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Washington, D.C. 20590

U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

COMPETENT AUTHORITY CERTIFICATION FOR A TYPE B(U)F FISSILE RADIOACTIVE MATERIALS PACKAGE DESIGN CERTIFICATE USA/0565/B(U)F-96, REVISION 4

REVALIDATION OF FRENCH COMPETENT AUTHORITY CERTIFICATE F/357/B(U)F-96

The Competent Authority of the United States certifies that the radioactive material package design described in this certificate satisfies the regulatory requirements for a Type B(U)F package as prescribed in the regulations of the International Atomic Energy Agency[1] and the United States of America[2].

1. Package Identification - TN-MTR.

2. Package Description and Authorized Radioactive Contents - as described in French Certificate of Competent Authority F/357/B(U)F-96, Revision Eaf (attached). Authorized contents are limited to MTR fuel elements loaded in a MTR-52SV2 basket as described in the French Certificate, Appendix 9, Content No. 9, specifically Sub-Content Number 1, intact elements, fuel type U_ySi_2 in Table 9.2.1 of the French certificate, excluding U_3O_8 alloy fuel assemblies, including:

   • Maximum of 22 spent fuel assemblies plus 16 fresh fuel assemblies per shipment,
   • Minimum enrichment of 19 weight percent U-235 and maximum enrichment of 21 weight percent U-235,
   • Maximum mass of uranium per assembly of 2 kg,
   • Assembly burnup less than 45,000 MWd/MTU,
   • Assembly cooling time greater than 964 days,
   • Maximum decay heat of 5 watts/assembly, and
   • Assemblies are to be loaded symmetrically in the center of the MTR-52SV2 basket with the fresh fuel assemblies on the exterior of the spent fuel assemblies for added shielding.

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[1] "Regulations for the Safe Transport of Radioactive Material, 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.

3. Criticality - The minimum criticality safety index is as stated in the French Certificate. The maximum number of packages per conveyance is determined in accordance with Table 11 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. This certificate provides no relief from the limitations for transportation of plutonium by air in the United States as cited in the regulations of the U.S. Nuclear Regulatory Commission 10 CFR 71.88.

   e. Records of Management System activities required by Paragraph 306 of the IAEA regulations[1] shall be maintained and made available to the authorized officials for at least three years after the last shipment authorized by this certificate. Consignors in the United States exporting shipments under this certificate shall satisfy the applicable requirements of Subpart H of 10 CFR 71.

5. Special Conditions -

   a. The Mechanical Criterion for cladding in Table 9.2.1 of the French Approval Certificate must use aluminum yield strength values for fully-annealed material. Data from Table 0A-9.1 0 of the package design safety report that reflect a fully-annealed condition are those for aluminum type 1050A, 3003, 5052, 5454, 5086, and 5083.

b. Prior to each shipment, the seals of the TN-MTR must demonstrate no leakage when tested to a sensitivity of at least 1E-4 Pa-m^3/sec standardized leakage rate (or 1E-3-ref-cm^3/sec).

c. The lid ethylene propylene diene monomer seals and the two cover plate EPDM seals are to be replaced at an interval not to exceed 1 year.

6. Marking and Labeling - The package shall bear the marking USA/0565/B(U)F-96 in addition to other required markings and labeling.

7. Expiration Date - This certificate expires on February 28, 2021.

This certificate is issued in accordance with paragraph(s) 810 and 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 September 30, 2018 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

July 25, 2019
(DATE)

Revision 4 - Issued to endorse French Certificate of Approval No. F/357/B(U)F-96, Revision Eaf, dated July 31, 2018, restricted to use with the standard lid and to content No. 9, sub-content 1 intact elements (excluding U3O8 alloy fuel elements) as described in the French certificate and with the stated conditions.

AUTORITÉ DE SÛRETÉ NUCLÉAIRE

TRANSPORT AND RESOURCES DEPARTMENT

This document is a translation of:
Certificat d'agrément d'un modèle de colis, F/357/B(U)F-96 (Eaf), numéro d'enregistrement CODEP-DTS-2018-030027

In case of deviation between the French and English versions, the French version governs.

PACKAGE MODEL APPROVAL CERTIFICATE

The French Governing Authority.

With respect to the request submitted by **TN International** by letter COR-18-004458-054 dated 22 May 2018;

With respect to the TN International Package Design Safety Report DOS-06-00032593 Rev. 15 of 17 November 2015 completed by appendix 2 of letter COR-18-004458-054,

hereby certifies that the package model comprising packaging **TN-MTR** described in appendix 0 index af and:

- loaded with fuels used for research purposes ("Material Testing Reactor (MTR) components"), irradiated or not, and placed in basket MTR-52SV2, as described in appendix 9, index af, is conform as a B (U) type package model loaded with fissile materials,
- emptied, contaminated or not, with or without internal fittings, is conform as a B(U) type package model or dispensed standard package depending on the level of contamination of the internal surfaces of the packaging and the surfaces of the internal fittings and the intensity of radiation on the external surface of the package,

with the instructions in the regulations and agreements listed below:

- International Atomic Energy Agency (IAEA) regulations for the safe transport of radioactive material, IAEA Safety Standards series, No. SSR-6, 2012 edition;
- European Agreement on the International Carriage of Dangerous Goods by Road (ADR);
- Regulations governing International Rail Transportation of Dangerous Goods (RID);
- International maritime code for dangerous goods (IMDG code of the IMO);
- Decision of 29 May 2009 modified concerning the carriage of dangerous goods by land routes (TMD decision);
- Order of 23 November 1987 (modified), on the Safety of Shipping, and particularly division 411 of the attached regulations (RSN Order).

