



**U.S. Department
of Transportation
Pipeline and
Hazardous Materials
Safety Administration**

East Building, PHH-23
1200 New Jersey Ave., SE
Washington, D.C. 20590

**COMPETENT AUTHORITY CERTIFICATION
FOR A TYPE AF FISSILE
RADIOACTIVE MATERIALS PACKAGE DESIGN
CERTIFICATE USA/0653/AF-96, REVISION 11**

REVALIDATION OF FRENCH COMPETENT AUTHORITY CERTIFICATE F/381/AF-96

This certifies that the radioactive material package design described is hereby approved for use within the United States for import and export shipments only. Shipments must be made in accordance with the applicable regulations of the International Atomic Energy Agency¹ and the United States of America².

1. Package Identification - TNF-XI
2. Package Description and Authorized Radioactive Contents - as described in French Certificate of Competent Authority F/381/AF-96 Di dated September 6, 2016 (attached), limited to contents as described in Appendices 2 and 7(attached), and subject to the following restrictions:
 - a. Type and Form of Material: Uranium oxide pellets, powder and scrap as described below. In Tables 1, 2 and 3, "Homogeneous UO₂ powder" refers to powders, such as fine powder, when those materials have not been subjected to any treatment that would lead to agglomeration; in Tables 1 and 2, "Heterogeneous UO₂ material" refers to heterogeneous materials, such as coarse powder, granulated powders, pellets, and scrap, when those materials 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.
 - b. Maximum quantity of material:
 - i. Uranium oxide pellets, powder, and scrap which meets the requirements of Enriched Commercial Grade Uranium, as defined in ASTM C996-10. U₃O₈ or UO_x, x>2 are authorized provided that the equivalent UO₂ mass is less than the limits specified in Table 1. For these contents there shall be no more than 25 kg of contents per pail and 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. 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.

¹ "Regulations for the Safe Transport of Radioactive Materials, 2012 Edition, No. SSR-6", published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

² Title 49, Code of Federal Regulations, Parts 100 - 199, United States of America.

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- ii. Uranium oxide pellets, powder, and scrap which 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 in Table 2. For these contents, there shall be no more than 25 kg of contents per pail and 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 $140^\circ C$ ($284^\circ F$). The presence of materials containing more hydrogen than polyethylene is not allowed in the package.
- iii. Uranium oxide powder scrap, which may contain impurities, and 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 $UO_{x,x>2}$ are authorized provided that the equivalent UO_2 mass is less than the limits specified in Table 3. For these contents there shall be no more than 25 kg of uranium oxide powder scrap contents per pail and 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 $140^\circ C$ ($284^\circ F$). The presence of materials containing more hydrogen than polyethylene is not allowed in the package.
- iv. 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, as described in Appendix 7. 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). For these contents there shall be 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. The residues are chemically stable and contain no

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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.

Table 1

Max ²³⁵ U Enrichment (weight %)	Homogeneous 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

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Table 2

Max ²³⁵ U Enrichment (weight %)	Homogeneous 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

Table 3

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

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3. Criticality - The minimum criticality safety index is 0.5 for contents described in Appendix 2 and listed above in 2.b.(i), 2.b.(ii), and 2.b.(iii). The minimum criticality safety index is 0.0 for contents described in Appendix 7 and listed above in 2.b.(iv). The maximum number of packages per conveyance is determined in accordance with Table X of the IAEA regulations cited in this certificate.
4. General Conditions -
 - a. Each user of this certificate must have in his possession a copy of this certificate and all documents necessary to properly prepare the package for transportation. The user shall prepare the package for shipment in accordance with the documentation and applicable regulations.
 - b. Each user of this certificate, other than the original petitioner, shall register his identity in writing to the Office of Engineering and Research, (PHH-23), Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington D.C. 20590-0001.
 - c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.
 - d. Records of management systems activities required by Paragraph 306 of the IAEA regulations¹ shall be maintained and made available to authorized officials for at least three years after the last shipment authorized by this certificate. Consignors exporting shipments from the United States shall satisfy the requirements of Subpart H of 10 CFR 71.
5. Special Conditions -
 - a. Except for package markings, labels, placards and determination of the transport index, the package shall be prepared for shipment and operated in accordance with the Operating Procedures approved by the U.S. Nuclear Regulatory Commission (attached). Package markings, labels, placards and determination of the transport index shall be in accordance with the IAEA regulations and the provisions of this certificate.
 - b. Each packaging must be acceptance tested and maintained in accordance with the Acceptance Tests and Maintenance Program approved by the U.S. Nuclear Regulatory Commission (non-proprietary version attached - proprietary version available from applicant).
 - 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.
 - d. All shipments shall use the proper shipping name "RADIOACTIVE MATERIAL, TYPE A PACKAGE, FISSIONABLE, non-special form" (UN 3327).
 - e. Transport by air is not authorized.

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6. Marking and Labeling - The package shall bear the marking USA/0653/AF-96 in addition to other required markings and labeling. Marking with NRC assigned identification number is not required.
7. Expiration Date - This certificate expires on December 31, 2021.

This certificate is issued in accordance with paragraph 816 of the IAEA Regulations and Section 173.472 and 173.473 of Title 49 of the Code of Federal Regulations, in response to the May 2, 2017 petition by TN Americas LLC, Columbia, MD and in consideration of other information on file in this Office.

Certified by:



William Schoonover

Associate Administrator for Hazardous Materials Safety

MAY 12 2017

(DATE)

Revision 11 - Issued to revalidate French Certificate of Approval No. F/381/AF-96, Revision Di, dated September 6, 2016 with restricted contents and specified operating, acceptance, test, and inspection procedures. Revised to add content described in Appendix 7.



