



## Department of Energy

Washington, DC 20585

November 19, 2024

MEMORANDUM FOR LANCE L. LACROIX  
MANAGER  
IDAHO OPERATIONS OFFICE

FROM:

JULIA C. SHENK **Julia C. Shenk** Digitally signed by Julia C. Shenk  
HEADQUARTERS CERTIFYING OFFICIAL  
DIRECTOR  
OFFICE OF PACKAGING AND TRANSPORTATION  
Date: 2024.11.19 14:07:47 -05'00'

SUBJECT: Renewal of DOE Certificate of Compliance Number 9341

In response to the email request from Nathan McBride, Idaho Operations Office, dated October 24, 2024, attached is Department of Energy (DOE) Certificate of Compliance (CoC) Number 9341, Revision 2, for the Model BEA Research Reactor (BRR) Package and its DOE Safety Evaluation Report (SER). Changes to the CoC are indicated by vertical bars in the right page margin.

This CoC is issued by DOE under the authority of 49 CFR Part 173.7(d) and is conditional upon the user fulfilling the applicable Operational and Quality requirements of 49 CFR parts 100-199 and 10 CFR Part 71, and the conditions specified in Item 5 of the CoC.

The expiration date of DOE CoC 9341, Revision 2 is January 31, 2030.

If you have any questions, please contact me or the Docket Manager at (803) 645-3490 or [lawrence.gelder@em.doe.gov](mailto:lawrence.gelder@em.doe.gov).

Attachments: CoC 9341 Rev 2 & SER

cc: Nathan McBride, ID  
Nick Adams, INL  
Chris Backus, Orano Federal Services, LLC  
Christopher Cable, EM-4.24  
Lawrence Gelder, Docket Manager  
Docket 25-09-9341



**CERTIFICATE OF COMPLIANCE  
For Radioactive Materials Package**

|                        |                  |                                |              |                     |
|------------------------|------------------|--------------------------------|--------------|---------------------|
| 1a. Certificate Number | 1b. Revision No. | 1c. Package Identification No. | 1d. Page No. | 1e. Total No. Pages |
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2. PREAMBLE

- 2a. This certificate is issued under the authority of 49 CFR Part 173.7(d).
- 2b. The packaging and contents described in Item 5 below meet the safety standards set forth in subpart E, "Package Approval Standards" and subpart F, "Package, Special Form, and LSA III Tests" Title 10, Code of Federal Regulations, Part 71.
- 2c. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application —

(1) Prepared by (*Name and Address*):

U.S. Department of Energy  
Idaho Operations Office  
1955 Fremont Ave.  
Idaho Falls, ID 83415

(2) Title and identification of report or application:

Safety Analysis Report  
*BEA Research Reactor Package  
Safety Analysis Report*, Docket No. 71-9341,  
Revision 2 DOE, as supplemented [see 5(e)].

(3) Date:

December 2020

4. CONDITIONS

This certificate is conditional upon fulfilling of the applicable Operational and Quality Assurance requirements of 49CFR parts 100 – 199 and 10CFR Part 71, and the conditions specified in Item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Transport Index, other Conditions, and References:

(a) Packaging

(1) Model Number: BEA Research Reactor (BRR) Package

(2) Description:

The purpose of the Model No. BRR package is to transport irradiated fuel elements or loose plates of a square fuel element from various test and research reactors. The packaging is comprised of a lead-shielded package body, payload basket, square loose plate box, an upper shield plug, a closure lid, upper and lower impact limiters, and utilizes American Society for Testing and Materials (ASTM) Type 304 stainless steel as its primary structural material. The packaging is a right circular cylinder with a dimension of 77.1 inches in length and 38 inches in diameter, not including the impact limiter attachments and the thermal shield. Lead shielding is located between two circular shells, in the lower end structure, and in the shield plug. The payload cavity has a diameter of 16 inches and a length of 54 inches.

*Impact Limiters* - Impact limiters are attached to each end of the package body. Each impact limiter is 78 inches in diameter and 34.6 inches in length, with a 15-inches long conical section towards the outer end. The impact limiter design consists of ASTM Type 304 stainless steel shells and polyurethane foam with an approximate density of 9 pounds per cubic foot (lb./ft<sup>3</sup>).