This certificate does not exempt the shipper from the need to comply with the requirements established by the authorities of countries across which or to which the package will be transported.

The validity of this certificate expires on **28 February, 2021**.

Registration number: **CODEP-DTS-2018-030027**

Signed in Montrouge, 31 July 2018

On behalf of the President of the ASN and by delegation, the Director for Transportation and Sources.

Fabien FÉRON

SUMMARY OF CERTIFICATE ISSUES

Issue	Expiry	Type of issue and modifications	Authority	Certificate Ref. No.	Revision															
					Body	t	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
24/01/2011	31/01/2016	Prolongation of content 1	ASN	**F/357/B(U)F-96**	Dv	-	v	v	-	-	-	-	-	-	-	-	-	-	-	-	-
04/01/2011	31/12/2015	Reserved	DSND	**F/357/B(U)F-96**	Dw	-	w	-	-	-	-	-	-	w	-	-	-	-	-	-	-
26/07/2011	31/01/2016	Extension to contents 2 to 11	ASN	**F/357/B(U)F-96**	Dx	-	x	-	x	x	x	x	-	x	x	x	x	x	-	-	-
12/12/2011	31/12/2015	Reserved	DSND	**F/357/B(U)F-96**	Dy	-	y	-	-	y											
01/07/2013	31/01/2016	Extension to contents 1 to 5 and 7 to 12	ASN	**F/357/B(U)F-96**	Dz	-	z	z	z	z	z	z	-	z	z	z	z	z	z	-	-
30/07/2014	31/01/2016	Extension to content 2	ASN	**F/357/B(U)F-96**	Daa	-	aa	-	aa	-	-	-	-	-	-	-	-	-	-	-	-
04/09/2015	31/01/2016	Extension to content 13	ASN	**F/357/B(U)-96**	Dab	-	ab	-	-	-	-	-	-	-	-	-	-	-	-	ab	-
26/02/2016	28/02/2021	Prolongation of contents 1 to 5, 9, 10 and 13, extension to content 14, integration of content 7 in content 2 and content 11 in content 5	ASN	**F/357/B(U)F-96**	Eac	-	ac	ac	ac	ac	ac	ac	-	-	-	ac	ac	-	-	ac	ac
07/07/2016	28/02/2021	Extension to content 13	ASN	**F/357/B(U)-96**	Ead	-	ad	-	-	-	-	-	-	-	-	-	-	-	-	ad	-
07/12/2017	28/02/2021	Extension to content 13	ASN	**F/357/B(U)-96**	Eae	-	ad	-	-	-	-	-	-	-	-	-	-	-	-	ae	-
31/07/2018	28/02/2021	Extension to content 9	ASN	**F/357/B(U)F-96**	Eaf	-	af	-	-	-	-	-	-	-	-	af	-	-	-	-	-

APPENDIX 0

TN-MTR PACKAGING

1. DESCRIPTION OF THE PACKAGING

The packaging was designed, manufactured, inspected, tested, maintained and used in compliance with the Package Design Safety Report DOS-06-00032593 Rev. 15 of 17 November 2015.

The packaging, of a cylindrical form, is shown in Figure 0.1.

References of the packaging plans:
- " TN-MTR packaging - safety drawing (general view) : PLA-15-00166811-000 Rev. 0";
- "packaging TN-MTR - detailed drawing (detail) : PLA-15-00166811-001 Rev. 0."

The overall external dimensions of the packaging are:
- length: 2,008 mm;
- diameter: 2,080 mm.

The cavity is a cylinder with a height of 1,080 mm and a diameter of 960 mm.

The empty weight (without basket or fuel elements) is 20,600 kg.

The maximum permissible weight for the package in the transport configuration is 23,400 kg.

The packaging comprises the main sub-assemblies described below.

1.1 Body

The body is composed of lead radiation protection fitted radially and axially (on the bottom side of the packaging) surrounded by resin thermal protection, housed in two stainless steel enclosures.

1.2 Packaging closure system

The packaging is closed using a "STANDARD" lid comprising lead radiation protection surrounded by a stainless steel housing. It is equipped with two orifices with closure plates.

1.3 Shock absorption system

Shocks triggered by falls are absorbed by a cover comprising a stainless steel structure filled with wood.