DIRECTION DU TRANSPORT ET DES SOURCES

**CERTIFICATE OF APPROVAL
OF A PACKAGE MODEL****F/381/AF- 96 (Di)
page 1/2**

The French competent authority,

Given the application submitted by the TN International company in the letter CEX-15-00115358-121 dated December 14th, 2015,

Given the TN International Safety Analysis Report DOS-06-00037028-000 Rev.6 of December 14th, 2015,

certifies that the package design called "TNF-XI", as described in appendix 0 index i and:

- loaded with oxides of uranium, unirradiated, enriched to a maximum of 5 % in ²³⁵U as described in appendix 2i, (content n°2) ;
- loaded with oxides of uranium, unirradiated, enriched to a maximum of 5 % in ²³⁵U as described in appendix 7i, (content n°7) ;

complies, as a Type A package containing fissile materials,

with the requirements of the regulations, agreements or recommendations listed below:

- Safety Standards Series– Regulations for the Safe Transport of Radioactive Materials – International Atomic Energy Agency n° SSR-6, 2012 Edition ;
- European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) ;
- Regulations concerning the International carriage of Dangerous goods by Rail (RID) ;
- European Agreement concerning the International Carriage of Dangerous goods by inland waterways (ADN) ;
- International Maritime Dangerous Goods Code (IMDG Code from IMO) ;
- Order of May 29th, 2009 concerning the carriage of dangerous goods by terrestrial ways (TMD Order) ;
- Order of November 23th, 1987 modified concerning the Ship Safety, section 411, attached (RSN Order).

This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported.

This certificate expires on **31/12/2021**.

Registration number: **CODEP-DTS-2016-033417**

Montrouge, **6th September 2016**

SUMMARY OF CERTIFICATE ISSUES

Issue	Expiration	Type of issue and modifications	Authority	Type of certificate	Revision index									
						t	0	1	2	3	4	5	6	7
05.08.2002	05.08.2007	First issue type A and type IP-2 package	DGSNR	AF-96	Aa	-	a	a	a	a	a	-	-	-
31.10.2002	05.08.2007	Extension type A and type IP-2 package	DGSNR	AF-96	Ab	-	b	b	b	b	b	-	-	-
04.07.2007	31.12.2011	Prorogation type A package	ASN	AF-96	Bc	-	c	c	c	-	-	-	-	-
04.07.2007	31.12.2011	Prorogation type IP-2 package	ASN	IF-96	Bd	-	d	-	-	d	d	-	-	-
25.11.2010	31.12.2011	Extension type A package	ASN	AF-96	Be	-	e	-	-	-	-	e	-	-
10.10.2011	31.12.2016	Prorogation type A package	ASN	AF-96	Cf	-	f	f	f	-	-	-	-	-
10.10.2011	31.12.2016	Prorogation type IP-2 package	ASN	IF-96	Cg	-	g	-	-	g	g	-	-	-
11.08.2014	31.12.2016	Extension type A package	ASN	AF-96	Ch	-	h	-	-	-	-	-	h	-
06.09.2016	31.12.2021	Prorogation and extension type A package	ASN	AF-96	Di	-	i	-	i	-	-	-	-	i

APPENDIX 0

TNF-XI PACKAGING

1. DESCRIPTION OF THE PACKAGING

The packaging is designed, manufactured, inspected, tested, maintained and used in compliance with the Safety Analysis Report TN International DOS-06-00037028-000 Rev. 6 of December 14th, 2015.

The TNF-XI packaging, of a generally rectangular shape, is presented in Figure 0.1.

The design drawing of the packaging is the drawing COGEMA LOGISTICS 12986-01 Rev. K.

The outer overall dimensions of the packaging are:

- Nominal height of body: 940 mm,
- Maximal nominal height of packaging: 1040 mm,
- Cross section of body: 1100 × 1100 mm (overall nominal dimensions).

The maximal weight of empty packaging (± 10 kg) is 660 kg.

The maximal weight of loaded packaging allowable in transport is 1050 kg.

The packaging comprises the main components described below.

1.1 Body

The body of the packaging consists of a steel external casing of rectangular shape, and four cylindrical internal wells, also made of steel, separated by a layer of shock-absorbing and thermally insulating material.

Each well consists of two steel shells separated by a filling of neutron shielding material. The natural boron concentration of this material is compliant with the value specified in chapter 0 of Safety Analysis Report.

1.2 Closing device

Each well is closed by a primary lid equipped with an elastomer gasket. The internal face is equipped with four steel teeth enabling the closing on the well flange by a "bayonet system".

The primary lid is protected by an upper plug formed by the superimposing of discs. This assembly is surrounded by a thin steel covering. The upper face comprises six steel teeth enabling closing on the body flange by a "bayonet system". Leaktightness between the plug and the body is provided by a seal.

1.3 Handling and storage components

The lower face of the packaging is equipped with steel forklift paths.

1.4 Safety functions

The main safety functions and the most important elements for safety are:

- **the containment** provided by the containment system constituted of:
 - the four stainless steel cylindrical inner shells;
 - the four flat stainless steel bottoms welded to the cylindrical inner shells;
 - the four primary lids and their seals;

- **the radiological shielding** mainly provided by:
 - the resin contained between the cylindrical inner and outer shells;
 - the foam in the packaging body;
 - the steel sheets contained in the primary lids, the inner shells, the four cylindrical inner and outer shells;
 - the borated steel sheets;
 - the discs near the upper plugs;
- **the safety criticality** provided the confinement system constituted of the elements described in chapter 0 of the safety analysis report ;
- **the protection against shock** is mainly provided by the shock absorber material contained in the body of the packaging ;
- **the protection against fire** mainly provided by insulating material.

2. MEASURES TO BE TAKEN BY CONSIGNOR BEFORE SHIPMENT

The package must be used in compliance with the operating instructions described in chapter DOS-06-00037028-600 Rev. 3 (Chapter 6A) of the Safety Analysis Report.

