; and Chapter 7A, “Acceptance Test and Maintenance Program,” Document No. DOS-06-0037028-700, Revision 0;

   c. The package must be maintained and operated in accordance with Chapter 8A, “Quality Assurance Applicable to TNF-XI Package Model,” Document No. DOS-06-0037028-800, Revision 1, of the application; and

   d. The package must be fabricated in accordance with Design Drawing No. 12986-001, Revision K.

2) The minimum thermal conductivity of the stainless-steel material (i.e., entry X2 Cr Ni 18-9 in Table 0.2, Chapter 0, “Description of the TNF-XI Packaging Model,” Document No. DOE-06-00370218-004, Revision 5) shall be 14.8 $W \cdot m^{-1} \cdot K^{-1}$ at 20°C.

If you have any questions regarding this matter, please contact me or Norma García Santos of my staff at (301) 415-6999.

Sincerely,

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

Docket No. 71-3092
EPID L-2018-LLA-0170

Enclosures:
1. Safety Evaluation Report
2. Enclosure 3 to E-51440 French Certificate of Approval Number F/381/AF-96 (Revision Dk) in English (ADAMS Accession No. ML18192B135)

SUBJECT: CERTIFICATE OF APPROVAL NO. F/381/AF-96, REVISION Dk, FOR THE MODEL NO. TNF-XI PACKAGE (DOCKET NO. 71-3092), DATE: ____________

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http://fusion.nrc.gov/nmss/team/sfst/sfst-licensing/10_cfr_71/tnf-xi_revalodation/Shared Documents/DSER_TNF-XI.docx

ADAMS Package Accession No.: ML
ADAMS Accession No. (Transmittal letter and SER): ML
ADAMS Accession No. (French Certificate of Competent Authority): ML18192B135

This closes L-2018-LLA-0170.

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DRAFT

SAFETY EVALUATION REPORT

Docket No. 71-3092
Model No. TNF-XI Package
Certificate of Approval No. F/381/AF-96
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Enclosure 1

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SUMMARY

By letter dated June 13, 2018 [Agencywide Documents Access and Management System (ADAMS) Package Accession No. ML18169A098], and as supplemented on August 21, 2018 (ADAMS Package Accession No. ML18250A059), October 24, 2018 (ADAMS Package Accession No. ML18313A063), February 26, 2016 (ADAMS Package Accession No. ML19071A143), and July 2, 2019 (ADAMS Package Accession No. ML19210D199), the United States (U.S.) Department of Transportation (DOT) requested our assistance in the revalidation review of the Model No. TNF-XI package for transporting Content No. 8, as authorized by the French Certificate of Approval No. F/381/AF-96, Revision Dk.

The NRC reviewed the information provided to the DOT by TN Americas LLC (Orano or the applicant) in its application for the Model No. TNF-XI package and its supplements against the regulatory requirements of the International Atomic Energy Agency (IAEA) Safety Standard Series No. 6 (SSR-6), "Regulations for the Safe Transport of Radioactive Material," 2012 Edition (IAEA, 2012a). Based on the statements and representations in the information provided by DOT and the applicant, the staff recommends the revalidation of the French Certificate of Approval No. F/381/AF-96, Revision Dk, Model No. TNF-XI package, for the contents included in Section 1.1.2, "Contents," of this safety evaluation report (SER).

1.0 GENERAL INFORMATION

Document No. DOS-06-00037028-000, Revision 9, of the application includes a description of the Model No. TNF-XI package (DOT, 2018a). Section 1.1 of this SER also includes a brief description of the package.

1.1 Package Description

1.1.1 Packaging

The TNF-XI package is built of stainless-steel. The packaging is box-shaped. The main components of the package are the following:

(1) packaging body

(a) four internal cylindrical wells,

(b) inner pails,

(c) inner casing, and

(d) shock-absorbing and heat-insulating material.

(2) a primary lid,

(a) two thermal insulating disks (phenolic foam) with an internal stiffener disk made of aluminum alloy; and

(b) a stainless-steel disk containing boron for the neutron absorption.

(3) lower face of the package

(a) forklift paths are made of a 3-millimeter (3-mm) [0.12 inches (in.)] thick stainless-steel sheet; and

(b) each forklift path is reinforced on the corners with a 3-mm (0.12-in.) thick stainless-steel sheet.

The packaging body has a nominal height of 940 mm (37 in.) and maximum overall nominal height of 1,040 mm (41 in.). The weight of the empty packaging is 660 kilograms (kg) [1,455 pounds (lb.)]. The maximum weight of the package is 1,050 kg (2,315 lb.). The major structural components of the package are the following (DOT, 2018a):

(1) four inner wells for retaining the radioactive material. Each inner well consists of two thin stainless-steel shells that are 1-mm (0.03-in.) thick. [They are separated by a space filled with a 34-mm (1.3-in.) thick neutron-poisoning BORA resin];

(2) four primary lids containing bayonet style closure systems with elastomer gasket construction for the inner wells. The primary lids can be either machined or welded in;

(3) four thermo-mechanical protection upper plugs for the primary lids; and

(4) an outer casing made of 2-mm (0.08-in.) thick stainless-steel sheets.

Per the application, the packaging is compliant with the drawing in Chapter 0, Appendix 1, of the Safety Analysis Report (SAR) (DOT, 2018a).

1.1.2 Contents

The applicant requested to add Content No. 8 to the Competent Authority Certificate for the Model No. TNF-XI. In general, Content No. 8 consists of uranium in the following forms of enriched unirradiated uranium (U) to a maximum of 20 weight percent (wt. %) of Uranium-235 (^{235}U):

(1) uranium oxides,

(2) uranyl nitrate,

(3) sodium diuranates, and

(4) ammonium diuranate.

These uranium complexes may be mixed with inorganic and organic residues (DOT, 2018a). As defined in the Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, Content No. 8 includes the following (DOT, 2019a):

(1) ***uranium-based material*** (uranium oxides form, uranyl nitrate form, sodium diuranates form or ammonium diuranate form) mainly in the form of lumps or fragments with the potential for a minimal quantity of powder due to the erosion of the primary material.

Additional examples of this type of content are calcined filter aid silicon dioxide; aluminum oxides; aluminosilicate calcined (with a small amount of iron and gadolinium oxides); calcium and aluminum fluorides; and sodium nitrate and gadolinium (hydroxides).

(2) ***inorganics solid-form organic solid-form residues.*** Either inorganics solid-form residues (e.g., metallic oxides and precipitates, glass or mineral complexes in solid form) or organic solid-form residues (e.g., polymers, elastomers). Content No. 8 also includes organic and inorganic residues (primarily of aluminum composition).

Additional examples of this type of content are aluminum (e.g., thin sheet, kraft paper, and composite fibers) (i.e., synthetic fibers or glass fibers); polyethylene resin; polyvinyl chloride, glass; glass wool or rock wool; alumina oxide and brick; gypsum; polyethylene resin with carbon black; and concrete.

The contents are placed in one or more inner pails. The inner pails can accommodate fissile material with or without plastic bags. Then, the inner pails are loaded into the package's wells.