1.4 Handling and securing components

Two trunnions can be used to handle the packaging.

The packaging is tied down to the means of transport using four lugs.

1.5 Safety functions

Containment is provided by the packaging enclosure, which comprises:

- the packaging cavity;
- the lid and orifice closure plates;
- internal lid seals and lid orifice closure plates.

Radiation protection by the layers of steal and lead in the packaging body and the closure system.

Sub-criticality is maintained by the insulation system comprising the components described in the appendices for the contents and the packaging, from which the cover and the layer of resin have been removed and replaced by air or water, according to the worst-case scenario.

Internal power is dissipated by packaging body components, particularly the fins welded to the external surface of the packaging.

Impact protection is ensured by the cover.

Fire protection is mainly ensured by the resin and the cover.

2. ACTIONS TO BE TAKEN BY THE SHIPPER PRIOR TO DISPATCHING THE PACKAGE

The packaging must be used in accordance with the applicable procedures listed in Chapter 6A of the Package Design Safety Report DOS-06-00032593-600 Rev. 10.

If the package contains canisters used to hold fuel elements, the effectiveness of drying must be guaranteed by complying with a dedicated procedure listed in the user manual.

3. MAINTENANCE PROGRAMME

The packaging must be maintained in accordance with the maintenance programme described in Chapter 7A of the Package Design Safety Report DOS-06-00032593-700 Rev. 3.

4. NOTIFICATION AND RECORDING OF SERIAL NUMBERS

The relevant authorities must be kept informed of any packaging that is taken out of service or transferred to another owner. Accordingly, an owner transferring packaging must provide the name of the new owner.

5. MANAGEMENT SYSTEM

The management system principles applied during the design, manufacturing, inspection, testing, maintenance and use of the package must comply with those described in Chapter 8A of the Package Design Safety Report Ref. DOS-06-00032593-800 Rev. 0.

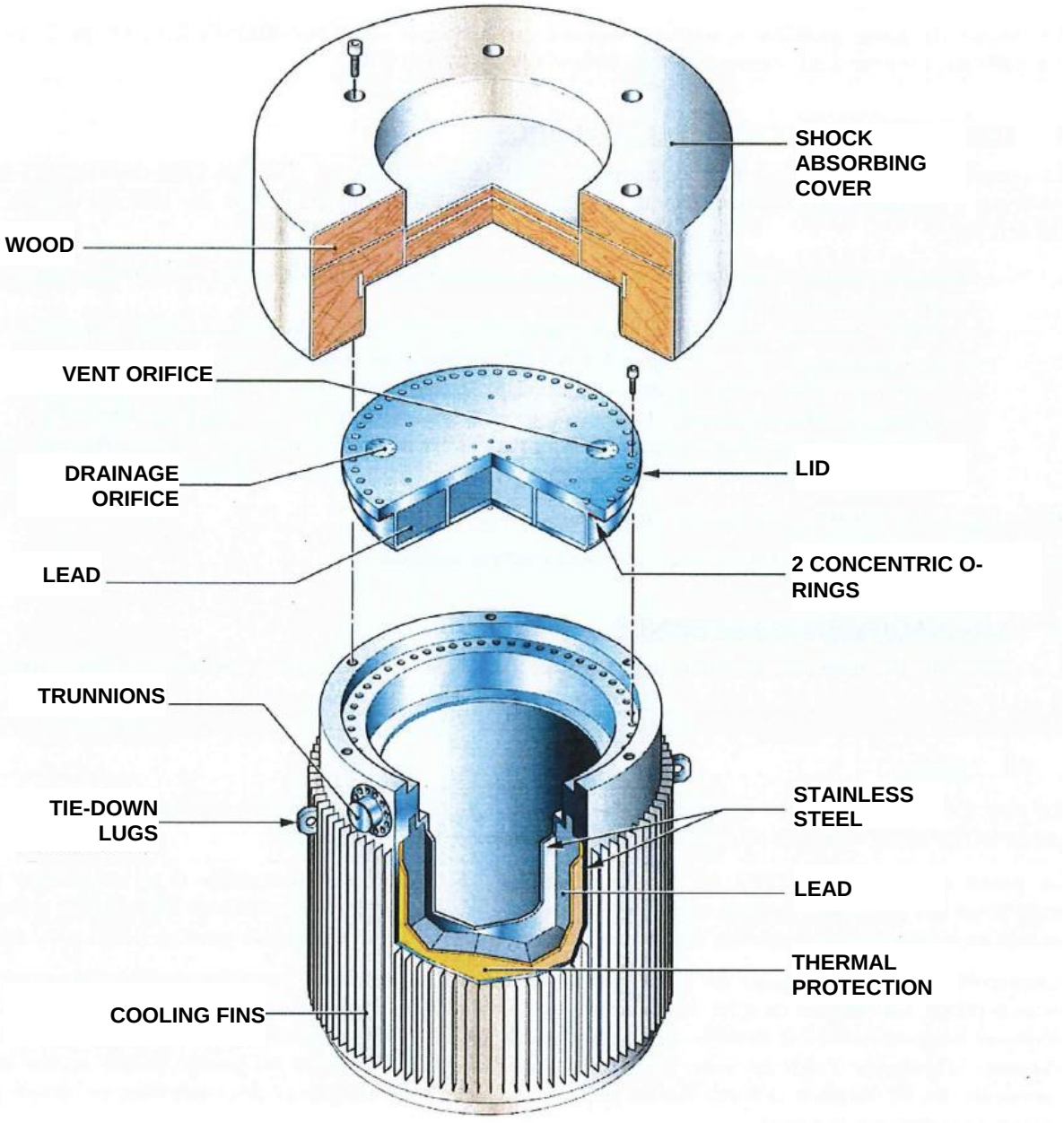
6. ADDITIONAL REQUIREMENTS FOR CONTAINED TRANSPORT

