~~OFFICIAL USE ONLY – SECURITY RELATED INFORMATION~~

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

April 24, 2017

Mr. Jayant Bondre
Chief Technical Officer
TN Americas LLC
7135 Minstrel Way
Suite 300
Columbia, MD 21045

SUBJECT: REVISION NO. 9 OF CERTIFICATE OF COMPLIANCE NO. 9301 FOR THE MODEL NO. TNF-XI PACKAGE

Dear Mr. Bondre:

As requested by your application dated October 13, 2016, as supplemented on February 15 and April 13, 2017, enclosed is Certificate of Compliance No. 9301, Revision No. 9, for the Model No. TNF-XI package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's Safety Evaluation Report is also enclosed.

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.

If you have any questions regarding this certificate, please contact me or Huda Akhavannik of my staff at (301) 415-5253.

Sincerely,

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

Docket No. 71-9301
TAC No. L25158

Upon removal of Enclosure 3, this document is uncontrolled

Enclosures:
1. Certificate of Compliance No. 9301, Rev. No. 9
2. Safety Evaluation Report
3. Registered Users List

cc w/encls 1 & 2: R. Boyle, Department of Transportation
J. Shuler, Department of Energy c/o L.F. Gelder
Registered Users

~~OFFICIAL USE ONLY – SECURITY RELATED INFORMATION~~

NRC FORM 618
(8-2000)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

# CERTIFICATE OF COMPLIANCE
## FOR RADIOACTIVE MATERIAL PACKAGES

| 1. a. CERTIFICATE NUMBER | b. REVISION NUMBER | c. DOCKET NUMBER | d. PACKAGE IDENTIFICATION NUMBER | PAGE | | PAGES |
|---|---|---|---|---|---|---|
| 9301 | 9 | 71-9301 | USA/9301/AF-96 | 1 | OF | 8 |

2. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

TN Americas LLC
7135 Minstrel Way
Columbia, MD 21045

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

TNF-XI Package Safety Analysis Report,
Revision 12, dated April 2017

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: TNF-XI

(2) Description

A shipping container for unirradiated enriched forms of homogenous and heterogeneous uranium oxides. The packaging body is a parallelepiped and is approximately 44 inches x 44 inches x 37 inches. The package contents are enclosed in pails which each have a borated stainless steel ring. Three pails are stacked inside four inner wells of the packaging body. Each inner well is closed by a primary lid and an upper plug.

The packaging body is constructed of an outer stainless steel envelope which is 0.08 inches thick. The space between the outer shell and the inner wells is filled with fire-retardant, open cell phenolic foam.

The four inner wells each have an inside diameter of 14 inches and height of 27 inches. The inner wells are constructed of (1) and outer shell of stainless steel sheet 0.04 inches thick, with a diameter of 17 inches, (2) and inner shell of stainless steel sheet 0.04 inches thick with a diameter of 14 inches, and (3) a flat bottom of 0.04 inch thick stainless steel sheet with a 0.08 inch thick borated stainless steel plate glued to it. A molded annular layer of neutron-poison BORA resin is inserted between the inner and outer steel shells of the inner well.

Each upper plug consists of two thermal insulating disks of phenolic foam, with an internal stiffener disk made of aluminum alloy. The upper plug assembly is encapsulated inside a 0.03 inch thick stainless steel envelope.

5.(a) (2) Description (continued)

The four primary lids closing off the inner wells are stainless steel circular plates 0.2 inches thick on the center part, and 0.4 inches thick on the periphery. Four bayonet teeth are welded to the primary lid to lock in the well flanges. A primary lid locker is located between the well flange and the primary lid to prevent the rotation of the primary lid during transport. The primary lid and the inner well are sealed by an elastomer gasket set in a rectangular groove machined on the inner face of the primary lid.

The approximate dimensions and weights of the package are as follows:

| | |
|---|---|
| Inner well inside diameter | 14 inches |
| Overall package dimensions | |
| Width | 44 inches |
| Length | 44 inches |
| Height | 41 inches |
| Maximum weight of contents in any pail | 25 kg |
| Maximum content weight | 300 kg |
| Maximum package weight (including contents) | 1050 kg |

(3) Drawings

The packaging is constructed in accordance with the Packaging Technology, Inc., Drawing No. 10799-SAR, Rev. 3, Sheets 1 through 7.