2.0 STRUCTURAL EVALUATION

The purpose of the structural evaluation is to verify that the structural performance of the package meets the regulatory requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a) with the addition of Content No. 8. A summary of the staff's structural evaluation is provided below.

2.1 Description of Structural Design

The Model No. TNF-XI, Revision Dk, transportation package is a containment vessel to transport Type A quantities of fissile materials in plastic bags. It is designed to protect the radioactive materials from normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as required by IAEA SSR-6, 2012 Edition (IAEA, 2012a).

Section 1.1 of this SER includes a general description of the package. Additional design features of the package include:

a. phenolic foam located at the base and side of the packaging body and the space between the inner wells,

b. all accessible surfaces made of stainless steel, and

c. forklift guides at bottom of the package to facilitate lifting and support of the package.

The applicant provided the general assembly drawings of the TNF-XI transportation package in Document Nos. 12986-006-A and B, and 12986-004-B, C, and D of the application where it identified the major components of the package (DOT, 2018a).

The staff reviewed the drawings for completeness and accuracy and finds that the applicant adequately describes the relevant details of the major components of the TNF-XI package.

2.2 Mechanical Analysis

The following sections include a discussion of the information provided by the applicant related to the mechanical analysis of the TNF-XI.

2.2.1 Stacking Test

The IAEA SSR-6, 2012 Edition, (IAEA, 2012a) requires subjecting the TNF-XI to the approach resulting on the maximum compression stress on the package:

(1) 5 times the mass of the package, or

(2) 13 kilopascals (kPa) [1.9 pounds force per square inch (lb_f/in^2)] times the vertical projected area of the package.

The applicant selected the first approach as the most challenging to the structural integrity of the package. The applicant performed calculations to demonstrate acceptability of this approach. In the SAR, Subsection 4.2.2, (Document No. DOS-06-00037028-100, Revision 02), the applicant calculated applicable stacking pressure loads based on the guidelines provided by IAEA SSR-6 (IAEA, 2018a) for the upper and lower sections of the package. This load was applied uniformly to the upper and bottom part of the package. The applicant compared the resulting pressure to applicable limits of the phenolic foam, the lateral plates of the external casing, and the forklift guides. The pressure load values were considerably lower than the buckling limits of the lateral plates and the forklift paths, and the crushing strength of the phenolic foam. The applicant concluded that the TNF-XI meets the regulatory requirements of the stacking test.

The staff reviewed the analysis and test results submitted by the applicant. Based on the information provided by the applicant, the staff finds that the package meets the regulatory requirements prescribed by IAEA SSR-6, 2012 Edition.

2.2.2 Lifting Test

In subsection 3.1.1 of the SAR (Document No. DOS-06-0037028-100 Rev. 02) (DOT, 2018a), the applicant stated that the packages are transported vertically in a 20-feet (ft.) long International Organization for Standardization (ISO 20') container and that the loading and the unloading in the container will be achieved by a forklift, through rear side doors. Therefore, there are no lifting devices used on the package.

2.2.3 Penetration Test

The applicant tested various specimen orientations and drop locations to ensure that the most severe drop conditions were covered. In Tables 1 and 2 of Appendix 1.6 of the application (Document No. 12986-Z-1-6, Revision 0), (DOT, 2018a), the applicant describes the drop sequences performed on various prototypes and their corresponding drop heights. The 40-in. [1-meter (1-m)] drop puncture test was performed for all five prototype specimens following the 30-ft (9-m) free drop tests. For the preliminary test specimens, the results showed neither puncture of the outer steel casing nor cracking of the welds. For the qualification and complementary tests, the packaging suffered various degrees of damage including local tearing of the outer steel casing and the upper plug, where the puncture bar hit. In Appendix 1-7 of the application (Document No. DOS-06-00037028, Revision 0) (DOT, 2018a), the applicant re-executed the 40-in. (1-m) puncture test on the impacted upper plug. The applicant confirmed that, at the completion of this test campaign, the packaging did not show significant degradation of its leak tightness capabilities; therefore, containment was maintained.

The staff reviewed the analysis and test results submitted by the applicant and finds that, in aggregate, these meet the regulatory requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a).

2.2.4 Tie-Down Test

The package does not incorporate any feature that is used as a tie-down device. It is designed such that 20 packages can be placed in a 20-ft (6-m) long oversea shipping container on two levels. Each level consists of five rows, which can accommodate two packages per row. The package is secured in the container using a structural tube frame on each side and on the top of the package. In SAR Section 3.1.2 (Document No. DOS-06-0037028-100, Revision 02), the applicant described a structural analysis of the package subject to the acceleration forces of 10 g, 5 g, and 2 g in the longitudinal, lateral, and vertical direction of travel, respectively, as prescribed in IAEA SSR-6, 2012b Edition (IAEA, 2012a). The applicant conservatively analyzed the maximum expected mass load of the package against the minimum crushing strength of the phenolic foam and concluded that there was sufficient contact pressure to withstand the imposed loads on the package for all scenarios.

The staff reviewed the analysis and test results submitted by the applicant and finds that these meet the regulatory requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a).

2.3 Structural Evaluation under Normal and Accidental Conditions of Transport

The following sections include a summary of the information provided by the applicant related to the structural analysis under normal and accident conditions of transport for the TNF-XI package.

2.3.1 Drop Tests

The applicant performed a series of sequential free-fall drop tests with various impact configurations as described in the SAR subsections 4.2 and 4.3 and Appendixes 1-5 through 1-7 (Document No. DOS-06-0037028-100, Revision 02) of the application (DOT, 2018a) to demonstrate compliance with the NCT and HAC requirements in the IAEA SSR-6, 2012 Edition (IAEA, 2012a). The applicant performed tests using a series of five full scale prototypes to account for NCT and HAC, including the following:

(1) Penetration tests with a 13-lb. (6-kg) bar,

(2) Free drop from 4 ft (1.2 m),

(3) Drop tests from 40 in. (1 m) onto a punch bar, and

(4) Free drop from 30 ft (9m).

The drop test orientations were chosen to cause maximum damage to the package. After the drop testing campaign, the applicant concluded that the containment system (i.e., the inner shells and the primary lids) was not breached during the series of drops. In addition, the minimum thickness of the neutron poisoning BORA resin was maintained at 34 mm (1.3 in.) (Document No. 12986-Z-1-5, Revision 0).

In addition to the physical drop tests, the applicant further analyzed the effects of an off-centered load on the primary lid. This analysis was performed using a partial simplified LS-DYNA model simulating a 30-ft (9-m) vertical drop onto the lid with imposed accelerations of up to 500 g. This acceleration value conservatively bounds all expected values in the NCT and HAC drop scenarios, including the effects of ageing phenolic foam hardening. Like in the drop tests, the applicant was able to conclude that there was no rupture of the primary lid and that leak tightness was maintained after the impact event.

The staff reviewed the analysis and test results submitted by the applicant and finds that these test and analysis, in aggregate, meet the regulatory requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a).