The correct closing of the pails used for the packaging of the contents must be subject to a visual inspection before loading in the cavity of the package.

3. MAINTENANCE PROGRAM

The maintenance program of the packaging is described in chapter DOS-06-00037028-700 Rev. 0 (Chapter 7A) of the Safety Analysis Report.

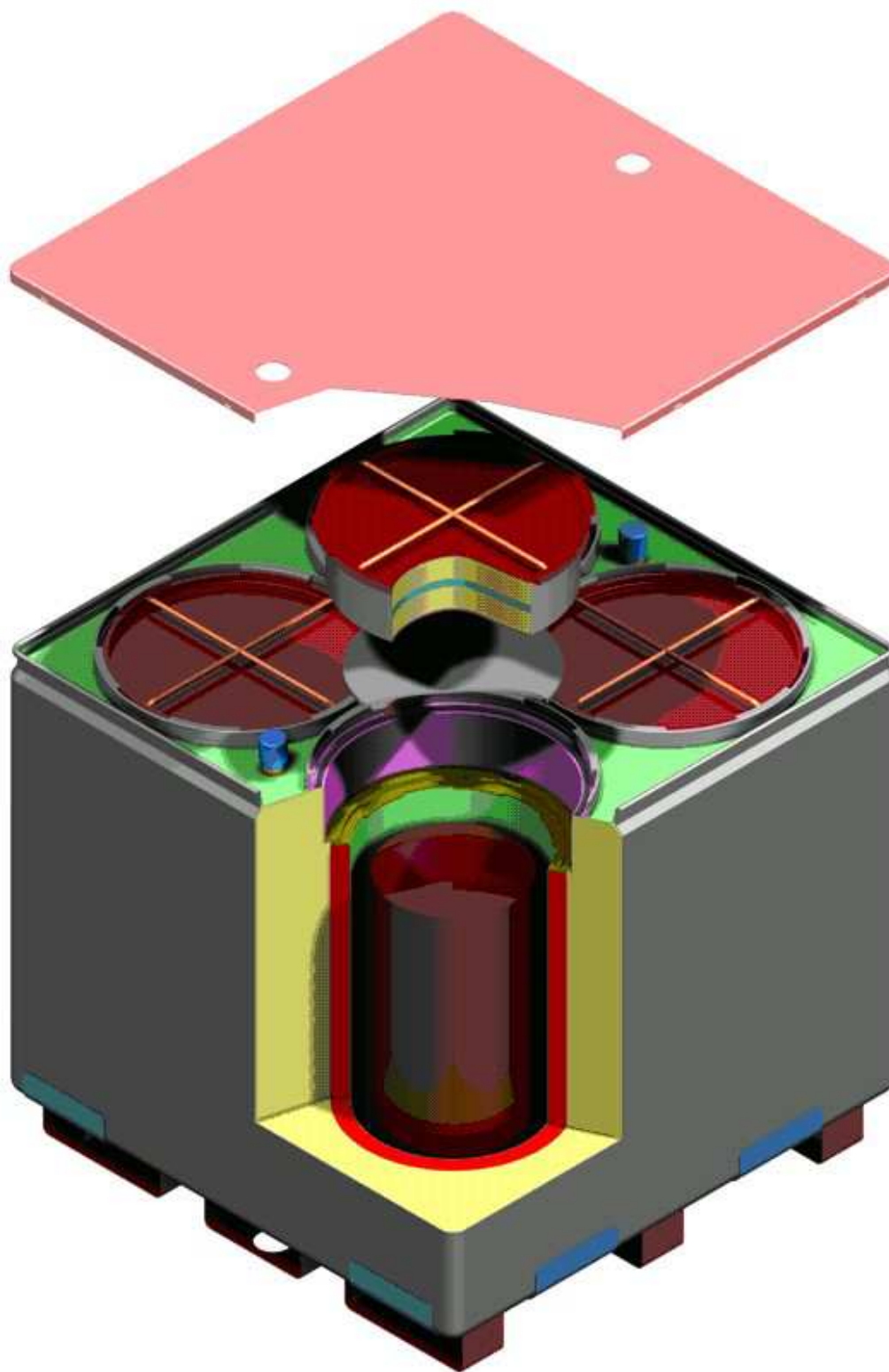
4. NOTIFICATION AND REGISTRATION OF SERIAL NUMBERS

Should a packaging be disposed of or change ownership, this must be notified to the competent authorities. Accordingly, the party relinquishing ownership of a packaging shall forward the name of the new owner.

5. QUALITY ASSURANCE

The applicable quality assurance principles for the packaging design, manufacture, inspection, tests, maintenance and use must be compliant with these described in chapter DOS-06-00037028-800 Rev. 1 (Chapter 8A) of the Safety Analysis Report.

FIGURE 0.1
SKETCH OF THE TNF-XI PACKAGE



APPENDIX 2

CONTENTS N° 2: URANIUM OXIDES (UO₂, UO₃, OR U₃O₈)

1. AUTHORIZED CONTENT DEFINITION

1.1 Physical form

The radioactive content is constituted of uranium oxides (UO₂, UO₃, or U₃O₈) in the form of powder, pellets or scraps of pellets.

1.2 Isotopic composition and maximal allowable weight

The maximal allowable weight of uranium oxide in each cavity (shared out in three pails) of the package is limited to the values defined in function of the maximum content enrichment in ²³⁵U, as follows:

Mass enrichment (e = ²³⁵ U/U _{tot})	UO ₂ , UO ₃ , U ₃ O ₈ (powder, pellets or scraps of pellets)
≤ 4.15%	75.0 kg
≤ 4.45%	64.5 kg
≤ 4.65%	58.5 kg
≤ 4.85%	53.5 kg
≤ 4.95%	51.5 kg
≤ 5%	50.0 kg
Density	≤ 10.96 g/cm ³

The powder of uranium oxide may contain impurities. The Aluminium and Carbon impurities shall not exceed the limit specified hereafter:

Elements	Maximum concentration (ppm)
Al	≤ 5,000
C	≤ 10,000

1.3 Maximal activity

The radioactive contents must comply with the “unirradiated Uranium” definition of the applicable regulation.