6a. Date of Issuance: November 19, 2024

6b. Expiration Date: January 31, 2030

FOR THE U.S. DEPARTMENT OF ENERGY

7a. Address (of DOE Issuing Office)

U.S. Department of Energy  
Office of Packaging and Transportation (EM-4.24)  
1000 Independence Avenue, SW  
Washington, DC 20585

7b. Signature, Name, and Title (of DOE Approving Official)

Julia C. Shenk

Digitally signed by Julia C. Shenk  
Date: 2024.11.19 14:05:39 -05'00'

Julia C. Shenk  
Headquarters Certifying Official  
Director  
Office of Packaging and Transportation

|                    |              |                            |          |                 |
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**Fuel Baskets** - There are six baskets used with the package, one for each type of fuel transported and one for isotope production targets. The baskets are made from welded construction using ASTM Type 304 stainless steel in plate, bar, pipe, and tubular forms. Each basket has a diameter of 15.63 inches and a length of 53.45 inches, and features a number of cavities that fit the size and shape of the fuel. The basket for square fuel accommodates two types of fuel assembly: (1) flat type fuels and (2) a 5x5 array of fuel rods enclosed within a rectangular can.

**Personnel Barrier** - When transporting isotope production targets, a personnel barrier is used to limit access to the package body such that personnel are prevented from touching the cask surface where the surface temperature may exceed the allowable limit for exclusive use shipments. The barrier does not have a radiological purpose.

**Spacer Pedestals** - For fuel elements or assemblies shorter than the length of a basket cavity, spacer pedestals are used in each cavity, as required, to support the fuel elements at the top of the basket. All spacer pedestals are made of stainless steel.

**Square Box or Loose Plate Box** - A square box accommodates square fuel loose plates. A loose plate box is used to transport up to 31 loose plates per box. The square fuel basket and loose plate box are made of stainless steel.

The package is designed to be transported as one package per conveyance, with its longitudinal axis vertical, by highway truck or by rail in exclusive use. When loaded and prepared for transport, the package is 119.5 inches in length, 78 inches in diameter (over the impact limiters), and weighs 32,000 pounds (lb.).

(3) Drawings:

The packaging is constructed in accordance with Orano Federal Services, LLC drawings:

| Drawing Number | Revision | Title                                                      |
|----------------|----------|------------------------------------------------------------|
| 3022946        | 0        | BRR Package Assembly SARP Drawing, Sheets 1-5              |
| 3022947        | 0        | BRR Package Impact Limiter SARP Drawing, Sheets 1-2        |
| 3022948        | 1        | BRR Package Fuel Baskets SARP Drawing, Sheets 1-5          |
| 3022949        | 0        | BRR Package Isotope Target Basket SARP Drawing, Sheets 1-2 |

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(b) Contents

(1) Type and Form of Radioactive Material:

- (i) *Irradiated MURR Fuel Element.* Irradiated University of Missouri Research Reactor (MURR) fuel element to a maximum burnup of 180 megawatt-day (MWD) or a depletion of 30.9% of Uranium-235 ( $^{235}\text{U}$ ). The minimum cooling time is 180 days after reactor shutdown. Each MURR element contains 24 fuel plates. Each fresh MURR fuel element contains  $775.0 \pm 7.8$  g  $^{235}\text{U}$ . The enrichment range is  $93 \pm 1$  wt.%  $^{235}\text{U}$ . The MURR element overall length, including irradiation growth, is 32.75 inches. The maximum decay heat per fuel element is 158 watts (W). The maximum number of fuel elements per basket is 8. The bounding weight of one element is 15 lb. Table 1.1 includes characteristics of a pre-irradiated MURR fuel element.

**Table 1.1 MURR - Key Fuel Element Parameters**

| Parameter                                   | Value            |
|---------------------------------------------|------------------|
| Maximum active fuel length (inches)         | 24.8             |
| Overall length (inches)                     | 32.75            |
| Minimum cladding thickness (inch)           | 0.008            |
| Nominal fuel matrix thickness (inch)        | 0.02             |
| Fuel matrix                                 | UAl <sub>x</sub> |
| Cladding material                           | Aluminum         |
| Maximum $^{235}\text{U}$ per element (g)    | 782.8            |
| Maximum enrichment (wt.%)                   | 94.0             |
| Maximum $^{235}\text{U}$ per fuel plate (g) | 46.0             |

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- (ii) *Irradiated MITR-II Fuel Element.* Irradiated Massachusetts Institute of Technology Research Reactor (MITR-II) fuel element to a maximum burnup of 165 MWD or a  $^{235}\text{U}$  depletion of 43.9%. The minimum cooling time is 120 days after reactor shutdown. Each MITR-II element contains 15 fuel plates. Each fresh MITR-II element contains  $510.0 \pm 3.0/-10.0 \text{ g } ^{235}\text{U}$ , which is 500 - 513 g  $^{235}\text{U}$ . The enrichment range is  $93 \pm 1 \text{ wt. \% } ^{235}\text{U}$ . The MITR-II element overall length, including irradiation growth, is 26.52 inches. The maximum decay heat per element is 150 W. The maximum number of fuel elements per basket is 8. The bounding weight of one element is 10 lb. Table 1.2 includes the key parameters for a pre-irradiated MITR-II fuel element.