2.3.2 Water Immersion Test

In Section 4.3.5 of the SAR (DOT, 2018a), the applicant noted that packaging is not leak tight under external overpressure and that water is assumed to be present in the inner wells for the criticality analysis. Therefore, the packaging structure is not subject to the loading of the water immersion test.

2.4 Evaluation Findings

Based on the review of Model No. TNF-XI application for the transport of Content No. 8, the staff finds that the statements and representations contained in this application meet the requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a).

3.0 MATERIALS EVALUATION

The staff reviewed the application with respect to compliance with the IAEA SSR-6 regulations, Revision 0 (IAEA, 2012a), consistent with the approval under the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk. The scope of staff's safety review for this revalidation request was focused on the package performance in combination with the new proposed contents, defined as Content No. 8 in Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk (DOT, 2018a).

The staff conducted a review of the package to determine, with reasonable assurance, that the performance of the materials used to build the package components is adequate per the regulations in IAEA SSR-6 (IAEA, 2012a). The staff also reviewed the application to ensure that

standards, specifications, and acceptance tests for fabrication of the package are properly defined and reasonable for supporting the intended functions of the package components under the loads and environments required for evaluation per IAEA SSR-6 (IAEA, 2012a).

The package components were not revised from the prior revalidation conducted in support of the current DOT Competent Authority Certificate USA/0653/AF-96 for import/export transport of the Model No. TNF-XI package. In addition, the staff notes that the NRC has previously completed a safety review of an identical package used for domestic transport (Certificate of Compliance for the Model No. TNF-XI package, Docket No. 71-9301) (NRC, 2017). The safety review for the latter package was used to inform the revalidation review, although the staff made determinations about compliance with IAEA SSR-6 regulations based solely on the revalidation application.

Table 3.1. Applicable Paragraphs of the IAEA SSR-6 Regulations (IAEA, 2012a) to the Model No. TNF-XI (Content No. 8).

Paragraph	Brief Description
501	"Before a packaging is first used to transport radioactive material, it shall be confirmed that it has been manufactured in conformity with the design specifications to ensure compliance with the relevant provisions of these Regulations and any applicable certificate of approval…"
502	"Before each shipment of any package, it shall be ensured that the package contains neither: (a) radionuclides different from those specified for the package design; nor (b) contents in a form, or physical or chemical state, different from those specified for the package design."
507	"In addition to the radioactive and fissile properties, any other dangerous properties of the contents of the package, such as explosiveness, flammability, pyrophoricity, chemical toxicity and corrosiveness, shall be taken into account in the packing, labelling, marking, placarding, storage and transport in order to be in compliance with the relevant transport regulations for dangerous goods of each of the countries through or into which the materials will be transported, and, where applicable, with the regulations of the cognizant transport organizations, as well as these Regulations."
614	"The materials of the packaging and any components or structures shall be physically and chemically compatible with each other and with the radioactive contents. Account shall be taken of their behavior under irradiation."
620	"Packages to be transported by air shall be so designed that if they were exposed to ambient temperatures ranging from –40°C to +55°C, the integrity of containment would not be impaired."
639	"The design of the package shall take into account temperatures ranging from –40°C to +70°C for the components of the packaging. Attention shall be given to freezing temperatures for liquids and to the potential degradation of packaging materials within the given temperature range."
640	"The design and manufacturing techniques shall be in accordance with national or international standards, or other requirements, acceptable to the competent authority."
644	"The design of any component of the containment system shall take into account, where applicable, the radiolytic decomposition of liquids and other vulnerable materials and the generation of gas by chemical reaction and radiolysis."

679	"The package shall be designed for an ambient temperature range of –40°C to +38°C unless the competent authority specifies otherwise in the certificate of approval for the package design."

3.1 Safety Review of Contents

The staff reviewed the new proposed contents with respect to physical and chemical compatibility with the package components. Section 1.1.2 of this SER includes a description of the contents.

The applicant clarified that, among the Content No. 8 materials, only aluminum may present a pyrophoricity risk under certain conditions. Content No. 8 in the Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, (DOT, 2018a) explicitly excludes the transport of aluminum metal powder. The applicant clarified that aluminum metal contained in Content No. 8 is only in form of thin sheets or fixed on a media. Further, the proportion of aluminum compared to the material of the media is limited.

The applicant clarified that the maximum temperatures of Content No. 8 remains low with respect to the possibility of the pyrophoricity [i.e., below 60°C (140°F) during NCT and below 100°C (212°F) during accidental conditions of transport] (DOT, 2019a). In addition, the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk (DOT, 2018a), states that, for Content No. 8 at temperatures less than or equal to 100°C (212 °F), the material content must have the following characteristics:

a. be chemically stable,

b. not contain liquids, and

c. be compatible with the material of the plastic bags, the pails, and the inner enclosure and seal of the primary containment lid.

The applicant also clarified that, in the inadvertent event that material in the content mixture were to be pyrophoric, DOT regulations, specifically 49 CFR 173.418, "Authorized packages - pyrophoric Class 7 (radioactive) materials," specifies allowable means for inerting pyrophoric contents (DOT, 2018c). An allowable operation for transport is to inert the contents to prevent self-ignition during transport by mixing them with large volumes of inerting materials, such as graphite, dry sand, or other suitable inerting material, or blended into a matrix of hardened concrete. The staff notes that compliance with 49 CFR 173.418 is appropriate for this revalidation, since the package is for import/export use only. However, since the applicant did not provide a technical basis in support of that rule, the staff only considers this to be an added defense-in-depth element to the applicant's justification for pyrophoricity not being credible during transport operations.

The staff reviewed the description of the Content No. 8 in the Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, (DOT, 2018a) and considers that the materials have been adequately described, in compliance with paragraph 502 of the IAEA SSR-6 regulations (IAEA, 2012a). The staff further considers that the application and the associated French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, (DOT, 2018a) adequately define content specifications and operational controls that provide

reasonable assurance that pyrophoricity and flammability of the contents is not credible during all transport conditions, in compliance with paragraph 507 of the IAEA SSR-6 regulations.

3.2 Safety Review of Packaging

3.2.1 Physical and Chemical Compatibility, Radiolysis

The Model No. TNF XI package is primarily fabricated of stainless-steel and aluminum alloys, which are not directly in contact, therefore, mitigating the risk of galvanic corrosion. In addition, per Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, liquids are not allowed for Content No. 8 at temperatures less than or equal to 100°C (212°F) (which bounds the content temperature during normal and accident conditions of transport). Therefore, other forms of corrosion aided by the contents are not considered credible. Based on this information, the staff considers that adverse reactions between metallic components in the packaging are not credible per paragraph 614 of the IAEA SSR-6 regulations (IAEA, 2012a).