(b) Contents

(1) Type and form of material

The following provides a description of the four types of material authorized in 5.(b)(1)(i), 5.(b)(1)(ii), 5.(b)(1)(iii), and 5.(b)(1)(iv):

Homogeneous $UO_2$ powder: Powders, such as fine powder, are those materials that were not subjected to any treatment that would lead to agglomeration.

Heterogeneous $UO_2$ material: Heterogeneous materials, such as coarse powder, granulated powders, pellets, and scrap, are those materials that do not meet the definition of homogeneous powders.

In case of a mix of several forms of fissile material, the mix shall be considered heterogeneous material.

(i) The uranium oxide pellets, powder, and scrap meets the requirements of Enriched Commercial Grade Uranium, as defined in ASTM C996-10. $U_3O_8$ or $UO_{x,\ x>2}$ are authorized provided that the equivalent $UO_2$ mass is less than the limits specified below:

5.(b)(1)(i) Type and Form of Material (continued)

| Max $^{235}U$ Enrichment (weight %) | Homogenous $UO_2$ Powder Maximum Loading (kg) | Heterogeneous $UO_2$ Material (Pellet and Scrap) Maximum Loading (kg) |
|---|---|---|
| ≤ 4.05 | 300 | 300 |
| 4.1 | 300 | 293 |
| 4.15 | 300 | 287 |
| 4.25 | 300 | 271 |
| 4.35 | 300 | 259 |
| 4.45 | 300 | 247 |
| 4.55 | 294 | 238 |
| 4.65 | 281 | 228 |
| 4.75 | 265 | 219 |
| 4.85 | 255 | 208 |
| 4.95 | 244 | 202 |
| 5.0 | 239 | 197 |

(ii) The uranium oxide pellets, powder, and scrap meets the requirements of Enriched Commercial Grade Uranium, as defined in ASTM C996-10. $U_3O_8$ or $UO_{x,\ x>2}$ are authorized provided that the equivalent $UO_2$ mass is less than the limits specified below:

| Max $^{235}U$ Enrichment (weight %) | Homogenous $UO_2$ Powder Maximum Loading (kg) | Heterogeneous $UO_2$ Material (Pellet and Scrap) Maximum Loading (kg) |
|---|---|---|
| ≤ 4.05 | 300 | 300 |
| 4.15 | 300 | 284 |
| 4.25 | 300 | 271 |
| 4.35 | 300 | 256 |
| 4.45 | 300 | 247 |
| 4.55 | 286 | 236 |
| 4.65 | 271 | 224 |
| 4.75 | 259 | 216 |
| 4.85 | 248 | 208 |
| 4.95 | 238 | 202 |
| 5.0 | 232 | 196 |

(iii) The uranium oxide powder scrap, which may contain impurities, meets the requirements of Enriched Commercial Grade Uranium, as defined in ASTM C996-10. The impurities aluminum and carbon shall not exceed 5,000 ppm and 10,000 ppm, respectively. $U_3O_8$ or $UOx.x_{>2}$ are authorized provided that the equivalent $UO_2$ mass is less than the limits specified below:

| Max $^{235}U$ Enrichment (weight %) | Homogenous $UO_2$ Powder Maximum Loading (kg) |
|---|---|
| ≤ 4.05 | 300 |
| 4.15 | 300 |
| 4.25 | 300 |
| 4.35 | 300 |
| 4.45 | 300 |
| 4.55 | 286 |
| 4.65 | 271 |
| 4.75 | 259 |
| 4.85 | 248 |
| 4.95 | 238 |
| 5.0 | 232 |

(iv) The uranium oxides in the form of powder and scraps, enriched up to a maximum of 5.0 wt.% U-235, may be mixed with residues consisting of incinerator ashes or earth, sand and residues from dissolution. $U_3O_8$ or $UO_{x,\ x>2}$, non-irradiated, are authorized when the uranium mass is less than 5 kg per well (each well containing three pails), or equivalent $UO_2$ mass less than 5.68 kg per well (each well containing three pails). The content is designated as Content #7.

(2) Maximum quantity of material per package

(i) For the contents described in 5.(b)(1)(i), no more than 25 kg of contents per pail. No more than 300 kg of contents per package. Presence of hydrogenated materials (with a hydrogen concentration less than hydrogen concentration in water) or water inside cavities and pails is allowed.

