# ENCLOSURE 2

# SARP UNC 2600

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# UNC 2600

# Safety Analysis Report for Packaging

# Application for License

# USA/5086/B(U)F

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# 1.0 General Information

This package consists of an outer steel drum and an inner steel cage assembly which centers and firmly locates an inner steel box. This box contains the fuel elements authorized for shipment. All aspects of design modification, fabrication, and use are controlled under the QA Plan approved under Docket 71-0088.

## 1.1 Introduction:

The UNC 2600 package is used to ship fuel elements with U-235 enrichments up to 100%. Fuel elements are clad components with no exposed fissile material. Each package is limited to a maximum of 375 grams. U-235. The loading will not exceed the $A_2$ values and will be verified prior to shipment.

No credit is taken in analysis for the shipping container. It is assumed to fail completely under the hypothetical accident condition. As a result, a Criticality Safety Index (CSI) of 50 is being assigned to the package.

## 1.2 Package Description:

### 1.2.1 Packaging:

(1) Weights:

| | |
|---|---|
| Nominal empty container | 840 lbs |
| Max. weight of contents | 265 lbs |
| Nominal gross weight | 1105 lbs |

(2) Materials of Construction:

The package is constructed of mild steel, using two high strength steel bolted closure flanges to retain the fuel box in an inner steel cage. The fuel box is also of mild steel construction. An oak wood block measuring at least 2-1/2" long is positioned at each end of the fuel box to prevent product damage and keep the product from moving during normal transport. Additionally, rubber bumpers are used at both ends, external to the cage, also to distribute the axial loads. The construction details are shown in Drawing B-2600-2, Sheets 1, 2, 3, 4, 5, and 6, Rev. 3 which is provided in Appendix 2.10.1.

(3) Description: (All Dimensions are Nominal)

The fuel box (inner container) is an 11 gage steel box with inside dimensions of 2-5/8" x 7" x 96". It is supported in a 22-1/2" I. D. by 102-1/2" long 14 gage steel drum by a welded reinforced insert cage. This cage is 97 " long, and is formed by nine 21-1/2" diameter by 3/8" thick steel plates (disks) spaced approximately 12" apart by 1-3/4" x 1/4" steel strips welded radially to each of the nine disks. The 12" sections at either end of the cage are further strengthened by eight 1" x 1" (1/8" angle) welded to the structure.

A channel to hold the fuel box is formed through the center of the cage by 1-1/2" x 1-1/2" x 1/8" angle irons which are also welded to each disk. Four additional 1" x 1" x 1/8" angles are used to further strengthen this fuel box slot. The fuel box is retained within the cage channel by two 1/2" thick diameter high strength 4130 steel closure flanges which are secured to each end of the cage with eight 7/8" SAE Grade 5 steel bolts.

The outer container closure is a 14 gage drum lid which is secured to the drum with a 12 gage bolt locking ring with drop forged lugs, one of which is threaded, having a 5/8" diameter bolt.

(4) Pressure Relief:

Pressure buildup is precluded because the drum lid has no gasket, facilitating pressure equalization.

### 1.2.2 Operational Features

Use of the package is simple, with minimal operational features. Proper use of the package is described in Section 7.

### 1.2.3 Contents of Package

(1) Type and Form of Material

The UNC-2600 package is used to ship unirradiated fuel elements. The element is a clad fuel component. The contained uranium may be enriched up to 100% in the U-235 isotope. Each element may be wrapped in protective plastic.

(2) Maximum Quantity of Material Per Package:

375 gram U-235 as clad fuel elements.

(3) Fuel Geometry Constraints:

The inner 11 gage steel box confines the uranium materials to a 2-5/8" x 7" cross section.

## 2.0 Structural Evaluations

### 2.1 Structural Evaluations:

#### 2.1.1 Discussion:

Section 1.2 identifies the principal construction details of the package design. Drawing B-2600-1 details the original design which had been drop tested, and is provided in Appendix 2.10.2 The current design, specified in Drawing B-2600-2 has been analytically evaluated using Finite Element Analysis (FEA).