Other materials used in the package include a proprietary polyester-based BORA resin (neutron absorber material) and a phenolic foam (impact limiter and fire-retardant material). The applicant clarified that the BORA resin is confined in stainless-steel components in a dry environment. Therefore, the applicant concluded that corrosion of the encasing stainless-steel components is not credible in that environment. The staff confirmed that application defines both (1) the *material specification* for the BORA material (per the chemical composition defined in Section 7.4 of the application) and (2) the *closure/encasing requirements* for the BORA material in the stainless-steel component. More specifically, the applicant clarified that the package requirements are specified in Design Drawing No. 12986-01, Revision K, and through Chapters 0 (Document No. DOE-06-00370218-004, Revision 5), 0-1, 0A, 6A, 7A, and 8A of the application (DOT, 2018a). Further, the applicant clarified that the design drawing does not define the material specification for the BORA material, because the requirement is specified in Chapter 0 of the application (Document No. DOE-06-00370218-004, Revision 5). The nondestructive acceptance test requirements for the welds of the stainless-steel casing in the BORA material are defined in Chapter 7A-1 of the application (Document No. DOS-06-0037028-701, Revision 0). Therefore, the staff considers that the applicant defined adequate design and acceptable test requirements that provide reasonable assurance of adequate performance of the stainless-steel material adjacent to the BORA material to be acceptable per paragraph 501 of the IAEA SSR-6 regulations (IAEA, 2012a). Since the applicant has defined some of these requirements outside of the design drawing, the staff recommends to include a condition for revalidation to ensure compliance with the design and acceptance test requirements in Chapters 0 (Document No. DOE-06-00370218-004, Revision 5), 6A (Document No. DOS-06-00037028-600, Revision 5), 7A (Document No. DOS-06-0037028-700, Revision 0), and 8A (Document No. DOS-06-0037028-800, Revision 1) of the application (DOT, 2018a).

The applicant clarified that the phenolic foam is chlorine-free and may contain up to 20 wt. % by weight of water, as specified in Section 7.4, Chapter 0 of the application (Document No. DOE-06-00370218-004, Revision 5) (DOT, 2018a). The applicant further clarified that these requirements are also specified in the fabrication specification. The applicant provided supporting standard specification in support of the M1-F1 specification of the phenolic foam

(DOT, 2019a). Therefore, the staff considers the applicant adequately justified the assumed properties and fabrication standards for the phenolic resin per paragraph 501, 614, and 640 of the IAEA SSR-6 regulations (IAEA, 2012a).

The applicant also cited operating experience of a visual inspection of a stainless-steel component directly exposed to the phenolic resin (i.e., same composition and water content) used in a similar package. The applicant explained that corrosion was not observed on the stainless-steel components in contact with the phenolic resin and provided an image of the component (Chapter 0, Figure 0.3, of the application) (DOT, 2018a). The package was fabricated in 2001 and inspected in 2008. Therefore, the applicant concluded that corrosion of the stainless steel, as aided by the presence of the phenolic resin, is not credible. The staff considers the applicant's justification for demonstrating adequate performance of the stainless-steel material adjacent to the phenolic resin material to be acceptable per paragraphs 501 and 507 of the IAEA SSR-6 regulations (IAEA, 2012a).

The applicant stated that there is no risk of radiolysis in the package as the thermal power of Content No. 8 is negligible. The applicant performed an evaluation with bounding content thermal power in support of this conclusion. Per the results of this evaluation, the staff considers that generation of flammable gases due to radiolysis is not expected and the package complies with paragraphs 614 and 644 of the IAEA SSR-6 regulations (IAEA, 2012a).

3.2.2 Temperature-Dependent Material Mechanical Properties

The applicant discussed the characteristics of the materials used for the structural components of the packaging and primary containment of Content No. 8 (as defined in Section 5A of the application). The applicant clarified that the mechanical performance of the package's structural materials [stainless-steel, phenolic foam (three types), BORA neutron-poison resin] is not impaired within the temperature range of -40°C (-40°F) to 75°C (167°F) (i.e., the maximum temperature reached in normal conditions of transport) (DOT, 2018a). Sections 3.2.2.1 to 3.2.2.5 of this SER include clarifications provided by the applicant.

3.2.2.1 Stainless steel

The applicant stated that stainless-steel material is not subject to brittle failure at temperatures down to -40°C (-40°F). The staff agrees with the conclusion.

3.2.2.2 Phenolic foam (impact limiter/thermal insulation material)

The applicant stated that the phenolic foam (Types 1, 2, and 3) can adequately perform within the temperature range of -200°C (-328°F) to 120°C (248°F). The staff notes that the applicant only provided evidence that the mechanical properties (i.e., compression strength) of the phenolic resin are maintained at temperatures as low as -40°C (-40°F), which is consistent with the low temperature requirement in paragraphs 639 and 679 of the IAEA SSR-6 regulations (IAEA, 2012a). The applicant did not justify adequate mechanical performance at temperatures as low as -200°C (-328°F), as stated in Section 2.1, Chapter 1, of the application (Document No. DOS-06-00037028-100, Revision 2) (DOT, 2018a). However, the staff recognizes that this justification is not necessary for compliance with IAEA SSR-6 regulations.

The applicant stated that cracking of the phenolic resin was not observed under mechanical testing at the low temperature requirement of -40°C (-40°F) per paragraphs 639 and 679 of the IAEA SSR-6 regulations (DOT, 2018a). The staff reviewed the applicant's justification based on

the discussion of compression curves at -40°C (-40°F) (Chapter 1, Appendix 2, Document No. 12986-Z-1-2, Revision 0), (DOT, 2018a) which supports the applicant's conclusion that the foam is not altered (i.e., no cracks) per the absence of irregular or sudden drops in the compressive stress in the plastic zone of these curves. Per these tests, the applicant concluded that the average stress corresponding to a crushing value equal to 50% exceeds the minimum requirement per Table 0.2 in Chapter 0 (Document No. DOE-06-00370218-004, Revision 5) of the application. The staff considers the justification provided by the applicant to be acceptable. Since the applicant defined these requirements outside of the design drawing, the staff recommends a condition for revalidation to ensure compliance with the design and acceptance test requirements in Chapter 0 of the application (Document No. DOE-06-00370218-004, Revision 5).

The applicant also provided a summary of testing on the mechanical properties (compression test) of the phenolic resin for -40°C (-40°F) up to 60°C (140°F) (Document No. R&DDT001-26-B-2, Revision 1) (DOT, 2018a). The applicant noted that only the results of the tests carried out on Type 1 material as the tests on the Type 3 material were inconclusive. The staff notes that the applicant did not test the Type 3 material. In addition, the applicant provided a summary of testing conducted to assess the performance of the phenolic resin when aged at 100°C (212°F) from one to four months. The testing compared the compression strength of the non-aged material to the aged material, which showed that the compressive strength of the material increases at the exposure to high temperature. The applicant used the mechanical properties at 60°C (140°F) to assess the phenolic resin performance, which justified that the expected loads, due to drop accidents, would not cause a breach in containment (Document No. DOS-06-0037028-100, Revision 2). The applicant clarified that the 60°C (140°F) temperature corresponds to the maximum temperature of the phenolic resin at NCT (per the package thermal evaluation in Chapter 2-5 of the application), which justifies not evaluating the higher temperature required for evaluation per paragraph 639 of the IAEA SSR-6 regulations [i.e. 70°C (158°F)]. Therefore, the staff concludes that the applicant adequately evaluated the phenolic resin performance per paragraphs 639 and 679 of the IAEA SSR-6 regulations (IAEA, 2012a).