5.(b)(2)(i) Maximum quantity of material per package (continued)

The auto-ignition temperature of the hydrogenated materials (with a hydrogen concentration less than hydrogen concentration in water) shall be greater than 140°C (284°F).

The presence of materials containing more hydrogen than water is not allowed in the package.

(ii) For the contents described in 5.(b)(1)(ii), no more than 25 kg of contents per pail. No more than 300 kg of contents per package. In each pail, the contents can be put in a polyethylene bag ($CH_2$) or in a bag made of a material with a hydrogen concentration less than that of polyethylene. The maximum hydrogen content of the bags within each cavity is a mass of 56 g H, which is equivalent to a maximum mass of 390 g polyethylene, considering all sources of hydrogenous material within each cavity.

The auto-ignition temperature of the bag material shall be greater than 140°C (284°F).

The presence of materials containing more hydrogen than polyethylene is not allowed in the package.

(iii) For the content described in 5.(b)(1)(iii), no more than 25 kg of uranium oxide powder scrap contents per pail. No more than 300 kg of uranium oxide powder scrap contents per package. In each pail, the contents can be put in a polyethylene bag ($CH_2$) or in a bag made of a material with a hydrogen concentration less than that of polyethylene. The maximum hydrogen content of the bags within each cavity is a mass of 56 g H, which is equivalent to a maximum mass of 390 g polyethylene, considering all sources of hydrogenous material within each cavity.

The auto-ignition temperature of the bag material shall be greater than 140°C (284°F).

The presence of materials containing more hydrogen than polyethylene is not allowed in the package.

(iv) For the content described in 5.(b)(1)(iv), Content #7, no more than 75 kg of uranium oxide powder and scraps mixed with residues, consisting of incinerator ashes or earth, sand and residues from dissolution, contents per well. No more than 300 kg uranium oxide powder and scraps mixed with residues, consisting of incinerator ashes or earth, sand and residues from dissolution, contents per package.

The incinerator ashes consist of mainly silica, alumina, alumina-silicates, metal oxides, phosphates, aluminum metal, charred wood, and charred plastic.

The earth, sand and dissolved residues consist of mainly silica, alumina, titanium, iron oxide and alumina-silicate. Other organic or inorganic compounds may be present in the form of trace amounts.

5.(b)(2)(iv) Maximum quantity of material per package (continued)

The residues are chemically stable and contain no liquid.

The radioactive material may be placed in plastic bags made of a material with a hydrogen concentration less than that of polyethylene.

The auto-ignition temperature of the bag material shall be greater than 140°C (284°F).

The presence of material containing more hydrogen than polyethylene is not allowed in the package. The presence of material containing beryllium is not allowed in the package.

(c) Criticality Safety Index:

(i) For the content described in 5.(b)(1)(i), 5.(b)(1)(ii), and 5.(b)(1)(iii): 0.5

(ii) For the content described in 5.(b)(1)(iv): 0.0

6. Transport by air is not authorized.

7. In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package shall be prepared for shipment and operated in accordance with the operating procedures in Chapter 7 of the application, as supplemented;

(b) The package must by acceptance tested and maintained in accordance with the Acceptance Tests and Maintenance Program in Chapter 8 of the application, as supplemented; and,

(c) Prior to each shipment, the stainless steel components of the packaging must be visually inspected. Packagings in which stainless steel components show pitting corrosion, cracking, or pinholes are not authorized for transport.

8. The packaging authorized by this certificate is hereby approved for use under the general license provision of 10 CFR 71.17.

9. Expiration date: November 30, 2018.

## REFERENCES

TN Americas LLC, application dated April 13, 2017.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

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

Date: 4/24/17

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

# SAFETY EVALUATION REPORT
**Docket No. 71-9301**
**Model No. TNF-XI**
**Certificate of Compliance No. 9301**
**Revision No. 9**

## SUMMARY

By letter dated October 13, 2016, as supplemented on February 15 and April 13, 2017, TN Americas LLC, (the applicant) requested an amendment to Certificate of Compliance (CoC) No. 9301, for the Model No. TNF-XI transportation package. The letter requested adding a new content, "Content #7," which consists of powder and scraps mixed with residues consisting of incinerator ashes or earth, sand, and residues from dissolution. The applicant also submitted a consolidated application.