The current design improves the mechanical retention of the fuel box within the cage, using a 12" O.D. x 1/2" thick 4130 AMS 6370 heat treated steel closure flange secured with eight 7/8" SAE Grade 5 steel bolts to each end of the cage. The use of these closure flanges adds less than 40 lbs. to the empty weight of the original package, and this is offset by a reduction in the product loading from 308 lbs. to 265 lbs. Additionally, the current design specifies that the bumper disks at each end of the cage be fabricated of a 60 durometer, $\geq$ 2500 psi rubber with a Bell Brittle Point temperature of at least -70F.

A prototype package (Drawing B-2600-1), representative of the original design has been previously tested as described in Section 2.7. The current design (Drawing B-2600-2) has been additionally evaluated for the drop test conditions using FEA. This evaluation is also described in Section 2.7.

### 2.2 Weights and Center of Gravity:

The center of gravity is essentially the center of the package in both the loaded and empty conditions.

## 2.3 Mechanical Properties of Materials:

The package is primarily fabricated of mild steel, and the 12" diameter closure flanges are 4130 AMS 6370 heat treated (Rockwell C = 28-33) steel. The properties of these steels, the SAE Grade 5 steel bolts, and the Rubber disks at each end of the cage are provided in Appendix 2.10.4.

## 2.4 General Standards For All Packages:

### 2.4.1 Minimum Package Size:

The package dimensions shown in drawing B-2600-2 exceed the minimum package size specifications of 10 CFR 71.

### 2.4.2 Tamperproof Features:

A tamperproof seal is inserted in the end of the bolt which secures the cover ring seal closure at the front of the package.

### 2.4.3 Positive Closure:

The inner box which contains the fuel is held closed with steel banding. The banded box is constrained by the angle iron channel within the welded cage assembly. This cage assembly is retained within the outer container, as demonstrated by the accident test sequence and the analysis discussed in Section 2.7. The outer container lid is held closed by the ring seal which is bolted closed.

### 2.4.4 Chemical and Galvanic Reactions:

The steel package construction is not vulnerable to degradation from such reactions during shipment, or as a result of accident conditions.

## 2.5 Lifting and Tiedown Standards For All Packages:

### 2.5.1 Lifting Devices:

Packages are lifted to and from the transport vehicle using appropriate slings, and other normal techniques. These are engaged with fork lifts or other standard mechanisms.

### 2.5.2 Tie Down Devices:

No tie down devices are incorportated as part of the package design.

## 2.6 Normal Conditions of Transport:

### 2.6.1 Heat

The low carbon steel construction of the package drums and internals, and the design and construction of the fuel elements retain ductility through a temperature range of -40 to +130 degrees, F. The rubber bumpers have a Bell Brittle Point at or below -70 F, and are serviceable at the specified -40 F. The package design imposes minimal stresses, and fracture of the steel construction or the non-brittle zirconium fuel cladding will not occur.

### 2.6.2 Cold

See Section 2.6.1

### 2.6.3 Pressure:

The package is closed with an ungasketed lid, and will not retain pressure differentials. If a gasketed lid were incorrectly applied, the outer drum may dimple, but the containment of the uranium contents will remain unimpaired.

### 2.6.4 Vibration:

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.6.5 **Water Spray:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.6.6 **Free Drop:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.6.7 **Corner Drop:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.6.8 **Penetration:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.6.9 **Compression:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

## 2.7 Hypothetical Accident Conditions

2.7.1 **Free Drop:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.7.2 **Puncture Test:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

2.7.3 **Thermal Test:**

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

### 2.7.4 Water Immersion:

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

### 2.7.5 Summary of Damage:

The criticality safety analysis does not credit the ability of the shipping container to protect the contents in any way. The assumption is that during the HAC, the fuel is ejected from the shipping container and attains an optimum configuration.

## 2.8 Special Form:

Not applicable

## 2.9 Fuel Rods:

Not applicable

## 2.10 Appendix:

2.10.1 Current Package Design Drawings

2.10.2 Original Package Design Drawings

# 3.0 Thermal Evaluation

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

# 4.0 Containment

## 4.1 Containment Boundary:

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

## 4.2 Requirements For Normal Conditions of Transport:

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

### 4.2.1 Release of Radioactive Materials

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable. It is assumed that all radioactive material is released.