Contained transport methods are not permitted unless authorised by the governing authority.

If packages are transported inside a closed transport unit (covered vehicle, transport container, canopies, etc.) the dissipation of heat may be modified. The thermal power must be such that the peak temperature of the resin, the fuel elements and the elastomer seals in the packaging fails to exceed the temperature limits defined in the Package Design Safety Report, taking into account the regulatory atmospheric conditions after thermal equilibrium is reached.

FIGURE 0.1

PACKAGE DIAGRAM



APPENDIX 9

MTR ELEMENTS, IRRADIATED OR NOT, PLACED IN BASKET MTR-52SV2

Package Design Safety Report DOS-06-00032593 Rev. 15 of 17 November 2015 completed by appendix 2 of letter COR-18-004458-054 of 22 May 2018 justifies the authorised content.

1. DEFINITION OF AUTHORISED CONTENT

The authorised radioactive content, described in Chapter 0A-9 of the Package Design Safety Report, ref. DOS-06-00032593-013 Rev. 5, comprises MTR elements, irradiated or not, satisfying the applicable specifications of the following tables: 9.1 and 9.2.1 to 9.2.4. More specifically:

- intact fuel elements with characteristics compliant with the following tables 9.1 and 9.2.1, known as sub-content no. 1;
- or fuel elements which are either intact, or failed and/or disassembled, with characteristics compliant with the following tables 9.1 and 9.2.2, known as sub-content no. 2;
- or intact fuel elements, irradiated in the ANSTO OPAL reactor, with characteristics which satisfy the following tables, 9.1 and 9.2.3, known as sub-content no. 3 or "ANSTO elements"; or intact fuel elements, irradiated in the OSIRIS reactor, with characteristics which satisfy the following tables, 9.1 and 9.2.4, known as sub-content no. 4 or "OSIRIS elements".

Mixable contents are listed in table 9.2.1.

The presence of materials with a greater hydrogen content than water is not permitted.

2. INTERNAL FITTINGS

The Internal fittings are described in Chapter 0A-9 of the Package Design Safety Report, ref. DOS-06-00032593-013 Rev. 5.

2.1. Basket

The basket concept drawing has the reference "COGEMA LOGISTICS 4466-104, revision A: Packaging TN-MTR – basket MTR 52SV2 – concept drawing". This basket is shown in figure 9.1.

The MTR-52SV2 type basket is an assembly of stainless steel discs and aluminium rings that support intersecting neutron-absorbing flats. These neutron-absorbing flats are composed of aluminium mixed with enriched boron or boron carbide. The steel discs and aluminium rings are assembled using 7 threaded rods.

Each steel disc is drilled with 52 square compartments. There is one neutron-absorbing flat for each square compartment. The steel discs, aluminium rings and neutron-absorbing flats are assembled such that these compartments remain aligned. The compartments have a cross-section of 94 x 94 mm and are made by installing 52 x 2 mm-thick stainless steel sleeves covering the entire height of the basket. Even if the load is incomplete, the 52 sleeves must be in position. The discs and rods are aligned by two rods placed at the edge of the basket.

2.2. Spacers

If elements must be wedged in the basket compartments, the spacers defined in Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5 must be used. These shims are shown in figure 0A-9.9 of this chapter.

2.3. Canister

The canister used to load failed and/or disassembled elements from sub-content no. 2 is described in Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

The reference of the canister concept drawing is PLA-10-00016538, revision 0: TN-MTR CASK – Canister for failed or disassembled plates loaded in MTR-52S (V2) basket – Concept drawing". The canister is shown in figure 9.2.

3. LOADING CONDITIONS

The MTR-52SV2 basket, loaded with its authorised contents, is exclusively transported in a packaging fitted with a "STANDARD" type lid.

The load must satisfy the criteria mentioned in table 9.1 and any loading plans defined in tables 9.2.1 to 9.2.4. If a lockout device is required for an empty compartment in order to ensure compliance with the loading plan, this device must allow for the unhindered circulation of water in the compartment and the free volume available for water must significantly exceed the volume occupied by the device. The lockout device must be removed before transport.