The applicant also clarified that the Type 3 phenolic resin used in the thermal insulating disks of each upper plug protecting the primary lids has the same composition and moisture-control requirements, except it has a lower density than the Type 1 and Type 2 phenolic resin. The applicant further justified that the mechanical properties (i.e., compressive strength) of the Type 3 material are bound by the Type 1/Type 2 material (as discussed in Chapter 1, Document No. DOS-06-00037028-100, Revision 2) (DOT, 2018a). The staff considers that the applicant adequately demonstrated that the assumed mechanical properties in the structural evaluation are valid for the temperature range of interest per paragraphs 639 and 679 of the IAEA SSR-6 regulations (IAEA, 2012a).

3.2.2.3 Polyester-based BORA resin (neutron absorber material)

The applicant stated that the polyester-based BORA resin is stable in the temperature range between -40°C (-40°F) and 150°C (302°F). Therefore, the staff concludes that the applicant provided mechanical properties (compressive modulus) of the BORA resin over the range of temperatures per paragraphs 639 and 679 of the IAEA SSR-6 regulations (IAEA, 2012a).

3.2.2.4 Ethylene propylene diene monomer (EPDM) seal material

The applicant stated that the seal used for the primary containment lid (in each of the four containment wells inside the package) is fabricated of an elastomer material (i.e., EPDM). Per

the seal manufacturer's test report, the EPDM material has a vitreous transition temperature lower than -40°C (-40°F) with adequate performance at temperatures up to 170°C (338°F). Further, the applicant clarified that Section 7.4, Chapter 0, of the application (Document No. DOE-06-00370218-004, Revision 5) defines the hardness requirement for the EPDM seal and includes a discussion about the requisite performance for an operating temperature range between -40°C (-40°F) and 100°C (212°F). The staff concludes that the applicant provided reasonable assurance that the performance of the EPDM material meets the temperature range of interest per paragraphs 639 and 679 of the IAEA SSR-6 regulation. Since the applicant has defined these requirements outside of the design drawing, the staff considers a condition for revalidation should be included, which ensures compliance with the design and acceptance test requirements in Chapter 0 of the application (Document No. DOE-06-00370218-004, Revision 5) (DOT, 2018a).

3.2.2.5 Polymer bags:

The primary containment to Content No. 8 is defined in Section 5A of the application, which does not include the twelve (12) stainless steel pails (3 pails per each of the four containment wells inside the package) (DOT, 2018a). Per Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, Content No. 8 may be packed in plastic bags placed inside the stainless steel pails that are stacked inside the primary containment wells. Per Section 5A of the application, the plastic bags are not credited for primary containment of Content No. 8. Further, per Appendix 8 of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, the plastic bags must have a chemical composition more hydrogenated than water, and the bags must withstand a temperature at least equal to 100°C. The staff considers that the latter requirement provides reasonable assurance for compliance with the operational temperature range of interest per paragraphs 639 and 679 of the IAEA SSR-6 requirements (IAEA, 2012a).

3.2.3 Material Thermal Properties

Table 0.2, Chapter 0, of the application (Document No. DOE-06-00370218-004, Revision 5) defines the thermal conductivities of the various packaging materials, used as input parameters in the thermal analyses in Chapter 2 of the application (Document No. DOS-06-0037028-200, Revision 3) (DOT, 2018a). The applicant clarified that the thermal conductivity of the stainless-steel material [i.e., thermal conductivity of X2 Cr Ni 18-9 defined as 36 Watt per meter per degree Kelvin ($W \cdot m^{-1} \cdot K^{-1}$)] listed in Table 0.2 is incorrect. The applicant clarified that the typical value given in American Society of Mechanical Engineers (ASME) Code for this type of material is 14.8 $W\ m^{-1} \cdot K^{-1}$ at 20°C. The applicant stated that the value considered in the package thermal evaluation (Appendix 1, Chapter 2-1, Document No. DOS-06-00037028-201, Revision 0) is 19.2 $W \cdot m^{-1} \cdot K^{-1}$ at 20°C. However, the applicant concluded that, since the package subcomponents fabricated of stainless-steel are thin, the difference between the value considered in Chapter 2-1 of the application (Document No. DOS-06-00037028-201, Revision 0) and that in the ASME Code will not have significant impact on the conclusions of Chapter 2 of the application (Document No. DOS-06-0037028-200, Revision 3). The applicant also provided references for the minimum thermal conductivities of the aluminum alloy (material 2017 A) and the BORA material resin, defined in Table 0.2 of the application, and clarified that the phenolic material is characterized for acceptance per the thermal conductivity requirements in Table 0.2. Therefore, the staff concludes that the applicant properly defined material thermal conductivities within the temperature range of interest per paragraphs regulations 639 and 679 of the IAEA SSR-6 regulations. Since the applicant defined these requirements outside of the design drawing, the staff recommends a condition for revalidation to ensures compliance with

the design and acceptance test requirements in Chapter 0 of the application (Document No. DOS-06-0037028-004, Revision 5). Further, since the applicant did not revise the application to redefine the thermal conductivity of the stainless-steel (of X2 Cr Ni 18-9) material. Therefore, the staff proposed to add a condition for revalidation to ensure that the minimum thermal conductivity of the stainless-steel is 14.8 $W \cdot m^{-1} \cdot K^{-1}$ at 20°C per the ASME Code (see Section 3.5 of this SER).

3.3 Acceptance and Maintenance Testing

The applicant defined acceptance test requirements, including weld requirements and non-destructive test requirements, for package components in Table 7A-1.1, Appendix 7A-1, of the application (Document No. DOS-06-00037028-701, Revision 00), per the safety categorization in Section 3 of Appendix 7A-1 of the application (DOT, 2018a). The applicant clarified that the design drawing does not identify these weld requirements and non-destructive test requirements. Instead, for each weld, these are identified in Table 0.4, Chapter 0, of the application (Document No. DOE-06-00370218-004, Revision 5). The staff reviewed Chapter 7A (Document No. DOS-06-00037028-700, Revision 0) and Appendix 7A-1 (Document No. DOS-06-00037028-701, Revision 00) of the application related to “Acceptance Testing and Maintenance Testing” of the package and considers the description acceptable for demonstrating compliance with paragraph 501 of the IAEA SSR-6 regulations. Since the applicant defined these requirements outside of the design drawing, the staff recommends a condition for revalidation should be included, which ensures compliance with the design and acceptance test requirements in Chapter 0 of the application (Document No. DOS-06-0037028-004, Revision 5) (see Section 3.5 of this SER).

3.4 Transport by Air

The package is not allowed for transport by air, and therefore IAEA SSR-6 regulations 620 is not applicable.