### 4.2.2 Pressurization of Containment Vessel

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

### 4.2.3 Coolant Containment

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

### 4.2.4 Coolant Loss

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

## 4.3 Containment Requirements For Hypothetical Accident Conditions

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

### 4.3.1 Fission Gas Products

This section is not applicable since the material being shipped is unirradiated.

### 4.3.2 Release of Contents

No credit is taken for the ability of the package to protect the content during transport; therefore, this section is not applicable.

## 5.0 Shielding Evaluation

The content of the shipping container is an unirradiated uranium fuel element. This does not result in any external dose.

## 6.0 Criticality Evaluation

As noted in the previous sections, no credit is taken for the ability of the package to protect the content during transport. The assumptions are: 1) the fissile material is released from the package, 2) the cladding fails, 3) the uranium becomes finely divided, 4) mixes optimally with water in a spherical geometry and 5) is fully reflected by water. To assure subcriticality in this configuration, the total amount of U-235 must be below the minimum critical mass.

The minimum critical mass of U-235 is about 820 grams[1]. To provide a safety margin, the maximum allowable amount of U-235 in a shipment will be limited to 750 grams. If the maximum number of shipping containers is limited to two per shipment, each container can have 375 grams U-235 with a CSI=50.

[1]LA-10860, 1986 Revision, "Critical Dimensions of System Containing $^{235}U$, $^{239}Pu$ and $^{233}U$" by H.C. Paxton, N.L. Provost.

# 7.0 Operating Procedures

The UNC-2600 Package is used to ship up to 375 g U-235 of fuel elements in non-decomposable form, and up to 100% enrichment in the U-235 isotope. CSI=50 per package, thus limiting two to a shipment. Maximum payload weight is 265 lbs. The detailed loading and unloading procedures are given below and are in compliance with subpart G of 10CFR71. All operating procedures for the UNC-2600 shipping package are approved by NOG plant management. These procedures have been prepared to meet the intent of NUREG/CR-4775, "Guide for Preparing Operating Procedures for Shipping Packages".

## 7.1 Procedures For Loading Package Discussion and Results

Unacceptable shipping packages shall be marked accordingly, and appropriately repaired before use.

PROCEDURE

1. Assure that the package is to be loaded in accordance with the Certificate of Compliance as specified in written procedures and check lists. Compliance with these procedures and completion of the check list shall be recorded on appropriate shipping documentation.

2. Each UNC-2600 package shall be inspected prior to each use. The following requirements are to be checked;

   - That the maintenance inspections required by Section 8.2 have been conducted within the 12 months of use.
   - Compliance with the requirements of Section 8.2.7.1.
   - That the package is in unimpaired physical condition.
   - Inspect inner box for damage.
   - Inspect bolts for thread condition.
   - Inspect the top closure flange surfaces for damage. Inspect drum lid, ring seal, and locking bolts for damage, and replace as necessary.

3. Requirements for Loading Box:

   - Verify that the shipment consists only of fuel elements. Each element may be wrapped in protective plastic.
   - Verify the total U-235 per package is less than 375 grams.
   - Verify that the $A_2$ values are not exceeded based on the actual isotopic values for the loaded contents.
   - Elements shorter than 91" may be positioned with longer oak wood spacers at the ends of the box to prevent their movement during transport. This bracing protects the element from shifting.
   - Verify contents do not exceed 265 lbs. consisting of elements, wrapping, and wood spacers.
   - Each loaded box is to be strapped closed with three (3) 0.02" tk. x 1/2" wide x 24" lg. (approx.) steel banding straps.

4. Requirements for Loading Box into Package:

   - Slide the sealed box into the channel, assuring the end is flush with the face of the disk.
   - Locate the 12" diam. 1/2" thick steel closure flange to align the bolt into the bolt holes, and secure each bolt with a nut. These are to engage the bolts welded to the backside of the disk, and tightened to a snug closure.