1.4 Maximal weight of powder

The total maximal weight of this content is 300 kg.

2. PACKAGING

Inner primary containers: pails

The uranium oxide may be placed in bags constituted of material more hydrogenated than water. Packed (or not) uranium oxide is placed in pails (three for each cavity) in stainless steel compliant with the following characteristics:

- Placed in vertical position,
- Material : stainless steel,
- Nominal diameter: 287.4 mm,
- Lid in stainless steel with closure ring,
- Empty weight: approximately 7 kg,
- The thickness of the pails is at least equal to 1 mm,
- Presence of a borated steel ring in the pails that must comply with the following characteristics: minimal height: 180 mm, minimal thickness: 2 mm, external diameter between 280 mm and 285 mm, natural boron mass content: greater than 1%, which represents a concentration in ^{10}B of $C \geq 8.7.10^{20}$ at/cm³. The borated ring may have a longitudinal weld.

Each cavity must always contain the three pails stacked in vertical position with their borated ring.

The maximal authorised mass of plastic material more hydrogenated than water is limited to 390 g per cavity. The operating temperature of the plastic bag must be equal or greater than 100°C.

3. CRITICALITY ANALYSIS

It is subject of chapters DOS-06-00037028-500 Rev.5 (chapter 5A), DOS-06-00037028-503 Rev.3 (chapter 5A-3) and DOS-06-00037028-504 Rev.0 (chapter 5A-4) of the Safety Analysis Report.

Confinement system considered is described in the chapter DOS-06-00037028-500 Rev.5 (chapter 5A) of the Safety Analysis Report.

Criticality Safety Index (CSI): 0.

APPENDIX 7

CONTENTS N° 7: URANIUM OXIDES (UO₂, UO₃, OR U₃O₈)

1. AUTHORIZED CONTENTS DEFINITION

1.1 Physical form

The radioactive content is constituted of uranium oxides (UO₂, UO₃, or U₃O₈) in the form of powder, pellets or scraps of pellets mixed with residues consisting in incinerator ashes or earth, sand and residues from dissolution.

1.2 Isotopic composition and maximal allowable weight

The maximal allowable weight of uranium in each cavity (shared out in three pails) of the package is limited to 5 kg of uranium under form of uranium oxides. The maximum mass enrichment “e” in ²³⁵U is limited to 5% ($e = \frac{^{235}\text{U}}{U_{\text{tot}}}$).

The residues incinerator ashes consist of mainly silica, alumina, aluminosilicates, metal oxides, phosphates, aluminium metal, charred wood and charred plastic in undefined part.

The earth, sand and dissolved residues consist of mainly silica, alumina, titania, iron oxide and aluminosilicate in undefined part. Other organic or inorganic compounds may be present in the form of traces.

The residues are chemically stable, contain no liquid.

The authorised quantity of uranium oxides and residues is limited to 75 kg per cavity.

1.4 Maximal activity

The radioactive contents must comply with the “unirradiated Uranium” definition of the applicable regulation.

1.5 Maximal weight of powder

The total maximal weight of this content is 300 kg.

2. PACKAGING

Inner primary containers: pails

The uranium oxide can be placed in bags constituted of material more hydrogenated than water. Packed (or not) uranium oxide is placed in pails (three for each cavity) in stainless steel compliant with the following characteristics:

- Placed in vertical position,
- Material : stainless steel,
- Nominal diameter: 287.4 mm,
- Lid in stainless steel with closure ring,
- Empty weight: approximately 7 kg,
- Presence of a steel ring (that can be borated) in the pails that must comply with the following characteristics: minimal height: 180 mm, minimal thickness: 2 mm, external diameter between 280 mm and 285 mm. The borated ring may have a longitudinal weld.

Each cavity must always contain the three pails stacked in vertical position with their borated ring.

The operating temperature of the plastic bag must be equal or greater than 100°C.

3. CRITICALITY ANALYSIS

It is subject of chapters DOS-06-00037028-500 Rev.5 (chapter 5A) and DOS-06-00037028-505 Rev.0 (chapter 5A-5) of the Safety Analysis Report.

Confinement system considered is described in the chapter DOS-06-00037028-500 Rev.5 (chapter 5A) of the Safety Analysis Report.

Criticality Safety Index (CSI): 0.

7.0 OPERATING PROCEDURES

7.1 Introduction

This section delineates the procedures for loading a payload into the TNF-XI packaging. Reference to specific TNF-XI packaging components (*items*) may be found in Appendix 1.3.1, *Packaging General Arrangement Drawings, specifically on the List of Material table.*

7.1.1 Preparation of the TNF-XI for Loading

1. TNF-XI body – Visually inspect all the bayonets mating with the primary lid in each well for damage.
2. TNF-XI body – Visually inspect all the bayonets mating with the upper plug in each well for damage.
3. TNF-XI body – Visually inspect all external surfaces for damage. The maximum acceptable dent is 1/2-inch deep.
4. TNF-XI body – Visually verify that the fusible plugs on each container side (8 total) and on the upper surface (6) are in place.
5. TNF-XI body – Visually verify that the stacking pins (2) on the upper surface are in place and tightly secured.
6. Upper Plug – Visually inspect the external surfaces of the lid for handling damage. Maximum acceptable dent is 1/2-inch deep.
7. Upper Plug – Visually verify the 2 fusible plugs located on the upper surface of each plug are in place.
8. Upper plug – Visually verify the foam rubber gasket in the lid is clean, in good condition with no tears or cuts, and is tightly adhering.
9. Primary lid and Upper plug – Visually verify the sealing surfaces and the locking bayonets are clean and undamaged.
10. TNF-XI packaging wells – Visually verify the proper installation of the primary lid gasket in each well.
11. Packaging wells – Visually verify that the interior of each well is clean and dry.
12. When deviations to items 1, 5 and 13 are found, the item is corrected before release to loading.
13. When deviations to items 2, 3, 4, 6, 7, 8, 9, 10, 11, 12 and 14 are identified, the package or packaging component is immediately removed from service, identified as non-conforming material, and dispositioned in accord with written procedures including the 10 CFR 71, Subpart approved QA Plan.