Shims are required:

- if the length of the load (fuel element or canister and any shims) is less than 1,054 mm, to ensure that the total length of the load is between 1,054 and 1,075 mm,
- if one or both of the two inert ends of the element have a length of less than 12 mm, to ensure that the active part of the fuel element fails to protrude beyond the basket.

These shims must comply with figure OA-9.9 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593- 013 Rev. 5.

4. SUB-CRITICALITY STUDY

The sub-criticality study is covered in Chapter 5A of the Package Design Safety Report, ref. DOS-06-00032593-500 Rev. 5 and its appendices.

- 5A-9, ref. DOS-06-00032593-509 Rev. 0,
- 5A-10, ref. DOS-06-00032593-505 Rev. 0,
- 5A-11, ref. DOS-06-00032593-511 Rev. 0,
- 5A-12, ref. DOS-06-00032593-516 Rev. 1.

The isolation system comprises:

- the packaging from which the shock absorbing cover has been removed and from which the resin has disappeared;
- basket MTR-52SV2;
- fissile contents to be transported;
- the canister, when transporting failed and/or disassembled elements, if specified in table 9.1.

Sub-criticality is guaranteed with the content as defined in table 9.1, assuming that water can enter any free spaces in the package.

Criticality Safety Index (CSI): 0 (number N: infinite).

TABLE 9.1

CHARACTERISTICS OF THE FUEL ELEMENTS TRANSPORTED IN PACKAGING TN-MTR FITTED WITH BASKET MTR 52SV2

			Sub-content no. 1 (Intact elements)	Sub-content no. 2 (Intact, or failed and/or disassembled elements)	Sub-content no. 3 (ANSTO elements)	Sub-content no. 4 (OSIRIS elements)
Maximum dimensions						
Elements not loaded in canisters	Section as part of a circle (mm)		≤ 93.8 (protuberances crossing the compartment diagonally are authorised if they remain within the geometric limits of the compartment)			
	Section as part of a square (mm^2)		≤ [90 x 90]			
	Section as part of a rectangle (mm^2)		≤ [81 x 93.8]			
	Length with shims if required (mm) L		1,054 ≤ L ≤ 1,075			
Elements loaded in canisters	Section as part of a square (mm^2)		Prohibited	≤ 83 x 83	Prohibited	
	Length with shims if required (mm)			≤ 995		
Maximum mass						
Total mass (internal fittings + content) (kg)			2,800			
Load mass per unit length (content + shims) per compartment (kg/cm)	with circular cross-section		≤ 0.074			
	with rectangular section (axb)	if a > 7.2 cm **and** b > 7.2 cm	≤ 0.107			
		if a ≤ 7.2 cm **or** b ≤ 7.2 cm	≤ [0.0149 x minimum (a,b)]			
Cavity filling gas			Air, helium or nitrogen			
Maximum thermal power of fuel elements						
No element loaded into a canister	Per compartment	(W)	≤ 42			
		(W/m of active length)	≤ 70			
At least one element loaded into a canister	Per compartment	(W)	Prohibited	≤ 15	Prohibited	
		(W/m of active length)		≤ 25		
Irradiation and cooling characteristics of fuel elements						
Thermal fluence (n_{th}/cm^2)			≤ 2×10^{22}			
Burnup (MWd / tU)			Table 9.3(1)		≤ 150,000	
Cooling time (years)					≥ 1	
Enrichment by weight of ^{235}U (before irradiation)					≤ 19.95	
Mass of U per element (kg)					≤ 2.564	
Other loading conditions						
Transporting failed elements			Prohibited	Authorised — cf. table 9.4 (2)	Prohibited	
Canister			Prohibited	Authorised (3)	Prohibited	

(1) The characteristics of the fuel elements must comply with one of the three cases described in table 9.3.

(2) The characteristics of the uranium contained in the failed zones must satisfy the provisions of table 9.4.

(3) Failed or disassembled elements from sub-content no. 2 must be loaded in canisters. Intact assemblies from sub-content no. 2 must not be loaded in canisters. A maximum of 36 canisters can be loaded in a packaging.

TABLE 9.2.1

CHARACTERISTICS OF INTACT FUEL ELEMENTS (SUB-CONTENT No. 1)