5. Requirements For Sealing Package:

   - Place the rubber disk into the package to fill the free space at the front end of the package.
   - Close the front of the package with a 14 ga. drum lid which has no gasket.
   - Secure this lid with a 12 ga. ring seal, and secure the seal by torquing (40-45 ft. lbs.) the locking bolt into the threaded end of the ring seal. Tighten jam nut against the locking bolt, and apply the tamper-safe seal to the locking bolt.

6. Survey Requirements:

   - Removable surface contamination

     $\leq$ 2200 (beta and gamma) dpm per 100 sq. cm.

     $\leq$ 220 (alpha) dpm per 100 sq. cm.

   - Radiation levels $\leq$ 200 mrem per hour on contact.

   - Radiation levels < 10 mrem per hour at 1 meter.

7. Each shipment of the UNC 2600 package shall require the preparation of, and retention for three years, of those records specified in 10CFR71.91 as appropriate.

8. Verify that each package has a proper metal identification plate welded to the outer drum.

9. All shipments shall be Exclusive Use.

## 7.2 Procedures For Unloading Package

The UNC-2600 package is designed to be unloaded with commonly available tools and equipment in accordance with the following procedures:

PROCEDURE

1. Prior to unloading, verify that the following documentation is included with the shipment.

   - Radiological survey data

   - Packing list

2. Conduct a survey prior to unloading to assure that:

   - Removable surface contamination

     $\leq$ 2200 (beta and gamma) dpm per 100 sq. cm.

     $\leq$ 220 (alpha) dpm per 100 sq. cm.

- Radiation levels $\leq$ 200 mrem per hour on contact
- Radiation levels < 10 mrem per hour at 1 meter

3. Remove the tamper-safe seal, drum lid, and the rubber disk to expose the bolted closure flange.

4. Loosen and remove the eight closure flange bolt nuts and remove the flange.

5. Remove the inner box from the package using a manual or mechanical means. Remove the three steel closure bands from the box, and remove the elements from the box in accordance with applicable criticality control limits.

6. Replace the empty box into the package, and resecure the closure flange with the eight bolt nuts finger tightened. Replace the drum lid with the ring seal, and secure.

## 7.3 Preparation of Empty Package for Shipment

Empty UNC-2600 packages will be prepared for shipment by verifying the absence of fuel, closing all closure bolts, and securing the lid with a ring seal. The locking bolt is to be tamper-sealed, and appropriate labels are to be affixed to the package exterior to signify that it is empty.

A survey shall be performed on the outer package surface to ascertain that the removable surface contamination is $\leq$ 2200 (beta and gamma) dpm per 100 sq. cm or $\leq$ 220 (alpha) dpm per 100 sq. cm.

# 8.0 Acceptance Tests and Maintenance Program

## 8.1 Acceptance Tests

No new fabrication is allowed; therefore, Section 8.1 is not applicable.

## 8.2 Maintenance Program

### 8.2.1 Structural and Pressure Tests

A general inspection of the shipping package shall be made annually while in service. See Section 8.2.7.1. Maintenance shall be performed prior to placing containers back into services once removed.

### 8.2.2 Leak Tests

Not applicable.

### 8.2.3 Subsystem Maintenance

Not applicable.

### 8.2.4 Valves, Rupture Discs, and Gaskets on Containment Vessel

Not applicable.

### 8.2.5 Shielding

Not applicable.

### 8.2.6 Thermal

Not applicable.

### 8.2.7 Miscellaneous

The following inspections are to be conducted;

#### 8.2.7.1 Within 12 Months Before Use, and Annually while in service

- The outer surface of the drum shall be visually inspected for rust and scratches. Such defects shall be sanded off and repainted. Any significant dents will be reworked.
- The inner cage will be removed from the outer drum and inspected for rust and broken welds. The former will be sanded and repainted, and the latter repaired.
- The bottom closure flange shall be inspected to assure that the bolt nuts are properly secured.

#### 8.2.7.2 Prior to Every Shipment

- Inspect inner box for damage.
- Inspect bolts for thread condition.
- Inspect the top closure flange surfaces for damage.
- Inspect drum lid, ring seal, and locking bolts for damage, and replace as necessary.