7.1.2 Loading the Payload into the TNF-XI

1. The uranium oxide payload will be contained in pails. Prior to the loading of the payload into the pails, visually verify that an undamaged boronated ring is correctly installed in each pail as shown in the drawings of Section 1.3.
2. A maximum of three pails may be loaded into a single well and the pails shall be placed so that the total mass of the payload material is distributed as evenly as practical among the four wells of the packaging. The maximum loading of any one well shall not exceed 25% of the maximum loading mass for the specific enrichment and type of content *as presented in the Certificate of Compliance for either Homogeneous UO₂ powder or Heterogeneous UO₂ material*.
3. After loading the pails into each well, the primary lid shall be placed into the well and rotated to engage the bayonets.
4. Secure the primary lid locker for each primary lid.
5. Lower each upper plug into position and rotate to engage the bayonets.
6. Install the securing plate after all upper plugs are in place.
7. Install safety cover.

7.1.3 Final Package Preparations for Transport

1. Install the tamper-indicating seal.
2. Not Used.
3. Monitor external radiation for each package per 49CFR §173.441¹.
4. Determine the surface contamination levels for each TNF-XI package per 49CFR §173.443.
5. Determine the criticality safety index for the loaded TNF-XI package per 49 CFR §173.403.

¹ Title 49, Code of Federal regulations Part 173 (49CFR 173), *Shippers – General Requirements for Shipments and Packagings*, current Edition

6. Complete all necessary shipping papers in accordance with Subpart C of 49 CFR 172².
7. TNF-XI package marking shall be in accordance with 10 CFR §71.85(c) and Subpart D of 49 CFR 172. Package labeling shall be in accordance with Subpart E of 49 CFR 172. Packaging placarding shall be in accordance with Subpart F of 49 CFR 172.

7.2 Procedures for Unloading the Package

This section delineates the procedures for unloading a payload (*items*) out of the TNF-XI packaging. Reference to specific TNF-XI packaging components may be found in Appendix 1.3.1, *Packaging General Arrangement Drawings, specifically on the List of Material table*.

7.2.1 Unloading the Transport Vehicle

1. *Position the vehicle for unloading.*
2. Check shipment conformity with the label on the container and the packages.
3. Open the doors of the transport container (if the packages are shipped in a container).
4. Extract the packages.
5. Visually inspect the packaging.

7.2.2 Removal of the Payload from the TNF-XI

1. Remove the tamper safe seal.
2. Remove the safety cover.
3. Remove the securing plate.
4. Remove the upper plug from each well.
5. Lift the primary lid locker and remove the primary lid from each well.
6. Remove the pails containing the uranium oxide payload using an appropriate extraction device (gripper or sucker).

7.2.3 Final Package Preparations for Transport of Unloaded TNF-XI

1. Complete all required shipping papers in accordance with Subpart C of 49 CFR 172.

² Title 49, Code of Federal Regulations, Part 172 (49 CFR 172), *Hazardous Materials Tables and Hazardous Communications Regulations*, current Edition.

2. TNF-XI package marking shall be in accordance with 10 CFR §71.85(c) and Subpart D of 49 CFR 172. Package labeling shall be in accordance with Subpart E of 49 CFR 172. Packaging placarding shall be in accordance with Subpart F of 49 CFR 172.

7.3 Preparation of an Empty Package for Transport

Previously used and empty TNF-XI packages shall be prepared and transported per the requirements of 49 CFR §173.428 and 49 CFR §173.433.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

Per the requirements of 10 CFR §71.85(c)¹, this section discusses the inspections and tests to be performed prior to first use of the TNF-XI package.

8.1.1 Visual Inspections

All TNF-XI packaging materials of construction and welds shall be examined in accordance with the requirements delineated on the drawings in Appendix 1.3.1, *Packaging General Arrangement Drawings*, per the requirements of 10 CFR §71.85(a).

8.1.2 Structural and Pressure Tests

8.1.2.1 Lift/Tie-down Device Load Testing

The TNF-XI packaging does not contain any lifting/tiedown devices that require load testing.

8.1.2.2 Containment Vessel Pressure Testing

Per the requirements of 10 CFR §71.85(b), no pressure testing is required because the maximum normal operating pressure is less than 35 kPa. (See paragraph 3.4.1).

8.1.3 Fabrication Verification Leak Tests

The TNF-XI packaging does not contain any seals or containment boundaries that require leak testing.

¹ Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), *Packaging and Transportation of Radioactive Material*, 1-1-98 Edition.