3.5 Evaluation Findings

The staff reviewed the adequacy of the materials used in the Model No. TNF-XI package for the transport of Content No. 8 to ensure that standards, specifications, and acceptance tests for fabrication of the package are properly defined and reasonable for supporting the intended functions of the package components under the loads and environments required for evaluation per the IAEA SSR-6 regulations (IAEA, 2012a). Per this review, the staff recommends revalidation of French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, with the following conditions:

1) In addition to the requirements of IAEA SSR-6, 2012 Edition:

   a. The package design must be in agreement with Chapter 0, “Description of the TNF-XI Packaging Model,” Document No. DOE-06-00370218-004, Revision 5;

   b. The package must be prepared for shipment and operated in accordance with Chapter 6A, “Operating Instructions of the Packaging,” Document No. DOS-06-00037028-600, Revision 5; and Chapter 7A, “Acceptance Test and Maintenance Program,” Document No. DOS-06-0037028-700, Revision 0;

c. The package must be maintained and operated in accordance with Chapter 8A, "Quality Assurance Applicable to TNF-XI Package Model," Document No. DOS-06-0037028-800, Revision 1, of the application; and

d. The package must be fabricated in accordance with Design Drawing No. 12986-001, Revision K.

2) The minimum thermal conductivity of the stainless-steel material (i.e., entry X2 Cr Ni 18-9 in Table 0.2, Chapter 0, "Description of the TNF-XI Packaging Model," Document No. DOE-06-00370218-004, Revision 5, shall be 14.8 $W{\cdot}m^{-1}{\cdot}K^{-1}$ at 20°C.

4.0 THERMAL EVALUATION

The purpose of the thermal review is to verify that the proposed changes to the package design meet the requirements for the thermal evaluation under the IAEA SSR-6, 2012 Edition (IAEA, 2012a). The staff reviewed the thermal properties of the materials used for the Model No. TNF-XI package and the description of the thermal analysis against the standards in the IAEA SSR-6, 2012 Edition. A summary of the staff's review is provided below.

4.1 Description of the Thermal Design

The Model No. TNF-XI is a Type AF package designed to transport a variety of isotopes in solid or liquid form (DOT, 2018a). The applicant is requesting to add Content No. 8 to the Certificate of Competent Authority to be issued by DOT (see Section 1.1.2 of this SER). The staff reviewed the following information related to the thermal evaluation for the Model No. TNF-XI (DOT, 2018a):

a. "Safety Analysis Report TNF-XI," DOS-06-00037028-000, Revision 9;

b. "Description of the TNF-XI Packaging Model," DOS-06-00037028-004, Revision 5;

c. "Thermal Analysis in Normal and Accident Conditions of Transport," 12986-Z-1-6, Revision 0;

d. "Preliminary Thermal Analysis Before IAEA Fire Test," DOS-06-00037028-201, Revision 0 (Chapter 2-1);

e. "Qualification Thermal Test Report," DOS-06-00037028-204, Revision 1 (including Chapter 2-3);

f. "Thermal Analysis of TNF-XI Under Normal Conditions of Transport and Accidental Conditions of Transports," DOS-06-00037028-206, Revision 1;

g. "Criticality-Safety Analysis of TNF-IX Package," DOS-06-00037028-500, Revision 6; and

h. French Certificate of Approval F/381/AF-96, Revision Di.

The staff reviewed the references above and determined that the applicant adequately described the thermal features of the Model No. TNF-XI package and that this information is in alignment with the package's thermal evaluation.

4.2 Thermal Evaluation under Normal Conditions of Transport and Hypothetical Accident Conditions

The staff confirmed that changes requested do not affect the previously approved design for this package.

4.3 Evaluation Findings

Based on the review of the statements and representations in the application for the Model No. TNF-XI package, the staff concludes that the applicant adequately described and evaluated the thermal design of the Model No. TNF-XI package. Therefore, the package meets the thermal requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a).

5.0 CONTAINMENT EVALUATION

The purpose of the containment review is to verify that the proposed changes to the package design satisfies the requirements for the evaluation of the containment boundary as required in the IAEA SSR-6, 2012 Edition. The staff reviewed the application and its supplements and confirmed that the containment system of the TNF-XI package is well described for revalidation. A summary of the staff's review is provided below.

5.1 Description of the Containment Boundary

The Model No. TNF-XI is designed to transport Type A fissile material [see Section 1.1.2 of this SER or Section 2.2 of the SAR (DOT, 2018a)]. The containment boundary of the TNF-XI package is described in Chapter 5A, "Criticality-Safety Analysis of TFN-XI Package," Section 2, "Confinement System." The requested addition of Content No. 8 does not affect the previous approval.

5.3 Evaluation Findings

Based on review of the statements and representations in the Model No. TNF-XI package application and its supplements (DOT, 2018a), the staff concludes that the applicant adequately described and evaluated the containment system for the TNF-XI package and that the package meets the containment requirements of the IAEA SSR-6, 2012 Edition (IAEA, 2012a). The staff recommends revalidation of the French Certificate of Approval No. F/381/AF-96, Revision Dk.

6.0 SHIELDING

The staff reviewed the application to ensure that the Model No. TNF-XI provides adequate shielding from the proposed Content No. 8 and verified that the package met the radiation level requirements within the IAEA SSR-6, 2012 Edition (IAEA, 2012a) for protecting people and the environment.

6.1 Shielding Evaluation under Normal Conditions of Transport and Hypothetical Accident Conditions

The staff evaluated the TNF-XI package with Content No. 8 in accordance with the requirements of IAEA SSR-6 regulations, 2012 Edition (IAEA, 2012a), which require to ship the package in an exclusive use closed vehicle (if either the surface dose rate exceeds 200 millirem per hour (mrem/hr.), or if the transport index exceeds 10). For exclusive use shipments, the regulations allow a dose rate of up to 1,000 mrem/hr. at the package surface.

The applicant used to have a certificate issued by the NRC for the domestic version of the Model No. TNF-XI, which included Contents Nos. 1 to 7 for transport in the TNF-XI (NRC, 2017). The DOT approved Contents Nos. 1 to 7 in the previous revalidation of the French Certificate of Approval No. F/381/AF-96 and requested the staff's recommendation to revalidate the certificate for Content No. 8 only (DOT, 2018a). Therefore, the staff limited the scope of this review to evaluate whether the TNF-XI package, with Content No. 8, complies with the dose rate requirements of paragraphs 523, 527, and 648(b) of the IAEA SSR-6, 2012 Edition (IAEA, 2012a).

The applicant presented its source term and shielding analysis of the contents in Document No. DOS-06-00037028-400, "Dose Rate Calculations Around the TNF-XI Packaging Model" (DOT, 2018a). The staff reviewed the EDR Tables in Sections 5 and 7 of Document No. DOS-06-00037028-400 and noted that, for each given location, the maximum EDR for Content No. 8 is less than that of Contents No. 4. Given the lower activity level and reduced mass of the uranium isotopes allowed in Content No. 8, staff confirmed that the activity of Content No. 8 will be less than that of Content No. 4. Therefore, the staff finds that Content No. 4 is bounding of Content No. 8 because there is large margin between the maximum EDR for Content No. 8 and No. 4.

