U.S. Department
of Transportation

**Pipeline and
Hazardous Materials
Safety Administration**

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

JAN 2 1 2020

Ms. Andrea Kock, Director
Division of Fuel Management,
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
11545 Rockville Pike, Mail Stop T4A60
Rockville, MD 20852-2738

Dear Ms. Kock:

In accordance with the Memorandum of Understanding between our agencies, I request that you review the attached French Certificate of Competent Authority F/437/AF-96, Revision Fs for the FCC-3 package and make a recommendation concerning our revalidation of the package for import and export use. In 2010 your staff reviewed revision Ci of the French certificate for this package, under Docket #71-3083, TAC #L24394.

To assist you in your review, I am providing a copy of the package design safety report for the FCC-3 package along with other supporting documents that I have received from our applicant, TN Americas LLC, in electronic form on the enclosed cd. TN Americas indicates a need for revalidation to support shipments in the fourth quarter of 2020.

If you have any questions or need any additional safety information, please feel free to contact Michael Conroy of my staff at (202) 366-3597 or via email at Michael.Conroy@dot.gov.

Sincerely,

Richard W. Boyle,
Radioactive Materials/ Research & Development
Division of Sciences, Engineering and Research
Office of Hazardous Materials Safety

Enclosures

orano

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@Orano_USA

December 12, 2019
E-55606

U.S. Department of Transportation
Attn: Mr. Richard W. Boyle, Chief
Pipeline & Hazardous Materials Safety Administration
Radioactive Materials Branch
1200 New Jersey Avenue, S.E.
East Building, PHH-20
Washington, DC 20590

Subject: Application for Validation of French Competent Authority Certificate F/347/AF-96 for Model No. FCC-3 Transport Package

Reference: [1] Competent Authority Certification for A Type Fissile Radioactive Materials Package Design, Certificate USA/0776/AF-96, Revision 0, Revalidation of French Competent Authority Certificate F/347/AF-96, dated September 24, 2010

Dear Mr. Boyle:

TN Americas LLC, on behalf of TN International, requests a U.S. Department of Transportation (DoT) revalidation of French Competent Authority Certificate F/347/AF-96 for Model No. FCC-3, in accordance with §173.473.

The request being submitted is to revalidate F/347/AF-96, Revision Fs as a Type AF packaging that meets the applicable requirements for fissile material packages in Section VI of the International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material, SSR-6, 2012 Edition.

DoT issued competent authority certification (CAC) USA/0776/AF-96, Revision 0, to revalidate the French Competent Authority (ASN) certificate F/347/AF-96, Revision Ci [1]. ASN approves the FCC-3 as a Type IP fissile material package for use in France, and issues a Type A, fissile material package approval for validation in the U.S. where the Type IP fissile material approval has not been incorporated into the hazardous material regulations for radioactive materials. The DoT CAC [1] expired on December 31, 2010.

TN Americas LLC requests that DoT reissue USA/0776/AF-96 as Revision 1. The FCC-3 SAR consists of a Table of Contents, Chapter 1.1, which provides a listing of the SAR chapters and appendices with the associated reference documents. Modifications to the FCC-3 SAR reference documents since the issue of the revalidation of F/347/AF-96, Revision Ci, are described in the "Status of revision" after the "Table of contents" for each chapter or appendix of the SAR.

Enclosures transmitted herein contain SUNSI. When separated from enclosures, this transmittal document is decontrolled.

In support of this application, the following enclosures are included:

- Enclosure 1 provides the French Approval Certificate of a Package Design, Number F/347/AF-96 (Revision Fs) in English.
- Enclosure 2 provides the French Approval Certificate of a Package Design, Number F/347/AF-96 (Revision Fs) in French.
- Enclosure 3 provides the English translation for the proprietary version of the TN International Safety Analysis Report for FCC-3, document number DOS-19-021165-000, Version 1.0, and the reference documents.
- Enclosure 4 provides the non-proprietary version of DOS-19-021165-000-NPV, Version 1.0, and reference documents.
- Enclosure 5 provides TN International's statement of proprietary information pursuant to 49 CFR 7.14, 49 CFR 105.30, and 10 CFR 2.390 to cover Enclosure 3. This document contains TN International's proprietary and business sensitive information.

Due to the size of the enclosure files, optical storage media (OSM) in DVD format containing this cover letter and Enclosures 1 through 5, is used to submit this application.

The reissue of the DoT revalidation allows import or export shipments of the FCC-3 to or from the U.S., which are planned to begin in the fourth quarter of 2020.

Should you have any questions or require additional information to support review of this application, please contact Mr. Peter Vescovi by telephone at 336-420-8325, or by e-mail at Peter.Vescovi@orano.group.

Sincerely,

Jay Thomas
Director, Transportation
TN Americas LLC

cc: Michael Conroy, U.S. Department of Transportation
Don Shaw, TN Americas LLC
Laurence Labbe, TN Americas LLC
Brigitte Latour, TN International

Enclosures:

1. French Approval Certificate of a Package Design, Number F/347/AF-96 (Revision Fs), English
2. French Approval Certificate of a Package Design, Number F/347/AF-96 (Revision Fs), French
3. TN International Safety Analysis Report for FCC-3, Document Number DOS-19-021165-000, Version 1.0, and the Reference Documents (Proprietary)
4. TN International Safety Analysis Report for FCC-3, Document Number DOS-19-021165-000-NPV, Version 1.0, and the Reference Documents
5. TN International Statement of Proprietary Information Pursuant to 49 CFR 7.14, 49 CFR 105.30, and 10 CFR 2.390

AUTORITÉ DE SÛRETÉ NUCLÉAIRE

TRANSPORT AND RESOURCES DEPARTMENT



**APPROVAL CERTIFICATE**
**FOR PACKAGE DESIGN**

The French Competent Authority,

Pursuant Article L. 595-1 of the Environment Code;

Pursuant to the request presented by the company **TN International** by letter COR-19-016933-015 dated 22 February 2019;

Pursuant to the safety analysis report DOS-18-016471-000 version 1.0, dated 20 February 2019;

Pursuant to the previously issued certificate, under reference F/347/IF-96 (Fr);

Certifies that the package model, constituted by the **FCC3** packaging, described below in appendix **0** at version s, and loaded with one of the following contents:

- a maximum of 2 new PWR 17x17 twelve-foot fuel assemblies, in Version 1 of the packaging, as described in Appendix 1 at version s;
- or, a maximum of 2 new PWR 15x15 fuel assemblies, in Version 1 of the packaging, as described in Appendix 2 at version s;
- or, a maximum of 2 new PWR 14x14 8-foot fuel assemblies, in Version 2 of the packaging, as described in Appendix 3 at version s;
- or, a maximum of 2 new PWR 14x14 10-foot fuel assemblies, in Version 2 of the packaging, as described in Appendix 4 at version s;
- or, a maximum of 2 boxes, containing new PWR 17x17 twelve-foot non-assembled fuel rods, in Version 1 of the packaging, as described in Appendix 5 at version s;
- or, a maximum of 2 boxes, containing new PWR 15x15 non-assembled fuel rods, in Version 1 of the packaging, as described in Appendix 6 at version s;
- or, a maximum of 2 boxes, containing new PWR 14x14 8-foot non-assembled fuel rods, in Version 1 of the packaging, as described in Appendix 7 at version s;
- or, a maximum of 2 boxes, containing new PWR 14x14 10-foot non-assembled fuel rods, in Version 1 of the packaging, as described in Appendix 8 at version s;

conforms to the requirements and regulations, agreements and recommendations for **type A packages loaded with fissile materials** listed below:

- 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);
- European Agreement on the International Carriage of Dangerous Goods by inland waterways (ADN);
- International maritime code for dangerous goods (IMDG code of the IMO);
- Decree dated 29 May 2009 (modified) concerning the Carriage of Dangerous Goods by Terrestrial Routes (TMD Order);
- Decree dated 23 November 1987 (modified) concerning the safety of ships, division 411 (RSN Order).

This certificate does not relieve the consignor from compliance with any requirements drawn up by the government of any country through or towards which the package will be transported. This Approval Certificate may be appealed, before the competent jurisdiction, within a period of two months from the date of its signature.

This certificate expires on **30 April 2023**

Registration number: **CODEP-DTS-2019-026916**

Signed in Montrouge, 14 August 2019

**For the President of the ASN and by delegation,**
**the Director for Transportation and Sources**

**Fabien FÉRON**

## SUMMARY OF CERTIFICATE VERSIONS

| Issue | Expiry | Type of issue and modifications made | Authority | Type of certificate | Revision index | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Body | t | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 31/01/00 | 31/01/05 | Initial approval | DGSNR | F/347/IF-85 | Aa | - | a | a | a | a | a | - | - | - | - | | | | |
| 27/11/02 | 31/01/05 | Extension | DGSNR | F/347/IF-85 | Ab | - | b | - | - | b | b | - | - | - | - | | | | |
| 12/02/04 | 31/01/05 | Extension | DGSNR | F/347/IF-85 | Ac | - | c | c | c | c | c | - | - | - | - | | | | |
| 30/12/04 | 31/01/10 | Renewal | DGSNR | F/347/IF-96 | Bd | - | d | d | d | d | d | d | d | d | d | | | | |
| 20/07/05 | 31/01/10 | Extension | DGSNR | F/347/IF-96 | Be | - | e | e | e | e | e | e | e | e | e | | | | |
| 02/10/06 | 31/01/10 | Extension | DGSNR | F/347/IF-96 | Bf | | e | e | e | e | e | e | e | e | e | f | f | f | f |
| 15/07/09 | 31/12/10 | Renewal | ASN | F/347/IF-96 | Cg | - | e | g | g | g | g | g | e | e | e | f | f | f | f |
| 31/08/09 | 31/12/10 | Extension | ASN | F/347/AF-96 | Ch | - | e | g | g | g | g | g | g | g | g | g | g | g | g |
| 11/09/09 | 31/12/10 | Renewal | ASN | F/347/AF-96 | Ci | - | f | h | h | h | h | h | g | g | g | g | g | g | g |
| 13/01/10 | 31/12/10 | Extension | ASN | F/347/IF-96 | Cj | - | j | j | j | j | j | j | h | h | h | h | h | h | h |
| 04/10/10 | 30/09/13 | Renewal | ASN | F/347/IF-96 | Dk | - | k | k | k | k | k | k | j | j | j | - | - | - | - |
| 04/10/10 | 30/09/13 | Renewal | ASN | F/347/AF-96 | Dl | - | l | l | l | l | l | l | k | k | k | - | - | - | - |
| 02/05/13 | 30/04/18 | Renewal | ASN | F/347/IF-96 | Em | - | m | m | m | m | m | m | l | l | l | - | - | - | - |
| 06/02/13 | 30/04/18 | Extension | ASN | F/347/IF-96 | En | - | m | n | - | - | - | - | m | m | m | - | - | - | - |
| 10/04/14 | 30/04/18 | Extension | ASN | F/347/IF-96 | Eo | | m | o | | | | | | | | | | | |
| 18/01/16 | 30/04/18 | Extension | ASN | F/347/IF-96 | Ep | - | p | - | p | p | p | | | | | | | | |
| 11/12/17 | 30/04/23 | Renewal | ASN | F/347/IF-96 | Fq | - | q | q | q | q | q | q | - | - | - | - | - | - | - |
| 29/12/17 | 30/04/23 | Modifications | ASN | F/347/IF-96 | Fr | - | r | q | q | q | q | q | q | q | q | - | - | - | - |
| 14/08/19 | 30/04/23 | Extension | ASN | F/347/AF-96 | Fs | - | s | s | s | s | s | s | s | s | s | - | - | - | - |

# APPENDIX 0

# FCC3 PACKAGING

## 1. PACKAGING DEFINITION

The packaging was designed, manufactured, inspected, tested, maintained and used in compliance with the Safety Analysis Report DOS-18-016471 version 1.0.
The packaging, of a generally cylindrical form, is presented in Figure 0.1.
The packaging design drawings are 229K0100, 229K0200 and 229K0700 for Version 1 and 229K0300 for Version 2.
The overall external dimensions of the packaging are:

- length: 4,931 mm;
- width: 1,145 mm;
- height: 1,217 mm.

The maximum permissible mass of the packaging, loaded for transport, is 4,385 kg.
The packaging comprises the following principal sub-assemblies:

### 1.1 Body

The FCC3 packaging comprises a horizontal cylindrical casing, which, in turn, comprises two connected half-shells, holding:

- a metallic cradle consisting of two stringers and suspended by means of shock mounts from the lower shell;
- internal equipment fitted to the cradle and designed to accommodate one of the types of content.