8.1.4 Component Tests

8.1.4.1 Phenolic Foam

This section establishes the requirements and acceptance criteria for production, installation, inspection, and testing of the rigid, open-celled, phenolic foam utilized within the TNF-XI packaging. The detailed procedures for production and testing of the phenolic foam are given the Transnucleaire specification contained in Section 8.3. These procedures ensure that the foam has the specified physical, chemical, thermal, mechanical, and dimensional properties summarized as follows:

- All foam items are M1-F1 phenolic foam. The chemical composition is [] water and [] dry foam. The minimum content of Hydrogen is [] by mass. The other constituents are Carbon ([] by mass) and oxygen ([] by mass).
- Foam densities are summarized in the table below and are calculated from the sample mass and the displaced volume after placing it in water. The density includes at least [] water.
- Compressive strengths are summarized in the table below and are verified per ISO 844.
- To protect against corrosion of the package's structural components, all foam items must have a leachable chloride content less than 20 ppm as per the CNRS/WICKBOLD method.
- All foam has a thermal conductivity of [] W/m/K at 20°C, dry.
- All foam is classified as M1 fire-resistant per NF P 92-501 meaning that the foam self-extinguishes after undergoing an oven test.
- All steel surfaces are brushed, cleaned, and degreased prior to installation or pouring of foam.

Table 8-1 Properties of Foam Items

Item No.	Foam Density (kg/m ³) at 20°C	Compressive Strength at 50% Crushing at 20°C (MPa)	Fabrication Techniques (See Appendix 8.3)
15	[] (type3)		molded
23	[] (type1)		molded
24	[] (type1)*		poured
22	[] (type2)		molded
44**	[] (type2)		molded

Notes:

* Because item 24 is poured, during fabrication its density is verified indirectly by measuring its mass [] and comparing it to the volume of the foamed space (487 liters).

** Item 44 is referred to as Item 24-1 in Appendix 8.3

Qualification of the foam:

The qualification test of the foam parts is described in Section 8.3.

8.1.4.2 Neutron Poison

This section establishes the requirements and acceptance criteria for inspection and testing of neutron poison utilized within the TNF-XI packaging. Two neutron poisons are utilized for this package, borated stainless steel and BORA resin. For both neutron poison materials, the criticality analysis in Chapter 6 assumes that the Boron credit is 75% of the minimum Boron concentration stipulated on the design drawings.

8.1.4.2.1 Borated Stainless Steel

All borated stainless steel meets the requirements of ASTM A 887-89 Type 304B4 Grade B. The borated stainless steel disks in the cavity and in the shield plugs are fabricated to Böhler Bleche specification A976SC. Because all borated stainless steel is supplied, the supplier of this material performs all qualification and acceptance testing of this material. The fabricator receives only material that has been certified according to the applicable standards. For completeness, the acceptance testing used by the supplier for the borated stainless steel is provided below.

Borated stainless steel disk acceptance tests (performed by supplier):

Stainless steel disks will be cut from “parent-plates” which are manufactured according to ASTM A 887-89 for type 304B4 material. Additionally, each “parent-plate” will undergo an acceptance test to demonstrate the desired neutron absorption capability of the sheets.

The principle of the test is to measure the reduction of the neutron flux caused by the Boron alloyed in the material. The test device containing a neutron source is placed on the test article, which is situated on a reflector table. An impulse counter in the test device measures the count rate for a period of time depending on the Boron content, thickness of the material, and the power of the neutron source. The supplied plates will be tested such that:

- 2.5% of the “parent-plates” from which stainless steel disks are cut will be tested using multiple points on a grid, to demonstrate the Boron uniformity.
- 97.5% of the “parent-plates” will be tested at one random location on the plate.

Rejection of a parent-plate will occur if it does not meet the specified criteria. Only conforming plate material will be supplied to the fabricator.

The acceptance criteria for testing of the borated stainless steel plate is based on the minimum Boron content of the plate (B_{\min}) and the plate's minimum thickness (th_{\min}).

- A reference test piece is cut from one sheet of the order, and the Boron content of the reference test piece is measured by chemical analysis (B_{ref}).
- The absolute minimum of the Boron content in the reference test piece ($B_{\text{ref_min}}$) is calculated by subtracting twice the standard deviation of boron homogeneity from the boron content measured above. The standard deviation of boron homogeneity is provided by the material supplier and is based on historical data. Thus, the absolute minimum of the Boron content corresponds to the lower bound of Boron content with 95% probability.
- The reference thickness is determined by the equation:

$$th_{\text{ref}} = B_{\min} \times th_{\min} / B_{\text{ref_min}}$$

- The reference piece is then machined is grounded to the reference thickness.
- The neutron absorption capacity of the reference piece is then analyzed by measuring the count rate (CR) with the same test equipment and procedure used to measure the CR in the acceptance tests. However, 50 measurements are to be taken at one location so that an average value ($CR_{\text{ref_mean}}$) and the standard deviation (SCR_{ref}) can be calculated.
- The acceptance limit for the count rate during acceptance testing must be less than or equal to:

$$CR \leq CR_{\text{ref_mean}} - 2 SCR_{\text{ref}}$$

Thus, the acceptance limit corresponds to the lower bound of the count rate with 95% confidence in the acquisition of the count rate data.

8.1.4.2.2 BORA Resin

BORA resin is a rigid polyester based compound with a high natural boron content having a minimum density of [] g/cm³. The mass percentage of the compounds used to make the resin is listed in Table 8-2. Additionally, small amounts of catalyst and accelerator are used to initiate and accelerate the polymerization.

Table 8-2 BORA Resin Composition

Component	Mass Percentage

For the boron carbide, the particles are between [] μm and [] μm in size. For the zinc borate, the average particles size is [] μm, and the maximum size [] μm. The discussion below regarding qualification testing of the resin shows that the particle concentration is uniform in the shell.

Material properties are documented in Section 8.4. The resin is mixed in a liquid form before pouring it into special molds. After polymerization, the shell is mounted onto the identified cavity.

BORA resin qualification process:

During the development of the product, material properties were characterized as a function of temperature, including the effect of temperature on material durability (see Section 8.4). Because this package is designed to handle fresh powder, the radiation environment is not severe enough to affect the material properties. For this reason, the effects of the radiation environment on the materials were not considered.