Based on the statements and representations in the application, as supplemented, the staff agrees that this change does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

## EVALUATION

By letter dated October 13, 2016, as supplemented on February 15 and April 13, 2017, TN Americas LLC, (the applicant) requested an amendment to Certificate of Compliance No. 9301, for the Model No. TNF-XI transportation package. The letter requested adding a new content, "Content #7," which consists of powder and scraps mixed with residues consisting of incinerator ashes or earth, sand, and residues from dissolution.

In a separate letter, AREVA Inc. (now known as TN Americas LLC) requested a name change of ownership to TN Americas LLC, for the Model Nos. TNF-XI transportation package. As part of an internal reorganization described in a letter dated November 18, 2016, CoC's owned by AREVA Inc. will have their ownership name changed to TN Americas LLC. This change does not result in any changes to the operation and maintenance of the Model No. TNF-XI package. Additionally, as part of the reorganization, the Quality Assurance Program originally issued to AREVA Inc. has been renamed to be issued to TN Americas LLC.

The applicant made changes to Chapter 1 to include discussion of the new content. Additionally, proprietary markings were updated throughout the SAR to reference to "2.390" as opposed to "2.790." The applicant also submitted a consolidated application by letter dated April 13, 2017.

*Materials*

The applicant's proposed change in this revision includes addition of contents with different impurities. In this section, the staff has performed an evaluation with respect to significant chemical, galvanic, or other reactions as stated in 10 CFR 71.43(d).

Content #7 consists of uranium oxides ($UO_2$, $UO_3$, or $U_3O_8$) in the form of powder and scrap, enriched up to a maximum of 5 wt. % U-235, which are mixed with residues consisting of incinerator ashes or earth, sand and residues from dissolution. The $U_3O_8$ or $UO_x$, $_{x>2}$, non-irradiated, material are authorized when the uranium mass is less than 5 kg per well (each well containing three pails), or when the equivalent $UO_2$ mass is less than 5.68 kg per well (each well containing three pails). The uranium oxide powder, scraps or pellets, may be packaged in plastic bags. The simplified package model contains the radioactive material in a single cylindrical cavity wrapped by a layer of Bora resin which is enclosed between two cylindrical steel walls. The authorized quantity is limited to 5 kg uranium (5.68 kg uranium oxide) per cavity of the Model No. TNF-XI package. The authorized quantity is limited to 75 kg uranium oxides and residues per cavity of the Model No. TNF-XI package. The presence of materials containing more hydrogen than water is not allowed in the package.

With respect to pyrophoricity, aluminum impurity level is up to 5000 ppm in the uranium oxide powder. ASTM C753 limits 300 ppm of aluminum impurity. The scrap is less than sub-mm (or scrap spherule radius of 0.10 cm) in size and may include aluminum. The applicant demonstrated that the residues, including aluminum, will be completely oxidized during incineration at 800 ˚C. Therefore, the risk of pyrophoricity is excluded from Content #7. There are no other metals in the contents specified as scrap, and residues of incinerator ashes or earth, sand and residues from dissolution.

In addition, the applicant conservatively assumed in qualification at normal conditions that the mass loss of Bora resin is due to water evaporation. However, since Bora resin is outside the containment system, water evaporation will not be directly in contact with the powdered metals.

Previously, the applicant conducted thermal analysis of materials (e.g., Bora resin or plastic bags). The staff reviewed the analyses and concludes that the amount of flammable gases due to material loss is not a safety concern. The applicant demonstrated that there is no gas generation or thermolysis expected since the expected temperature is below the thermolysis temperature. The incinerator ashes will be less than 100 ˚C with prior incineration at 800 ˚C. Sand and residues from dissolution is below 100 ˚C. Plastic bags are below 100 ˚C. The auto-ignition temperature of the material used for the plastic bag is above 300 ˚C.

With respect to radiolysis, the applicant had previous demonstration of no significant radiolysis effects. The spectrum of the maximum radioactive content was very conservative. Therefore, given the very low power, generation of flammable gases due to radiolysis is not expected.

Evaluation Findings

Based on review of the statements and representations associated with Content #7 in the application and RAI responses, the staff concludes that the materials performance has been adequately described and evaluated and that the package has adequate materials performance to meet the requirements of 10 CFR Part 71.43(d).