This internal equipment comprises:

- A support frame, whose rigid structure, in the form of an inverted "T", is designed to hold the contents horizontally. The fabricated part of the frame contains neutron-absorbing resin. A tilting mechanism at the bottom plate is used to rotate the support frame to a vertical position for loading and unloading of fuel assemblies;
- two L-shaped doors, filled with neutron-absorbing resin, which are attached to the support frame and used to enclose the contents;
- a bottom plate, to support the fuel assemblies when loading or unloading when the support frame is in a vertical position;
- a two-part top plate used to close off the cavities and to wedge the contents at the other end.

### 1.2 Closing system

The two cylindrical half-shells are connected using 30 bolts.
The doors and top plates are connected to the frame using hinge pins and ball locking pins. The bottom plate is screwed to the frame.

### 1.3 Shock absorbing systems

Two axial shock absorbers are fitted to the end of the upper shell. They are made up of two metallic boxes containing a block of balsa wood.
Two additional axial shock-absorbers are fixed on the top plates when transporting assemblies with RCCA.

### 1.4 Handling and tie-down components

Handling can be performed using standard lifting machinery, with the aid of an appropriate lifting beam or slings fitted with shackles or hooks.
Two lifting modes are possible:

- using the 4 lifting boxes welded to the upper shell: these lifting boxes are composed of folded sheet metal with a hole for passing a shackle or a hook;

- using the passages for the forks located under the lower shell.

In addition, the packaging is designed to be lashed down during transport, as per the requirements laid out in Chapter 1.7 of DOS-12-00057684-070 Rev. 1 of the Safety Analysis Report.

### 1.5 Safety functions

- **Criticality protection is provided by** the elements identified in the appendices describing the contents, such as the insulation system, and in terms of the packaging, the elements below:
  - The internal equipment: comprising the frame, doors and end plates, as well as radial and axial supports for the fuel rod boxes and the fuel rod boxes themselves, with the assembly as a whole forming two neutron cavities;
  - The neutron-absorbing resin placed in the doors and frame;
  - The top and bottom shells protecting the internal system during normal and accidental transport conditions (NCT and ACT).
- **The fuel is protected from shocks**, principally, by the two half-shells and the internal equipment system.
- **Fire protection is provided, principally, by** the two half-shells, the internal fittings and the resin contained within the doors and frame.

## 2. ACTIONS TO BE TAKEN BY THE SHIPPER PRIOR TO DISPATCH OF THE PACKAGE

The packaging must be used in line with applicable procedures, in compliance with the instructions for use in Chapter 1.7 of DOS-12-00057684-070 Rev. 1 of the Safety Analysis Report.

The sender must check that, for all screws providing a security function of Class 10.9 or higher, the surface treatment has been carried out, in accordance with the following precautions:

- The surface is not prepared by etching prior to treatment, unless the pickled surface has been neutralized;
- Degassing, starting 3 hours or less after the completion of the surface treatment work.

## 3. MAINTENANCE PROGRAM

The packaging is subject to maintenance in accordance with the provisions described in the Chapter 1.8 of DOS-12-00057684-080 Rev. 1 of the Safety Analysis Report.

Any packaging that does not satisfy the criteria given in the Maintenance Program must be taken out of service until the appropriate corrective action has been carried out.

## 4. NOTIFICATION AND RECORDING OF SERIAL NUMBERS

If any packaging is retired from service or changes owner, this must be reported to the competent authorities. To this end, the owner transferring the packaging will provide the name of the new owner.

## 5. QUALITY MANAGEMENT SYSTEM

The principles of the quality management system applied during the design, manufacture, inspection, testing, maintenance and use of the package must comply with those described in Chapter 1.9 - Ref. DOS-12-00057684-090 Rev. 0 of the Safety Analysis Report.

**FIGURE 0.1**
**PACKAGING ARRANGEMENT DRAWING**

**Security-Related Information**
**Figure Withheld per 10 CFR 2.390**

# APPENDIX 1

## CONTENT NO. 1

## FRESH 17x17 PWR TWELVE-FOOT FUEL ASSEMBLIES

The contents should be loaded into an FCC 3 Version 1 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel assemblies

The authorized radioactive contents, as described in Chapter 1.3 - Ref. DOS-18-016471-006 version. 1.0 of the Safety Analysis Report, comprise a maximum of two fresh fuel assemblies, designed for use in pressurized water reactors (PWR), as detailed below:

| **Characteristics of the fuel rods before irradiation:** | |
|---|---|
| Type of array | 17x17 |
| Nominal grid pitch [mm] | 12.6 |
| Length (foot) | 12 |
| Maximum total weight of assembly, with or without RCCA (kg) | 757 |
| Maximum $UO_2$ weight per assembly (kg) | 591 |
| Nominal active length (mm) | 3,658 |
| Maximum number of fuel rods | 288 (1) |
| **Characteristics of the fuel rods before irradiation:** | |
| Cladding: | |
| - Material | Zirconium alloy, possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.52 |
| - Minimum outer diameter (mm) | 9.40 |
| Pellets: | ENU (2) |
| - Maximum diameter (mm) | 8.30 |
| - Maximum oxide density (100% of theoretical density) | 10.96 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

(1) This number corresponds to the maximum number of rods likely to be inserted into the structure (carcass or assembly framework), including into guide tubes.
(2) ENU: enriched natural uranium

Residue of glycerin (a maximum of 5 grams) may be present on each of the assemblies or on the mock-up assembly.

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All assemblies making up a load must adhere to the conditions defined in the table below.

| Type of assembly | Maximum number of assemblies authorized for a load | Maximum initial enrichment level per rod ($^{235}U/U_{total}$) (%) | Minimum number of rods in each loaded assembly (1) |
|---|---|---|---|
| 17x17 | 2 | 5 | 264 |

(1) Incomplete $UO_2$ fuel rod assemblies can be completed using gadolinium rods or rods containing depleted uranium or other metallic materials, or even by solid metallic rods (graphite & beryllium not included) which may contain neutron absorbers. These additional rods or bars will have dimensions equivalent to the $UO_2$ rods. By "number of rods per assembly", we mean the total number of fuel rods and replacement rods or bars.