The qualification of the pouring of BORA resin is performed with the mold intended for use in the manufacturing process and by qualified operators, prior commencing manufacturing. In addition, a separate “test sample” is poured for each shell that is fabricated. Each shell/test sample is poured from a unique batch so that non-conformity in a shell does not impact other shells.

Qualification of BORA resin manufacturing process will occur if:

- The mass of each compound used in making the resin is within ±0.5% of its nominal mass.

- The BORA resin shell meets the dimensional inspection criteria (thickness and height).
- The BORA resin shell meets the density criteria.
- Samples are taken at multiple locations in the top, middle, and bottom of the shells as well as the “test sample” that is made at the end of the pour. The “test sample” corresponds to the sample that will be used for conducting the acceptance test. All specimens must meet the minimum density requirement ([] g/cm³) in order for qualification to occur. Qualification test data is provided in Table 8-3.
- The BORA resin shell meets the Boron content requirements as measured by mass spectroscopy given that the concentration of B-10 in natural Boron is 19.9 atom-percent (18.43 wt-%).
- Test specimens are cut from a qualification test shell at multiple locations. First, the density of each test specimen is measured. Next, the percentage of Boron content is measured by mass spectroscopy. All test specimens must meet the minimum resin density ([] g/ cm³) and minimum Boron percentage [] requirements in order for qualification to occur. Qualification test data are provided in Table 8-4.
- The BORA resin shell meets the minimum Boron content determined by calculation.

The above tests show that:

- The proper amount of natural boron (and B-10) is in each pour.
- The resin density and the natural boron (and B-10) content is uniform in each shell.

Thus, ensuring the minimum resin density, proper material dimensions, the minimum Boron content, and homogeneity of the Boron, guarantee that the resin will have the proper B-10 number density of [] B¹⁰/b-cm.

Additionally, the tests show that the test sample is appropriate to use for the verification of density during acceptance testing.

Table 8-3 Qualification Test Data

Qualification Test Article	Calculated % Boron*	Measured Average Density**	
24	[]	Top	
		Middle	
		Bottom	
		Test Sample	
25	[]	Top	
		Middle	
		Bottom	
		Test Sample	
26	[]	Top	
		Middle	
		Bottom	
		Test Sample	

* Natural Boron content. Calculated from the masses of the compounds used to mix the resin. The B-10 content is equal to 18.43% of natural Boron content.

** average density is the average of 3 samples at shell location and 1 sample for the casting sample

Table 8-4 Mass Spectroscopy Qualification Test Results (from Test Report 12986-R-10, Rev 0, see Section 8.5)

Base Sample	B-nat* (%)	Measured Density (g/cm ³)	Middle Sample	B-nat* (%)	Measured Density (g/cm ³)	Top Sample	B-nat* (%)	Measured Density (g/cm ³)
B1a			M1a			H1a		
B1b			M1b			H1b		
B2a			M2a			H2a		
B2b			M2b			H2b		
B3a			M3a			H3a		
B3b			M3b			H3b		
B4a			M4a			H4a		
B4b			M4b			H4b		
Average			Average			Average		

* The B-10 content is equal to 18.43% of natural Boron content.

BORA resin qualification at low temperature conditions:

The chemical properties of the BORA resin do not change under cold temperature, only the mechanical characteristics such as the compression modulus which increases in cold conditions. Thus, it has no impact on the TNF-XI package design.

Additionally, the thermal expansion of the BORA resin material is [] K⁻¹. The change in thickness of the shell (34 mm thick) in cold conditions is equal to:

$$h = [] \text{ mm}$$

This small change in thickness will not change the B-10 areal density in the shell.

BORA resin qualification at normal conditions:

The maximum temperature of the BORA resin shell in normal conditions of transport is 62°C (Section 3.6.2, Figure 5) including the effects of insolation.

During the qualification of the resin, a resin sample (25×35×100 mm) was weighed after being heated to a temperature of 50°C for 4032 hours (168 days).

The loss of mass measured after the heating period was approximately []

Conservatively it is assumed that this loss of mass is due to water evaporation. The atomic mass ratio of hydrogen in water is :

$$\text{Hydrogen} : 2 / 18 = 11.11 \%$$

Then, the loss of hydrogen is equal to:

$$[]$$

This means that the hydrogen content in the BORA resin, at minimum equal to [] (according to Section 1.2.1.3), is reduced to [] which is negligible. Recall that in manufacturing, the density is at least [] g/cm³ whereas criticality calculations were performed with [] g/cm³.

The minimum density requirement allows a decrease in hydrogen to:

[] Thus, conservatively assuming a maximum loss in hydrogen content, the required hydrogen concentration will be present in the resin.

BORA resin acceptance tests:

The quantity of Boron in the resin are checked to ensure that the concentrations exceed those used in the criticality studies (see chapter 6 of this Safety Analysis Report). Shells that do not conform to prescribed mass, density, or dimensional requirements are rejected.

Each BORA resin shell will be manufactured with qualified molds and each shell will be verified for:

- Component mass: Each component mass must be within ±0.5% of its nominal mass

- Dimensional requirements: minimum thickness, as well as height, to ensure complete coverage when the shell is placed between the inner and outer shells of the inner well.
- Density: direct measuring of the resin density of 3 specimens is taken from the test sample. The minimum acceptable density from acceptance testing ([] g/cm³) is greater than the minimum density assumed for the material ([] g/cm³). Density measurements cannot be made on the shell itself because the test is destructive. Qualification test data indicates homogeneity between test sample and the corresponding shell.
- Natural Boron content: calculated from measuring the mass of the components used in making the resin. Given the percentage of natural Boron in the sample, the amount of B-10 can be determined given there is 19.9 atom-percent (18.43 wt-%) of B-10 in natural Boron.

The satisfaction of these requirements guarantee that the BORA resin shell has the proper B-10 density of [] B¹⁰/b-cm. Each resin shell is fabricated from a unique batch of resin. Thus, failure of the shell to meet the specified criteria results in the rejection of only that particular shell.