Permissible values										
Type of fuel elements		Assembled flat plate elements								
Fuel core		U_3Si_2 alloy, possibly mixed with aluminium		U_3O_8 alloy, possibly mixed with aluminium			$UA1_x$ or U_ySi_z alloy, possibly mixed with aluminium			
Cladding	Material	Aluminium cladding								
	Mechanical criterion [1]	$1\,471{,}5 \times \frac{\rho_{éq} \times b^2}{t} \leq R_e$								
Number of elements in the basket		≤ 52	≤ 51 [2]	≤ 52		≤ 50 [3]	≤ 52	≤ 40 [4]	≤ 52	
Enrichment by weight of ^{235}U (%)		≤ 21	≤ 19.95	≤ 21		≤ 21	≤95		≤ 92	≤ 85
$V/^{235}U$ [5] (cm^3/g)		≥ 4	≥ 2.5	≥ 4		≥ 2.5	≥ 4	≥ 2.37	≥ 3.6	≥ 3
Mass of ^{235}U per compartment before irradiation (g)		≤ 200	≤ 470	≤ 200	≤ 380	≤ 640	≤ 200	≤ 460	≤ 450	≤ 200
Mixes [6]		Authorised	Prohibited	Authorised	Prohibited		Authorised	Prohibited	Authorised	
Presence of solid aluminium end pieces		Authorised		Prohibited			Authorised			
Height of the active part of the plates (mm)		≤ 1,030								
Protrusion of the active part outside of the basket (mm)		0								

(1) Where:
- b, nominal width of the plate (mm),
- t, nominal thickness of the plate (mm),
- ρ_{eq}, the equivalent density of the plate (fissile core and cladding) (kg/mm^3),
- Re, the yield strength of the fuel cladding (MPa) considered at the maximum temperature under normal conditions of transport depending on the power actually transported, as given in table 0A-9.10 in Chapter 0A-9 of the Package Design Safety Report DOS-06-00032593-013 Rev. 5, depending on the grade of cladding used.

(2) The loading plan must comply with figure OA-9.4 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

(3) The loading plan must comply with figure OA-9.6 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

(4) The loading plan must comply with figure OA-9.3 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

(5) $V/^{235}U$: ratio calculated for the flat plates:
- where V is the product of the nominal thickness of a plate multiplied by the nominal fissile height and by the nominal fissile width,
- where ^{235}U is the total mass of 235U of the element divided by the number of plates.

(6) Elements which satisfy the characteristics of one of the columns in this table, and are "authorised", as indicated, can be mixed with other "authorised" elements in this table.

TABLE 9.2.2

CHARACTERISTICS OF INTACT, FAILED AND/OR DISASSEMBLED ELEMENTS (SUB-CONTENT No. 2)

Permissible values		
Number of fuel elements in the basket		≤ 52 (1)
Type of fuel elements		Elements with flat plates, whether failed or not, disassembled or not. A maximum of 36 failed or disassembled elements can be placed in the basket
Fuel core		UAl_x or U_ySi_z alloy possibly mixed with aluminium
Cladding	Material	Aluminium
	Mechanical criterion (for intact elements) (2)	$1\,471{,}5 \times \frac{\rho_{éq} \times b^2}{t} \leq R_e$
$V/_{235}U$ (3) (cm^3/g)		≥ 4
Mass of ^{235}U per compartment before irradiation (g)		≤ 220
Mixes		Prohibited
Height of the active part of the plates (mm)		≤ 1,030
Protrusion of the active part outside of the basket (mm)		0
Presence of solid aluminium end pieces		Prohibited

(1) The loading plan must comply with figure OA-9.5 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

(2) Where:
- b, nominal width of the plate (mm),
- t, nominal thickness of the plate (mm),
- ρ_{eq}, the equivalent density of the plate (fissile core and cladding) (kg/mm^3),
- Re, the yield strength of the fuel cladding (MPa) considered at the maximum temperature under normal conditions of transport depending on the power actually transported, as given in table 0A-9.10 in Chapter 0A-9 of the Package Design Safety Report DOS-06-00032593-013 Rev. 5, depending on the grade of cladding used.

(3) $V/^{235}U$**:** : ratio calculated for the flat plates:
- where V is the product of the nominal thickness of a plate multiplied by the nominal fissile height and by the nominal fissile width,
- where ^{235}U is the total mass of uranium 235 for the element divided by the number of plates or the mass of 235U in a disassembled plate.

TABLE 9.2.3

CHARACTERISTICS OF INTACT FUEL ELEMENTS IRRADIATED IN THE ANSTO OPAL REACTOR (SUB-CONTENT No. 3)

Permissible values	
Number of fuel elements in the basket	≤ 50 (1)
Type of fuel elements	Elements with flat plates A maximum of 5 elements with plates having slipped from their initial position can be fitted in the basket.
Fuel core	U_3Si_2 alloy, possibly mixed with aluminium
Cladding	AG3-NET or Al 6061 alloy cladding
$V/^{235}U$ (2) (cm^3/g)	≥ 2.3
Mass of ^{235}U per compartment before irradiation (g)	≤ 490
Mixes	Prohibited
Height of the active part of the plates (mm)	≤1,030
Protrusion of the active part outside of the basket (mm)	0
Presence of solid aluminium end pieces	Authorised

(1) The loading plan must comply with figure OA-9.7 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

(2) $V/^{235}U$: ratio calculated for the flat plates:
- where V is the product of the nominal thickness of a plate multiplied by the nominal fissile height and by the nominal fissile width,
- where ^{235}U is the total mass of 235U of the element divided by the number of plates.