All assemblies included in a load, bar one, can be replaced by dummy assemblies.
The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical State: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison with a mixture density of not more than 10.96 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. MAINTAINING SUB-CRITICALITY

The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-1 DOS-12-00057682-501 Rev. 0.

Criticality-Safety Index (CSI): 0.625 (Number N=80)

# APPENDIX 2

## CONTENTS N°2

## FRESH 15x15 PWR FUEL ASSEMBLIES

The contents should be loaded into an FCC 3 Version 1 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel assemblies

The authorized radioactive contents, as described in Chapter 1.3 - Ref. DOS-18-016471-006 version 1.0 of the Safety Analysis Report, comprise a maximum of two fresh fuel assemblies, designed for use in pressurized water reactors (PWR), as detailed below:

| | |
|---|---|
| **Characteristics of the fuel rods before irradiation:** | |
| Type of array | 15x15 |
| Nominal grid pitch (mm) | 14.3 |
| Maximum total weight of assembly, with or without RCCA (kg) | 749 |
| Maximum $UO_2$ weight per assembly (kg) | 589 |
| Nominal active length (mm) | 3,658 |
| Maximum number of fuel rods | 224 (1) |
| **Characteristics of the fuel rods before irradiation**: | |
| Cladding:<br>- Material | Zirconium alloy,<br>possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.57 |
| - Minimum outer diameter (mm) | 10.68 |
| Pellets: | ENU (2) |
| - Maximum diameter (mm) | 9.4 |
| - Maximum oxide density (100% of theoretical density) | 10.96 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |
| (1) This number corresponds to the maximum number of rods likely to be inserted into the structure (carcass or assembly framework), including into guide tubes.<br><br>(2) ENU: Enriched natural uranium | |

Residue of glycerin (a maximum of 5 grams) may be present on each of the assemblies.

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All assemblies making up a load must adhere to the conditions defined in the table below.

| Type of assembly | Maximum number of assemblies authorized for a load | Maximum initial enrichment level per rod ($^{235}U/U_{total}$) (%) | Minimum number of rods in each loaded assembly (1) |
|---|---|---|---|
| 15x15 | 2 | 5 | 204 |

(1) Incomplete $UO_2$ fuel rod assemblies can be completed using gadolinium rods or rods containing depleted uranium or other metallic materials, or even by solid metallic rods (graphite & beryllium not included) which may contain neutron absorbers. These additional rods or bars will have dimensions equivalent to the $UO_2$ rods. By "number of rods per assembly", we mean the total number of fuel rods and replacement rods or bars.

All assemblies included in a load, bar one, can be replaced by dummy assemblies.
The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical State: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.96 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. MAINTAINING SUB-CRITICALITY

The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-1 DOS-12-00057682-501 Rev. 0.

Criticality-Safety Index (CSI): 0.625 (Number N=80)

# APPENDIX 3

## CONTENT No. 3

## FRESH 14x14 PWR EIGHT-FOOT FUEL ASSEMBLIES

The contents should be loaded into an FCC 3 Version 2 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel assemblies

The authorized radioactive contents, as described in Chapter 1.3 - Ref. DOS-18-016471-006 version 1.0 of the Safety Analysis Report, comprise a maximum of two fresh fuel assemblies, designed for use in pressurized water reactors (PWR), as detailed below:

| | |
|---|---|
| **Characteristics of the fuel rods before irradiation:** | |
| Type of array | 14x14 |
| Nominal grid pitch (mm) | 14.1 |
| Length (foot) | 8 |
| Maximum total weight of assembly, with or without RCCA (kg) | 448 |
| Maximum $UO_2$ weight per assembly (kg) | 346 |
| Nominal active length (mm) | 2,413 |
| Maximum number of fuel rods | 195 (1) |
| **Characteristics of the fuel rods before irradiation**: | |
| Cladding:<br>- Material | Zirconium alloy,<br>possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.57 |
| - Minimum outer diameter (mm) | 10.68 |
| Pellets: | ENU (2) |
| - Maximum diameter (mm) | 9.40 |
| - Maximum oxide density (100% of theoretical density) | 10.96 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234U/U}{}_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

(1) This number of rods corresponds to the maximum number of rods likely to be inserted into the structure (carcass or assembly framework), including into the guide tubes
(2) ENU: enriched natural uranium

Residue of glycerin (a maximum of 5 grams) may be present on each of the assemblies.

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All assemblies making up a load must adhere to the conditions defined in the table below.

| Type of assembly | Maximum number of assemblies authorized for a load | Maximum initial enrichment level per rod ($^{235}U/U_{total}$) (%) | Minimum number of rods in each loaded assembly (1) |
|---|---|---|---|
| 14x14 | 2 | 5 | 179 |

(1) Incomplete $UO_2$ fuel rod assemblies can be completed using gadolinium rods or rods containing depleted uranium or other metallic materials, or even by solid metallic rods (graphite & beryllium not included) which may contain neutron absorbers. These additional rods or bars will have dimensions equivalent to the $UO_2$ rods. By "number of rods per assembly", we mean the total number of fuel rods and replacement rods or bars.

All assemblies included in a load, bar one, can be replaced by dummy assemblies.
The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical State: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.96 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. MAINTAINING SUB-CRITICALITY

The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-3 DOS-12-00057682-503 Rev. 0.

Criticality-Safety Index (CSI): 0 (Number N infinite)

# APPENDIX 4

## CONTENT No. 4

## FRESH 14x14 PWR TEN-FOOT FUEL ASSEMBLIES

The contents should be loaded into an FCC 3 Version 2 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel assemblies

The authorized radioactive contents, as described in Chapter 1.3 - Ref. DOS-18-016471-006 version 1.0 of the Safety Analysis Report, comprise a maximum of two fresh fuel assemblies, designed for use in pressurized water reactors (PWR), as detailed below:

| | |
|---|---|
| **Characteristics of the fuel rods before irradiation:** | |
| Type of array | 14x14 |
| Nominal array pitch (mm) | 14.1 |
| Length (foot) | 10 |
| Maximum total weight of assembly with or without RCCA (kg) | 557 |
| Maximum $UO_2$ weight per assembly (kg) | 437 |
| Nominal active length (mm) | 3,048 |
| Maximum number of fuel rods | 195 (1) |
| **Characteristics of the fuel rods before irradiation**: | |
| Cladding:<br>- Material | Zirconium alloy,<br>possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.57 |
| - Minimum outer diameter (mm) | 10.68 |
| Pellets: | ENU (2) |
| - Maximum diameter (mm) | 9.40 |
| - Maximum oxide density (100% of theoretical density) | 10.96 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

(1) This number of rods corresponds to the maximum number of rods likely to be inserted into the structure (carcass or assembly framework), including into the guide tubes.
(2) ENU enriched natural uranium

Residue of glycerin (a maximum of 5 grams) may be present on each of the assemblies.