*Criticality*

The packaging in this application is unchanged from those already reviewed by Staff in prior safety evaluation reports (SERs.) In this application, only Content #7 and the applicant's evaluation model are new.

Content #7 is described earlier in this SER. The aspects important to criticality safety are: enrichment; fissile mass; moderator material; and reflector material. The applicant has proposed a total mass limit for uranium of 5 kg enriched to a maximum 5% $^{235}U$. The total mass of all contents shall not exceed 75 kg per pail, with a maximum of 4 pails per package. The applicant held the moderator material and fissile mass geometry constant through its evaluations. This yielded a model where the reflector material is unrealistically segregated from the moderator. However, this doesn't necessarily result in a comprehensive evaluation of the reactivity of the materials. The applicant showed that the fissile mass limit yields significant subcritical margin in all the evaluated cases, which included some more reactive reflector material that is not permitted to be loaded. For these reasons, staff finds the applicant's material and geometry assumptions acceptable since the moderator material analyzed is conservative compared to the residue and packaging material permitted in the CoC.

The applicant used the same methodology that was approved in prior amendments, except the applicant developed a simplified criticality model to evaluate Content #7. The simplified model consists of a single pail with reflective boundary conditions on all external faces. This effectively models an infinite array of pails while ignoring the rest of the packaging that surrounds each pail. The applicant converted selected array cases from previous, full-package analyses and converted them to infinite arrays. The applicant varied the package pitch and found that the simplified package bounds the full-package model in all cases. For these reasons, staff finds that the applicant sufficiently demonstrated the simplified model to be conservatively more reactive than the full-package model.

The applicant varied scrap size, scrap shape, fissile bolus shape, bolus size, and bolus location. The applicant varied densities of interspersed water and the simplified package pitch. The remaining sensitivity evaluations are unchanged from the previous review. In all cases, the applicant opted to use the most limiting parameter in its model. Staff finds that the applicant sufficiently investigated these parameters to determine the most reactive configuration.
The applicant did not choose sufficient benchmarks to determine the bias and uncertainty for all the materials evaluated in Appendix B of the SAR. However, the applicant did appropriately benchmark the materials permitted in the CoC. The applicant found that the $k_{eff}$ of all but one in-cavity reflector material falls within 6.1% of the most reactive case. These materials were adequately benchmarked in the previous amendment and are described in Appendix A of the SAR. Given the difference between the most reactive approved moderator and reflector material, and the subcritical margin, staff finds this approach acceptable in this case.

Staff conducted confirmatory analysis using a modified version of the full-package model. The staff model moved the boundary of an existing, full-package model to the extent of the steel shell around the upper plug and set a mirror boundary condition rather than create a new model. Staff varied the radius of polyethylene-moderated spheres of 5% $^{235}U$ enriched $UO_2$ to determine the most reactive case and used that dimension in all subsequent evaluations. Considering only the reflector materials permitted in the CoC, staff results did not match the most reactive reflector materials determined by the applicant. With the same outlier, the staff's results were within 6.3% of the most reactive reflector material, and the range of the staff's results closely matched that of the applicant. Given the variations between the two models resulted in closely matched results, staff finds that these differences are minor and the applicant's results are acceptable.

For the reasons discussed above, staff finds the applicant has provided enough assurance that the package will remain subcritical under the most reactive, credible configurations under NCT and HAC, and the package meets the requirements of 10 CFR 71.

**CONDITIONS**

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

Condition No. 3(a) has been updated to change the name of the CoC Holder from "AREVA Inc." to "TN Americas LLC".

Condition No. 3(b) has been updated to include the latest consolidated application.

Condition No. 5.(b)(1), "Type and form of material," has been updated to include the new content. Condition No. 5.(b)(1)(iv) is added to describe the new content and Condition No. 5.(b)(2)(iv) is added to establish maximum quantity of material per package for the new content.

Condition No. 5(c), "Criticality Safety Index," has been updated to include the criticality safety index for Content #7.

Condition No. 9 which allowed use of Revision No. 7 of the certificate until February 28, 2016 has been deleted. The previous Condition No. 10 is now Condition No. 9.

The References section has been updated to include the consolidated application.

**CONCLUSION**

Based on the statements and representations in the amendment request and the staff's evaluation, 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. 9301, Revision No. 9, on 4/24/17.