TABLE 9.2.4

CHARACTERISTICS OF THE INTACT FUEL ELEMENTS IRRADIATED IN THE OSIRIS REACTOR (SUB-CONTENT No. 4)

Permissible values	
Number of fuel elements in the basket	≤ 51 (1)
Type of fuel elements	Assembled flat plate elements
Fuel core	U_3Si_2 alloy, possibly mixed with aluminium
Cladding	AG3-NET or AG2-NET alloy cladding
V/235U (2) (cm^3/g)	≥ 2.5
Mass of ^{235}U per compartment before irradiation (g)	≤ 470
Mixes	Prohibited
Height of the active part of the plates (mm)	≤ 1,030
Protrusion of the active part outside of the basket (mm)	0
Presence of solid aluminium end pieces	Prohibited

(1) The loading plan must comply with figure OA-9.4 of Chapter 0A-9 of the Package Design Safety Report ref. DOS-06-00032593-013 Rev. 5.

(2) V/^{235}U: ratio calculated for the flat plates:
- where V is the product of the nominal thickness of a plate multiplied by the nominal fissile height and by the nominal fissile width,
- where ^{235}U is the total mass of 235U of the element divided by the number of plates.

TABLE 9.3

IRRADIATION AND COOLING CHARACTERISTICS FOR SUB-CONTENT No. 1 AND No. 2

	Case 1	Case 2	Case 3
^{235}U enrichment prior to irradiation (% by mass)	≤ 21	≤ 93.5	≤ 93.5
Mass of U per element (kg)	≤ 2.564	≤ 0.972	≤ 0.694
Burnup (MWd/t_U)	≤ 150,000	≤ 250,000	≤ 450,000
Cooling time (years)	≥ 1	≥ 1	≥ 3

TABLE 9.4

CHARACTERISTICS OF THE URANIUM IN FAILED ZONES FOR ELEMENTS IN SUB-CONTENT No. 2

Cooling time (years) (9 (Ź))		**≥ 1**	**≥ 2**	**≥ 3**	**≥ 5**	**≥ 10**
Mass of U (g) before irradiation contained in failed zones(3)	If the failed elements are transported in a package with intact elements	≤ 2,800	≤ 3,000	≤ 3,200	≤ 3,600	≤ 4,800
	If failed elements are transported in a package without other elements	≤ 3,600	≤ 3,800	≤ 4,000	≤ 4,500	≤ 6,000

(1) For failed elements with a cooling time between two consecutive durations as per the table, refer to the shortest period in order to determine the maximum mass of uranium authorised in the failed zones.

(2) The cooling time for intact elements must be at least equal the cooling time of failed elements.

(3) The method used to determine the mass of uranium contained in the failed zones before transport is described in Chapter 0A of the Package Design Safety Report.