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All assemblies making up a load must adhere to the conditions defined in the table below.

| Type of assembly | Maximum number of assemblies authorized for a load | Maximum initial enrichment level per rod ($^{235}U/U_{total}$) (%) | Minimum number of rods in each loaded assembly (1) |
|---|---|---|---|
| 14x14 | 2 | 5 | 179 |

(1) Incomplete $UO_2$ fuel rod assemblies can be completed by gadolinium rods; or rods containing depleted uranium or other metallic materials, or even by solid metallic rods (graphite & beryllium not included) which may contain neutron absorbers. These additional rods or bars will have dimensions equivalent to the $UO_2$ rods. By "number of rods per assembly", we mean the total number of fuel rods and replacement rods or bars.

All assemblies included in a load, bar one, can be replaced by dummy assemblies.
The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical state: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.96 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. MAINTAINING SUB-CRITICALITY

The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-3 DOS-12-00057682-503 Rev. 0.

Criticality-Safety Index (CSI): 0 (Number N infinite)

# APPENDIX 5

## CONTENT No.5

## 17x17 PWR TWELVE-FOOT FUEL RODS

The contents should be loaded into an FCC 3 Version 1 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel rods

The authorized radioactive contents, as described in Chapter 1.3 DOS-18-016471-006 version 1.0 of the Safety Analysis Report, comprise fresh fuel rods designed for use in pressurized water reactors (PWR), as detailed below:

| **Characteristics of the fuel rods before irradiation:** | |
|---|---|
| Type of array | 17x17 |
| Length (foot) | 12 |
| Maximum total mass per cavity (kg) | 751 |
| Maximum total mass of rods per box (kg) | 461 |
| Max mass of $UO_2$ (kg) | 380/box (1) or 20/package (2) |
| Nominal active length (mm) | 3,658 |
| Maximum number of fuel rods per box | 185 |
| Cladding: | |
| - Material | Zirconium alloy, possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.52 |
| - Minimum outer diameter (mm) | 9.40 |
| Pellets: | ENU (4) |
| - Maximum diameter (mm) | 8.30 |
| - Maximum oxide density (97.5 % of theoretical density) | 10.69 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Minimum content, by mass, of $Gd2O_3$ in gadolinium fuel rods (%) (3) | 2 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

(1) This maximum mass is only applicable to gadolinium contents and those using spacers.
(2) This maximum mass is only applicable to non-gadolinium contents and those using neither axial nor radial spacers.
(3) Rods with a $Gd_2O_3$ content of less than 2% are assumed equal to $UO_2$ rods (without gadolinium).
(4) ENU: enriched natural uranium

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All rods making up a load must adhere to the conditions defined in the table below.

| Type of array | Maximum number of rods authorized per load, per box | Maximum initial enrichment level of each rod making up the load ($^{235}U/U_{total}$) (%) | Minimum number of rods in the load (1) |
|---|---|---|---|
| 17x17 | 185 (2) | 5 | Full row of fuel rods or inert rods |

(1) Incomplete rows of fuel rods may be topped up using solid stainless steel (or Zirconium alloy) bars with a nominal diameter of between 9.5 mm and 10 mm, possibly containing a neutron poison. The term "number of rods per box" means the total number of fuel rods and steel (or zirconium alloy) bars.
(2) When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 20 kg.

The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical state: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.69 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. INTERNAL FITTINGS

The internal fittings comprise a fuel rod box, as described in Chapters 1.3-1 & 1.3-2 DOS 12-00057684-031 & 032 Rev. 0.

### 2.1 Rod boxes

These non-assembled rods are grouped in FCC3 fuel rod channels, which are inserted in place of fuel assemblies in the FCC3 version 1.

The channel is made of a U-shaped plate closed at the ends and reinforced with two stringers welded on the upper part of the plate.

A radial and axial wedging system adapts to the length of the rods and ensures their positioning. A general arrangement drawing is given in Figure 5.1.

The minimum height of the radial support is 85 mm.

### 2.2 Spacers

A set of 2 spacers is used to provide longitudinal support to the box within the cavity (one spacer at the top, another at the bottom). The spacers are described in detail in Chapter 1.3-1 of DOS-12-00057684-031 Rev. 0.

## 3. MAINTAINING SUB-CRITICALITY

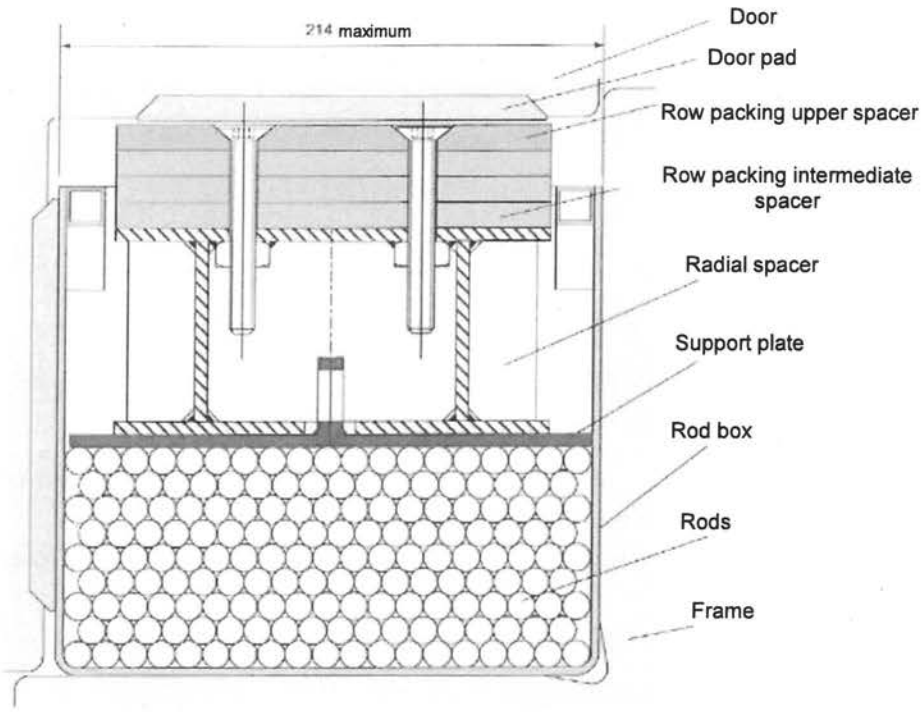
The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-2 DOS-12-00057682-502 Rev. 0 of the Safety Analysis Report.