The domestic and French package design of the Model No. TNF-XI are essentially the same, with two main exceptions:

a. the French package is authorized to transport Content No. 8, an

b. the French package was reviewed against the IAEA SSR-6, 2012 Edition, and not 10 CFR Part 71.

For the aforementioned reasons and DOT's approval of Content No. 4 as authorized content in the Certificate of Competent Authority for the Model No. TNF-XI, the staff finds the addition of Content No. 8, as authorized content for the TNF-XI package, will meet the requirements of paragraphs 523, 527, and 648(b) of the IAEA SSR-6 regulations (IAEA, 2012a).

6.2 Evaluation Findings

Based on review of the statements and representations in the TNF-XI package application and as discussed in the paragraphs above, the staff has reasonable assurance that the TNF-XI package meets the requirements in paragraphs 523, 527, and 648(b) in the IAEA SSR-6, 2012 Edition (IAEA, 2012a). The staff recommends revalidation of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk.

7.0 CRITICALITY EVALUATION

The applicant requested the addition of Content No. 8 to the Competent Authority Certificate for the Model No. TNF-XI package. The packaging design in the revalidation is unchanged from that which had been previously approved by the staff in prior safety evaluation reports (SERs) for the domestic certificate issued by NRC.

The staff reviewed the application for revalidation of the TNF-XI package to ensure that the package with the requested additional contents remain subcritical under the requirements of IAEA regulation SSR-6, 2012 Edition (IAEA, 2012a). The staff specifically focused the review to the addition of Content No. 8 as an allowable content in the TNF-XI package. Section 1.1.2 of this SER includes a description of the proposed Content No. 8.

7.1 Description of Criticality Design

Per discussion with DOT, the DOT approved Contents Nos. 1 to 7 in the previous revalidation of the French Certificate of Approval No. F/381/AF-96 based on documentation related to the domestic certificate. The criticality design of the French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, for the Model No. TNF-XI package is the same as the expired domestic version (NRC, 2019) of the certificate of compliance for the package design approved by the NRC (NRC, 2017). Therefore, the staff limited the scope of this review to evaluate whether the TNF-XI package, with Content No. 8, complies with the criticality safety requirements of the IAEA SSR-6, 2012 Edition (IAEA, 2012a).

The applicant did not propose changes to the assumptions used in the analysis for the neutron poison plates and borated resin (BORA resin) neutron poison, which have been approved for up to 75% credit of the entrained boron. The basic criticality safety control is based on limiting the mass of fissile material in the package based on enrichment.

7.2 Nuclear Fuel Contents

Content No. 8 consists of various forms of uranium enriched up to 20 wt. % of ^{235}U. Section 1.1.2 of this SER includes a description of the proposed Content No. 8.

7.3 General Consideration for Criticality Safety

The applicant evaluated the reactivity for both a single package (IAEA 2018a, paragraph 680) and infinite array configurations (IAEA 2018a, paragraph 685) for NCT and HAC by modeling one cavity within the TNF-XI package and using mirror reflection of the contents. The staff finds this approach to be acceptable, since the neutrons are conserved within the modeled cavity and neglects any neutron absorption or escape from the surrounding package materials and encompasses any potential mechanical or thermal damage to the package, yielding a conservative analysis.

The applicant also performed a parametric study of the most reactive contents of the TNF-XI package by assuming a mass of 5 kg (11.02 lb.) of uranium metal enriched to 5 wt.% in each cavity and 0.5 kg (1.10 lb.) of uranium metal enriched to 20 wt.% per cavity. All calculations were performed at optimum moderation using uranium metal and CH_2 [because it is more hydrogenated than water at a similar density (0.96 g/cm^3) and provides additional conservatism] assuming the fissile material was in the most reactive geometrical configuration in each cavity to bound the effects on reactivity from any hydrogenated packaging materials. Several sensitivity

studies were performed to obtain the most reactive configuration of the fissile material within the TNF-XI package, including the geometrical shape of the fissile contents, the position of the material within the cavity, various reflector materials to bound the possible residues, moderation within the cavity, and variable water density around the outside of the model [Chapter 5-A6, “Criticality Safety Analysis of the TNF-XI Package Loaded with Content No. 8,” (DOT, 2018a)].

The simplified model used by the applicant as described in Figure 5A-6-1 assumes an inner cavity diameter of 354 mm (1.2 m) with a height of 674 mm (2.2 m) with the inner shell, BORA resin, inner bottom, bottom disk, primary lid, upper plug and external shell of the plug modeled. The pails used to hold the material and the borated ring are not included as specified in the applicant’s response to the staff request for additional information (DOT, 2019b). This revised approach provides additional conservatisms to assuring criticality safety of the package.

7.3.1 Evaluation of Single package and Infinite Arrays of packages

The bounding parameter analysis assumes a single package with 5.0 kg (11.02 lb.) of 5 wt. % enriched ^{235}U metal at optimum moderation in a spherical shape with the material centered in the bottom of the package cavity. The use of uranium metal bounds all potential content types identified as Content No. 8. The uranium sphere was modeled within the cavity filled with the bounding BeO (beryllium oxide) reflector, with mirrored reflection outside of the model. The applicant performed a parametric study on potential reflectors that may be present in the TNF-XI package, including BeO, Be steel, graphite, lead, concrete water, and aluminum, and demonstrated that beryllium oxide bounds all potential reflectors that may be present within the TNF-XI package. The maximum calculated multiplication factor for the single package was $k_{eff} + 3\sigma = 0.881$.

The applicant also performed an analysis of a single package with ^{235}U metal enriched to 20 wt.% with a mass of 0.5 kg (1.10 lb.), which yielded a lower maximum $k_{eff} + 3\sigma$ of 0.759. The reduction in the amount of fissile material at this higher enrichment resulted in a lower k_{eff} of the system consistent with the minimum spherical masses of ^{235}U versus enrichment presented in LA-10860-MS, “Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U,” as expected Since the conditions of the models are the same for the package array evaluation due to the full reflection of the model, the applicant’s analysis bounds both the single package and an infinite array of packages, since full reflection is a very conservative assumption. The staff finds this assessment to be acceptable, since the package body, lid, and base are stainless-steel, the k_{eff} of the single package with the containment system reflected is bounded by the infinite array of packages.

7.3.2 Criticality Safety Index (CSI)

The applicant determined that the CSI for the TNF-XI package containing Content No. 8 remained at zero because the applicant demonstrated that an infinite array of packages under NCT and HAC remains subcritical. The staff finds that the applicant correctly calculated the CSI as defined in SSR-6, para 686, and therefore, it is acceptable.

7.4 Demonstration of Maximum Reactivity

The staff evaluated the proposed TNF-XI package with Content No. 8 as an allowable content and compared it to the previously approved domestic TNF-XI package (Docket No. 71-9301) analysis (NRC, 2017). The applicant performed calculations using the CRISTAL V1.2 system of codes using the MORET4 Monte Carlo code and the APOLLO2 macroscopic cross-sections for

new Content No. 8 using similar modeling techniques as the certificate of compliance No. 9301 analyses to evaluate NCT and HAC using optimum moderation, water intrusion, and fuel assembly tolerances. In all instances, the applicant's calculated k_{eff}'s were substantially below the acceptance criteria of $k_{eff} + 3\sigma = 0.950$. The maximum k_{eff} of the package with the new content is calculated to be $k_{eff} + 3\sigma = 0.881$ for Content No. 8.