FIGURE 9.1
DIAGRAM OF BASKET MTR-52SV2

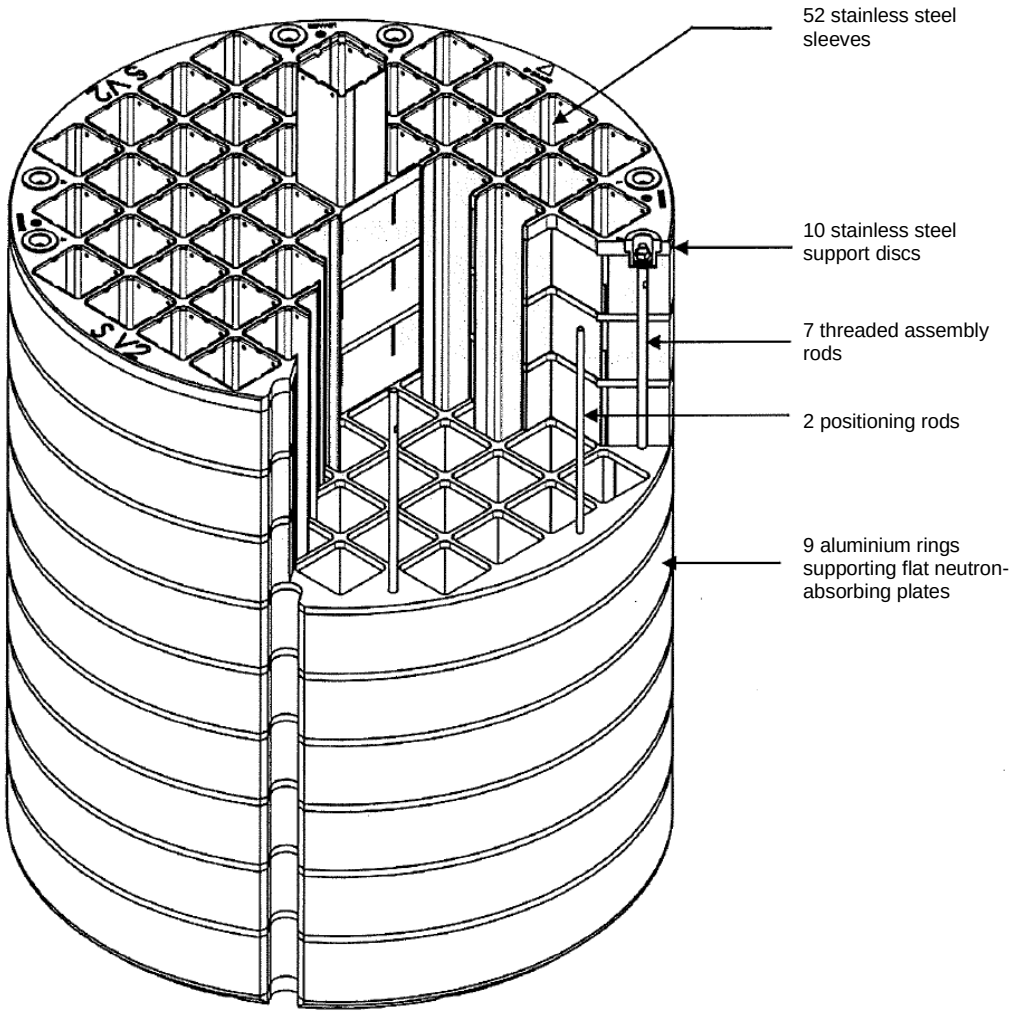
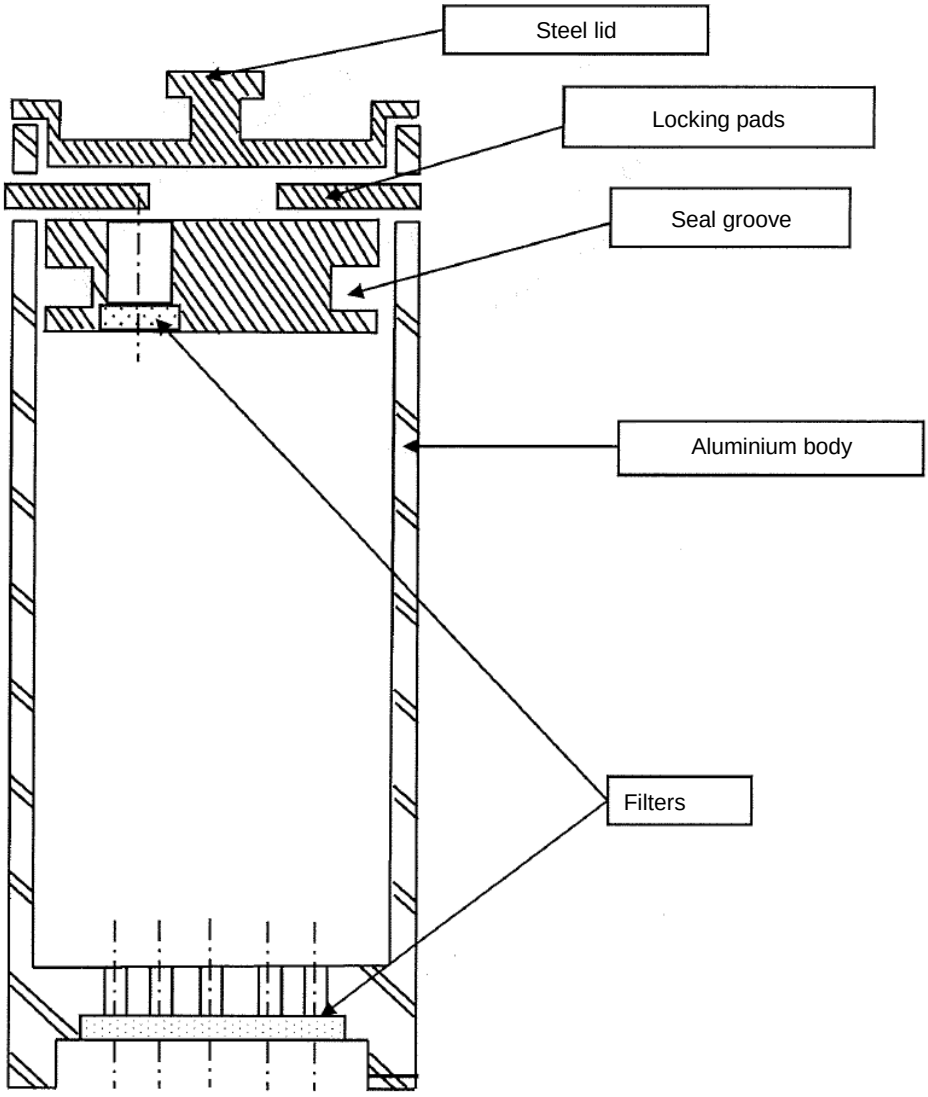


FIGURE 9.2

DIAGRAM OF THE CANISTER USED FOR FAILED AND/OR DISASSEMBLED ELEMENTS



U.S. Department of
Transportation

**Pipeline and
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