When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 20 kg.

Criticality-Safety Index (CSI):

- When transporting $UO_2$ rods with radial and axial support, the criticality-safety index is equal to 0 (number N infinite),
- When transporting $UO_2$-$Gd_2O_3$ rods, with or without radial and axial support, criticality-safety index is equal to 0 (number N infinite),
- When transporting small quantities of $UO_2$ rods without radial or axial support, criticality-safety index is equal to 50 (Number N=1),

**FIGURE 5.1**
**ROD BOX DIAGRAM**



# APPENDIX 6

## CONTENTS No.6

## 15x15 PWR FUEL RODS

The contents should be loaded into an FCC 3 Version 1 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel rods

The authorized radioactive contents, as described in Chapter 1.3 DOS-18-016471-006 version 1.0 of the Safety Analysis Report, comprise fresh fuel rods designed for use in pressurized water reactors, as detailed below:

| **Characteristics of the fuel rods before irradiation:** | |
|---|---|
| Type of array | 15x15 |
| Maximum total mass per cavity (kg) | 751 |
| Maximum total mass of rods per box (kg) | 470 |
| Maximum mass of $UO_2$ (kg) | 389/box (1) or 21.1/package (2) |
| Nominal active length (mm) | 3,658 |
| Maximum number of fuel rods per box | 148 |
| Cladding: | |
| - Material | Zirconium alloy, possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.57 |
| - Minimum outer diameter (mm) | 10.68 |
| Pellets: | ENU (4) |
| - Maximum diameter (mm) | 9.40 |
| - Maximum oxide density (97.5 % of theoretical density) | 10.69 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Minimum $Gd_2O_3$ content (by mass) of gadolinium rods (%) (3) | 2 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

(1) This maximum mass is only applicable to gadolinium contents and those using spacers.
(2) This maximum mass is only applicable to non-gadolinium contents and those using neither axial nor radial spacers.
(3) Rods with a $Gd_2O_3$ content of less than 2% are assumed equal to $UO_2$ rods (without gadolinium).
(4) ENU: enriched natural uranium

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All rods making up a load must adhere to the conditions defined in the table below.

| Type of array | Maximum number of rods authorized per load, per box | Maximum initial enrichment level of each rod making up the load ($^{235}U/U_{total}$) (%) | Minimum number of rods in the load (1) |
|---|---|---|---|
| 15x15 | 148 (2) | 5 | Full row of fuel rods or inert rods |

(1) Incomplete rows of fuel rods may be topped up using solid stainless steel (or Zirconium alloy) bars with a nominal diameter of between 10.7 mm and 11 mm, possibly containing a neutron poison. The term "number of rods per box" means the total number of fuel rods and steel (or zirconium alloy) bars.
(2) When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 21.1 kg.

The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical state: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidised, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.69 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. INTERNAL FITTINGS

The internal fittings comprise a fuel rod box, as described in Chapters 1.3-1 & 1.3-2 DOS 12-00057684-031 & 032 Rev. 0.

### 1.1 Fuel rod box

These non-assembled rods are grouped in FCC3 fuel rod channels, which are inserted in place of fuel assemblies in the FCC3 version 1.

The channel is made of a U-shaped plate closed at the ends and reinforced with two stringers welded on the upper part of the plate.

A radial and axial wedging system adapts to the length of the rods and ensures their positioning. A general arrangement drawing is given in Figure 6.1.

The minimum height of the radial support is 85 mm.

### 1.2 Spacers

A set of 2 spacers is used to provide longitudinal support to the box within the cavity (one spacer at the top, another at the bottom). The spacers are described in detail in Chapter 1.3-1 of DOS-12-00057684-031 Rev. 0.

## 3. MAINTAINING SUB-CRITICALITY

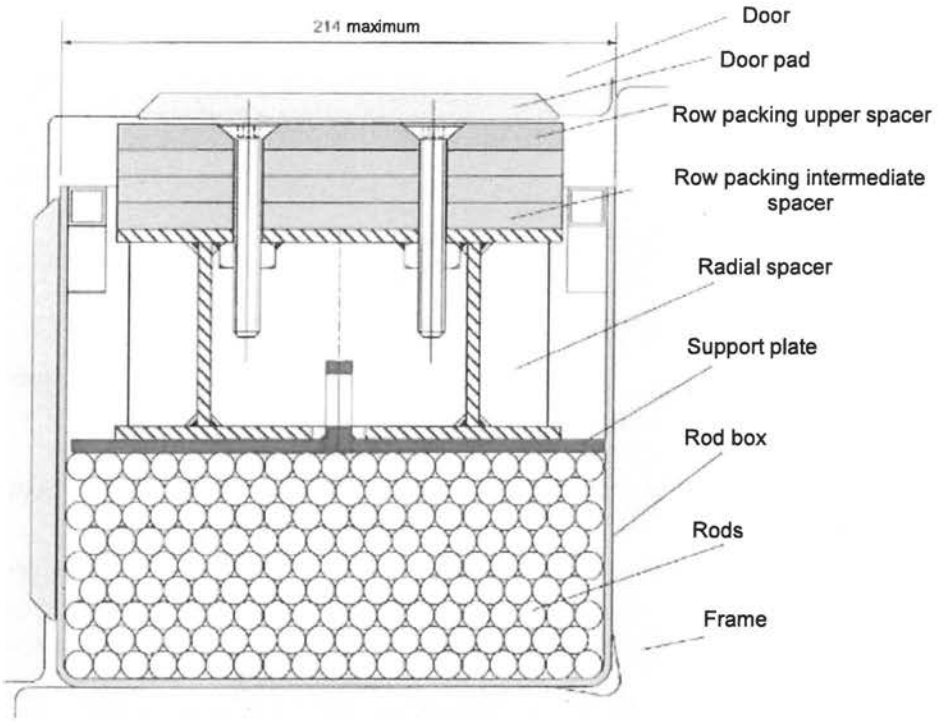
The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-2 DOS-12-00057682-502 Rev. 0.