The staff performed confirmatory calculations based on the information provided by the applicant in Chapter 5A-6 using the SCALE 6.1 computer code system with the KENO VI three-dimensional Monte Carlo code and the continuous energy ENDF/B-VII cross-section library using assumptions similar to those used by the applicant. The staff's calculations confirmed the applicant's results for the addition of Content No. 8 in the TNF-XI package. The staff determined that the increase in enrichment was offset by the reduction in uranium mass of Content No. 8, resulting in a lower k_{eff}. The staff finds that the maximum reactivity meets the acceptance criteria of $k_{eff} + 3\sigma = 0.95$.

7.5 Benchmark Evaluations

The applicant performed a benchmarking analysis to demonstrate that the code and cross section set can accurately determine the k_{eff} of both low and high enriched uranium systems and determine the bias and bias uncertainty, if any, for this specific package. The applicant utilized the previous benchmarking analysis performed for certificate of compliance No. 9301 package safety analysis for the ^{235}U at 5 wt. % and supplemented their benchmarking analysis to address the new enrichment of up to 20 wt. % ^{235}U in response to staff's RAI (DOT, 2019b). Both analyses utilize the "standard route" in the APOLLO-MORET4 of the CRISTAL V1.2 criticality package and are based on the use of the multigroup cross-section library CEA93-V6 based on the JEF2.2 European evaluation. This "standard route" provides for the validation of fissile media based on the International Handbook of Evaluated Criticality Safety Benchmark Experiments (ICSBEP). To address the higher enrichment, the applicant included experiments with various configurations and reflectors to adequately address the new content. With the addition of these additional experiments in the applicant's validation, the ^{235}U at 20 wt. % continues to overestimate the calculated k_{eff} for both water and BeO reflection, and staff finds that the applicant's benchmarking adequately encompasses the addition of Content No. 8 as an allowable content in the TNF-XI package. The results of the benchmarking analyses do not show any significant bias and bias uncertainty, nor do the results show any trending in the bias.

7.5 Evaluation Findings

The staff found that the proposed addition of Content No. 8 in the TNF-XI package will remain subcritical for all routine, normal, and accident conditions of transport. The staff based its finding on its verification of adequate system modeling performed by the applicant, which maintained a maximum k_{eff} of 0.95 for all analyzed scenarios. Therefore, the package meets the requirement in the IAEA SSR-6, 2012 Edition, Paragraphs 637(a) and 682.

8.0 QUALITY ASSURANCE

The purpose of the quality assurance (QA) review is to verify that the proposed changes to the package design meet the requirements of the IAEA SSR-6, 2012 Edition. The staff reviewed the description of the QA program for the Model No. TNF-XI package against the standards in the IAEA SSR-6, 2012 Edition (IAEA, 2012a).

8.1 Staff's Evaluation of the Quality Assurance Program

The applicant developed and described a QA program for activities associated with transportation packaging components important to safety (DOT, 2018a). Those activities include design, procurement, fabrication, assembly, testing, modification, maintenance, repair, and use. The applicant's description of the QA program [i.e., management system and compliance assurance programs in IAEA SSR-6, 2012 Edition (IAEA, 2012a)] meets the requirements of the applicable IAEA SSR-6, 2012 Edition. The staff finds the QA program description acceptable, since it allows implementation of the associated QA program for the design, procurement, fabrication, assembly, testing, modification, maintenance, repair, and use of the Model No. TNF-XI transportation package.

The staff finds, with reasonable assurance, that the QA program for the TNF-XI transportation packaging:

a. meets the requirements in IAEA SSR-6, 2012 Edition, and

b. encompasses design controls, materials and services procurement controls, records and document controls, fabrication controls, nonconformance and corrective actions controls, an audit program, and operations or programs controls, as appropriate, adequate to ensure that the package will allow safe transport of the radioactive material authorized in this approval.

8.2 Evaluation Findings

Based on review of the statements and representations in the Model No. TNF-XI package application and as discussed in this SER section, the staff has reasonable assurance that the TNF-XI package meets the requirements in IAEA SSR-6, 2012 Edition (IAEA, 2012a). The staff recommends revalidation of French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk.

9.0 REFERENCES

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(IAEA, 2012a) International Atomic Energy Agency, IAEA SSR-6, "Regulations for the Safe Transport of Radioactive Material," 2012 Edition, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1570_web.pdf.

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(DOT, 2019b)	Conroy, Michael, U. S. Department of Transportation (DOT), letter to Norma García Santos, U. S. Nuclear Regulatory Commission (NRC), July 2, 2019, ADAMS Package Accession No. ML19210D199.
(NRC, 2017)	McKirgan, John, U. S. Nuclear Regulatory Commission (NRC), letter to Jayant Bondre, TN Americas LLC, April 24, 2017, ADAMS Package Accession No. ML17115A049.
(NRC, 2019)	McKirgan, John, U. S. Nuclear Regulatory Commission (NRC), letter to Mr. Glen Mathues, TN Americas LLC, January 18, 2019, ADAMS Accession No. ML19018A036.

CONDITIONS

The staff recommends the revalidation of French Competent Authority Certificate of Approval F/381/AF-96, Revision Dk, for the Model No. TNF-XI package, with the following additional conditions:

1) In addition to the requirements of IAEA SSR-6, 2012 Edition:

   a. The package design must be in agreement with Chapter 0, “Description of the TNF-XI Packaging Model,” Document No. DOE-06-00370218-004, Revision 5;

   b. The package must be prepared for shipment and operated in accordance with Chapter 6A, “Operating Instructions of the Packaging,” Document No. DOS-06-00037028-600, Revision 5; and Chapter 7A, “Acceptance Test and Maintenance Program,” Document No. DOS-06-0037028-700, Revision 0;

c. The package must be maintained and operated in accordance with Chapter 8A, “Quality Assurance Applicable to TNF-XI Package Model,” Document No. DOS-06-0037028-800, Revision 1, of the application; and

d. The package must be fabricated in accordance with Design Drawing No. 12986-001, Revision K.

2) The minimum thermal conductivity of the stainless-steel material (i.e., entry X2 Cr Ni 18-9 in Table 0.2, Chapter 0, “Description of the TNF-XI Packaging Model,” Document No. DOE-06-00370218-004, Revision 5) shall be $14.8\ W \cdot m^{-1} \cdot K^{-1}$ at 20°C.

CONCLUSION

Based on the statements and representations contained in the documents referenced above, and the conditions listed above, the staff concludes that the changes to the Model No. TNF-XI package meet the requirements of IAEA SSR-6, 2012 Edition (IAEA, 2012a).

Issued with letter to R. Boyle, U. S. Department of Transportation,
on ___________________.