A sampling of data from existing shell acceptance tests is provided in Table 8-5 for verification with 95% confidence that the calculated Boron concentration and the minimum resin density specified in the acceptance test procedure are greater than the required minimum values. The 36 data points are taken from shells made both early (casting number from 96 to 115) and later (casting number from 1179 to 1235) in the manufacturing process. This shows that the 95% confidence is valid over time.

Table 8-5 BORA Resin Acceptance Test Data

	Casting No	Calculated % Boron-natural	Measured Average Density (g/cm ³)
1	96		
2	98		
3	100		
4	103		
5	97		
6	99		
7	95		
8	91		
9	105		
10	107		
11	111		
12	112		
Sample Size (n)		12	12
Average			
Standard Deviation (σ)			
95% Probability (2σ)			
95% Lower Bound**			
Minimum allowable			

Table 8-5 (continued) BORA Resin Acceptance Test Data

	Casting No	Calculated % Boron-natural	Measured Average Density (g/cm ³)
13	146		
14	144		
15	143		
16	139		
17	129		
18	120		
19	113		
20	119		
21	135		
22	134		
23	118		
24	115		
Sample Size (n)		12	12
Average			
Standard Deviation (σ)			
95% Probability (2σ)			
95% Lower Bound**			
Minimum allowable			
25	1205		
26	1211		
27	1212		
28	1214		
29	1204		
30	1229		
31	1228		
32	1235		
33	1213		
34	1208		
35	1199		
36	1179		
Sample Size (n)		12	12
Average			
Standard Deviation (σ)			
95% Probability (2σ)			
95% Lower Bound**			
Minimum allowable			

* Each density is the average of that measured from three specimen from each casting sample

** The lower bound determined from acceptance test data is greater than the larger of the two lower bounds determined during qualification testing [] Thus, the qualification tests bound the acceptance test data.

8.1.5 Test for Shielding Integrity

The TNF-XI package does not contain any biological shielding.

8.1.6 Thermal Acceptance Tests

The material properties utilized in Chapter 3.0, *Thermal*, are consistently conservative for the Normal Conditions of Transport (NCT) thermal analysis performed. The Hypothetical Accident Condition (HAC) fire certification testing of the TNF-XI package (see Section 2.10.1, *Certification Tests*) served to verify material performance in the HAC thermal environment. As such, with the exception of the tests required for specific packaging components, as discussed in Section 8.1.4, *Component Tests*, specific acceptance tests for material thermal properties are not required or performed.

8.2 MAINTENANCE PROGRAM

8.2.1 Structural and Pressure Tests

8.2.1.1 Weight Verification

Verification of the package's empty mass must occur within three years prior to a shipment or within the last 15 transports (whichever is in a shorter amount of time), to ensure that no water in-leakage has occurred in the foam region of the package.

8.2.1.2 Surface Inspection

Visual inspection shall be performed on the visible surfaces of the package exterior, plugs, lids, and cavities for indications of chemically induced corrosion, within three years of a shipment or within the last 15 transports (whichever is in a shorter amount of time). This ensures that degradation such as pitting or through wall corrosion has not taken place.

8.2.1.3 Lifting/Tie-down Device Load Testing

The TNF-XI package does not contain any lifting/tie-down devices that require load testing.

8.2.1.4 Containment Boundary Pressure Testing

No pressure tests are necessary to ensure continued performance of the TNF-XI packaging.

8.2.2 Leak Tests

No leak tests are necessary to ensure continued performance of the TNF-XI packaging.

8.2.3 Subsystem Maintenance

8.2.3.1 Fasteners

The TNF-XI package does not contain any fasteners that require maintenance.

8.2.3.2 Seals

Seals are to be replaced every 3 years if necessary.

8.2.4 Valves, Rupture Disks and Gaskets on Containment Vessel

8.2.4.1 Valves

The TNF-XI package does not contain any valves.

8.2.4.2 Rupture Disks

The TNF-XI package does not contain any rupture disks.

8.2.4.3 Gaskets

The TNF-XI package does not contain any containment vessel gaskets.

8.2.5 Shielding

The TNF-XI package does not contain any biological shielding.

8.2.6 Thermal

No thermal tests are necessary to ensure continued performance of the TNF-XI packaging.

8.3 Appendix A

Transnucleaire Specification 12986-A-7E issue 6

Specification for Series Production of Phenolic Foam Components

Note: This specification contains proprietary information and is exempt from public disclosure per 10 CFR 2.390.

Proprietary Information for 8.3, Appendix A, Transnucleaire
Specification 12986-A-7E issue 6, Specification for Series
Production of Phenolic Foam Components, pages 1 through 14 are
withheld Pursuant to 10 CFR 2.390.

8.4 Appendix B

Transnucleaire BORA Resin Data Sheet

12986-R-08, Revision 2, 28/5/2002

Note: This data sheet contains proprietary information and is exempt from public disclosure per 10 CFR 2.390.

Proprietary Information for 8.4, Appendix B, Transnucleaire
BORA Resin Data Sheet, 12986-R-08, Revision 2, 28/5/2002,
pages 1 through 3 are withheld Pursuant to 10 CFR 2.390.

8.5 Appendix C

Transnucleaire BORA Resin: Homogeneity of Components

TNF-XI Test Procedure

12986-R-10, Revision 0, 3/2002

Note: This test procedure contains proprietary information and is exempt from public disclosure per 10 CFR 2.390.

Proprietary Information for 8.5, Appendix C, Transnucleaire
BORA Resin: Homogeneity of Components, TNF-XI Test
Procedure, 12986-R-10, Revision 0, 3/2002, pages 1 through 4 are
withheld Pursuant to 10 CFR 2.390.