When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 21.1 kg.

Criticality-Safety Index (CSI):

- When transporting $UO_2$ rods with radial and axial support, criticality-safety index is equal to 0 (number N infinite),
- When transporting $UO_2$-$Gd_2O_3$ rods with or without radial and axial support, criticality-safety index is equal to 0 (number N infinite),
- When transporting small quantities of $UO_2$ rods without radial or axial support, criticality-safety index is equal to 50 (number N=1),

**FIGURE 6.1**
**ROD BOX DIAGRAM**



# APPENDIX 7

## CONTENT No. 7

## 14x14 PWR EIGHT-FOOT FUEL RODS

The contents should be loaded into an FCC 3 Version 1 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel rods

The authorized radioactive contents, as described in Chapter 1.3 DOS-18-016471-006 version 1.0 of the Safety Analysis Report, comprise fresh fuel rods designed for use in pressurized water reactors (PWR), as detailed below:

| **Characteristics of the fuel rods before irradiation:** | |
|---|---|
| Type of array | 14x14 |
| Length (foot) | 8 |
| Maximum total mass per cavity (kg) | 751 |
| Maximum total mass of rods per box (kg) | 433 |
| Maximum mass of $UO_2$ (kg) | 362/box [1] or 21.1/package [2] |
| Nominal active length (mm) | 2,413 |
| Maximum number of fuel rods per box | 204 |
| Cladding: | |
| - Material | Zirconium alloy, possibly pre-oxidised |
| - Minimum metal thickness (mm) | 0.57 |
| - Minimum outer diameter (mm) | 10.68 |
| Pellets: | ENU [4] |
| - Maximum diameter (mm) | 9.40 |
| - Maximum oxide density (97.5 % of theoretical density) | 10.69 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Minimum $Gd_2O_3$ content (by mass) of gadolinium rods (%) [3] | 2 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

[1] This maximum mass is only applicable to gadolinium contents and those using spacers.
[2] This maximum mass is only applicable to non-gadolinium contents and those using neither axial nor radial spacers.
[3] Rods with a $Gd_2O_3$ content of less than 2% are assumed equal to $UO_2$ rods (without gadolinium).
[4] ENU: enriched natural uranium

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All rods making up a load must adhere to the conditions defined in the table below.

| Type of array | Maximum number of rods authorised per load, per box | Maximum initial enrichment level of each rod making up the load ($^{235}U/U_{total}$) (%) | Minimum number of rods in the load (1) |
|---|---|---|---|
| 14x14 | 204 (2) | 5 | Full row of fuel rods or inert rods |

(1) Incomplete rows of fuel rods may be topped up using solid stainless steel (or Zirconium alloy) bars with a nominal diameter of between 10.7 mm and 11 mm, possibly containing a neutron poison. The term "number of rods per box" means the total number of fuel rods and steel (or zirconium alloy) bars.
(2) When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 21.1 kg.

The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical State: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.69 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. INTERNAL FITTINGS

The internal fittings comprise a fuel rod box, as described in Chapters 1.3-1 & 1.3-2 DOS 12-00057684-031 & 032 Rev. 0.

### 1.1 Fuel rod box

These non-assembled rods are grouped in FCC3 fuel rod channels, which are inserted in place of fuel assemblies in the FCC3 version 1.

The channel is made of a U-shaped plate closed at the ends and reinforced with two stringers welded on the upper part of the plate.

A radial and axial wedging system adapts to the length of the rods and ensures their positioning. A general arrangement drawing is given in Figure 7.1.

The minimum height of the radial support is 85 mm.

### 1.2 Spacers

A set of 2 spacers is used to provide longitudinal support to the box within the cavity (one spacer at the top, another at the bottom). The spacers are described in detail in Chapter 1.3-1 of DOS-12-00057684-031 Rev. 0.

## 3. MAINTAINING SUB-CRITICALITY

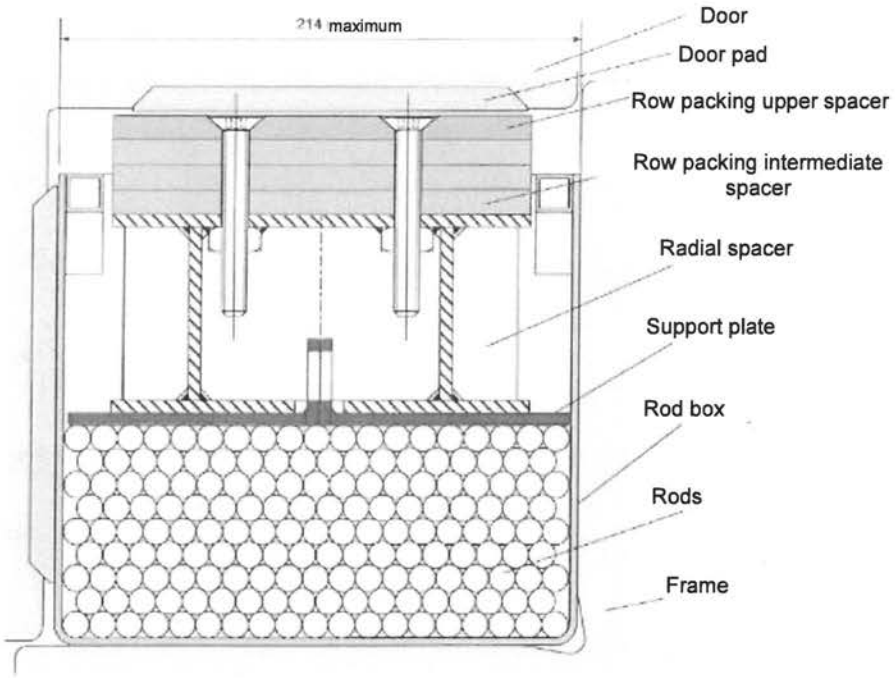
The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-2 DOS-12-00057682-502 Rev. 0.

When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 21.1 kg

Criticality-Safety Index (CSI):

- When transporting $UO_2$ rods with radial and axial support criticality-safety index is equal to 0 (number N infinite),
- When transporting $UO_2$-$Gd_2O_3$ rods with or without radial and axial support criticality-safety index is equal to 0 (number N infinite),
- When transporting small quantities of $UO_2$ rods without radial or axial support criticality-safety index is equal to 50 (number N=1),

**FIGURE 7.1**
**ROD BOX DIAGRAM**



# APPENDIX 8

## CONTENT NO. 8

## 14x14 PWR TEN-FOOT FUEL RODS

The contents should be loaded into an FCC 3 Version 1 packaging.

## 1. DEFINITION OF AUTHORIZED RADIOACTIVE CONTENTS

### 1.1 Characteristics of the fuel rods

The authorized radioactive contents, as described in Chapter 1.3 DOS-18-016471-006 version 1.0, of the Safety Analysis Report, comprise fresh fuel rods designed for use in pressurized water reactors (PWR), as detailed below:

| **Characteristics of the fuel rods before irradiation:** | |
|---|---|
| Type of array | 14x14 |
| Length (foot) | 10 |
| Maximum total mass per cavity (kg) | 751 |
| Maximum total mass of rods per box (kg) | 443 |
| Maximum mass of $UO_2$ (kg) | 374/box (1) or 21.1/package (2) |
| Nominal active length (mm) | 3,048 |
| Maximum number of fuel rods per box | 167 |
| Cladding: | |
| - Material | Zirconium alloy, possibly pre-oxidized |
| - Minimum metal thickness (mm) | 0.57 |
| - Minimum outer diameter (mm) | 10.68 |
| Pellets: | ENU (4) |
| - Maximum diameter (mm) | 9.40 |
| - Maximum oxide density (97.5 % of theoretical density) | 10.69 |
| - Maximum initial enrichment ($^{235}U/U_{total}$) (%) | 5 |
| - Maximum mass ratio $^{232}U/U_{total}$ (%) | $5.10^{-8}$ |
| - Maximum mass ratio $^{234}U/U_{total}$ (%) | 0.055 |
| - Maximum mass ratio $^{236}U/U_{total}$ (%) | 0.05 |
| Minimum $Gd_2O_3$ content (by mass) of gadolinium rods (%) (3) | 2 |
| Maximum absolute internal fuel rod pressure at 20°C (bar) | 32.7 |

(1) This maximum mass is only applicable to gadolinium contents and those using spacers.
(2) This maximum mass is only applicable to non-gadolinium contents and those using neither axial nor radial spacers.
(3) Rods with a $Gd_2O_3$ content of less than 2% are assumed equal to $UO_2$ rods (without gadolinium).
(4) ENU: enriched natural uranium

The mechanical resistance properties of the materials used in the rod cladding must respect the following table:

| | |
|---|---|
| **$R_{p0.2}$ (MPa)** | ≥ 250 |
| **$R_m$ (MPa)** | ≥ 400 |
| **$A_t$ (% over 50 mm)** | ≥ 25 |

### 1.2 Loading conditions

All rods making up a load must adhere to the conditions defined in the table below.

| Type of array | Maximum number of rods authorized per load, per box | Maximum initial enrichment level of each rod making up the load ($^{235}U/U_{total}$) (%) | Minimum number of rods in the load (1) |
|---|---|---|---|
| 14x14 | 167 (2) | 5 | Full row of fuel rods or inert rods |

(1) Incomplete rows of fuel rods may be topped up using solid stainless steel (or Zirconium alloy) bars with a nominal diameter of between 10.7 mm and 11 mm, possibly containing a neutron poison. The term "number of rods per box" means the total number of fuel rods and steel (or zirconium alloy) bars.
(2) When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 21.1 kg.

The presence of a desiccant is allowed.
The presence of materials with a greater hydrogen content than water as part of the packaging is not permitted.

Maximum activity level per packaging: The maximum activity of the content is less than 1 $A_2$.

Physical State: Fuel rod assemblies containing sintered pellets in a Zirconium alloy cladding, possibly pre-oxidized, meeting the criteria given in Paragraph 1.1 of the appendix.

Chemical composition: Uranium oxide pellets ($UO_2$) and/or fuel pellets made up a mixture of $UO_2$ at a $^{235}U$ enrichment level not exceeding 5% and a body acting as a neutron poison, with a mixture density of not more than 10.96 g/cm$^3$. The pellets may contain chrome oxides (but no other form of doping product).

Special form: The materials being shipped are not in special form.

## 2. INTERNAL FITTINGS

The internal fittings comprise a fuel rod box, as described in Chapters 1.3-1 & 1.3-2 DOS 12-00057684-031 & 032 Rev. 0.

### 2.1 Rod boxes

These non-assembled rods are grouped in FCC3 fuel rod channels, which are inserted in place of fuel assemblies in the FCC3 version 1.

The channel is made of a U-shaped plate closed at the ends and reinforced with two stringers welded on the upper part of the plate.

A radial and axial wedging system adapts to the length of the rods and ensures their positioning. A general arrangement drawing is given in Figure 8.1.

The minimum height of the radial support is 85 mm.

### 2.2 Spacers

A set of 2 spacers is used to provide longitudinal support to the box within the cavity (one spacer at the top, another at the bottom). The spacers are described in detail in Chapter 1.3-1 of DOS-12-00057684-031 Rev. 0.

## 3. MAINTAINING SUB-CRITICALITY

The demonstration of maintaining sub-criticality is the subject of Chapter 2.5-2 DOS-12-00057682-502 Rev. 0.

When transporting small quantities of $UO_2$ fuel rods without radial or axial supports, the maximum permissible mass of $UO_2$ per package is 21.1 kg.

Criticality-Safety Index (CSI):

- When transporting $UO_2$ rods with radial and axial support criticality-safety index is equal to 0 (number N infinite),
- When transporting $UO_2$-$Gd_2O_3$ rods with or without radial and axial support criticality-safety index is equal to 0 (number N infinite),
- When transporting small quantities of $UO_2$ rods without radial or axial support criticality-safety index is equal to 50 (number N=1),

**FIGURE 8.1**
**ROD BOX DIAGRAM**