**Table 1.2 MITR-II - Key Fuel Element Parameters**

| Parameter                                   | Value            |
|---------------------------------------------|------------------|
| Maximum active fuel length (inches)         | 22.76            |
| Overall length (inches)                     | 26.52            |
| Minimum cladding thickness (inch)           | 0.008            |
| Nominal fuel matrix thickness (inch)        | 0.03             |
| Maximum fuel matrix width (inches)          | 2.171            |
| Fuel matrix                                 | UAl <sub>x</sub> |
| Cladding material                           | Aluminum         |
| Maximum $^{235}\text{U}$ per element (g)    | 513              |
| Maximum enrichment (wt. %)                  | 94.0             |
| Maximum $^{235}\text{U}$ per fuel plate (g) | 34.3             |

- (iii) *Irradiated ATR Fuel Element.* Irradiated Advanced Test Reactor (ATR) fuel element to a maximum burnup of 480 MWD or a  $^{235}\text{U}$  depletion of 58.6%. The minimum cooling time is 1,670 days (4.6 years) after reactor shutdown. Each ATR fuel element contains 19 plates. The YA fuel element has 19 plates, but only 18 contain fuel.

There are two general classes of ATR fuel element, XA and YA. The enrichment range is  $93 \pm 1$  wt.%  $^{235}\text{U}$ . The XA fuel element has a fresh fuel loading of  $1,075 \pm 10$  g  $^{235}\text{U}$ . The YA fuel element has a fresh fuel loading of  $1,022.4 \pm 10$  g  $^{235}\text{U}$ . A second YA fuel element design (YA-M) has the side plate width reduced by 15 mils. The ATR element overall maximum length, after removal of the end box structures, 51.0 inches. The maximum number of fuel elements per basket is 8. The bounding weight of one element is 25 lb. The maximum decay heat per element is 30 W. Table 1.3 includes characteristics of a pre-irradiated ATR fuel element.

**Table 1.3 ATR-II - Key Fuel Element Parameters**

| Parameter                                         | Value          |
|---------------------------------------------------|----------------|
| Maximum active fuel length (inches)               | 48.77          |
| Overall length (inches)                           | 51             |
| Minimum cladding thickness for Plate 1 (inch)     | 0.018          |
| Minimum cladding thickness for Plates 2-18 (inch) | 0.008          |
| Minimum cladding thickness for Plate 19 (inch)    | 0.018          |
| Nominal fuel matrix thickness (inch)              | 0.02           |
| Fuel matrix                                       | $\text{UAl}_x$ |
| Cladding material                                 | Aluminum       |
| Maximum $^{235}\text{U}$ per element (g)          | 1,085          |
| Maximum enrichment (wt.%)                         | 94.0           |
| Maximum $^{235}\text{U}$ per fuel plate (g)       | 85.2           |

- (iv) *Irradiated TRIGA fuel elements.* Table 1.4 includes the dimensions of pre-irradiated Training, Research, Isotopes, General Atomics (TRIGA) fuel elements. The TRIGA fuel matrix is uranium mixed with zirconium hydride. The BRR package is limited to the transportation of the following types of TRIGA fuel:

1. Standard 100 series.
2. Instrumented 200 series. The fuel region is as the same as 100 series but contain thermocouples used to measure temperature during reactor operation. Instrumented rods may be longer than 100 series.
3. Fueled Follower Control Rods (FFCR) (300 series). The rods contain boron carbide neutron absorber outside the active fuel region.
4. Cluster Rods (400 series). It is typically built with three or four cluster rods to make a cluster assembly.
5. Instrumented Cluster Rods (500 series). Fuel is the same as cluster rod but thermocouples used to measure temperature during reactor operation. Instrumented cluster rods may be longer.

Cluster Rods (i.e., TRIGA fuel series 400 and 500) must be disassembled from the cluster assembly for transport in the BRR package.

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**Table1.4 Characteristics of Pre-Irradiated TRIGA Fuel**

| Type                                             | ID <sup>1</sup> | Cladding        | Fuel Length (in.) | U (wt. % Fuel) | <sup>235</sup> U (wt. %) | U (g) | <sup>235</sup> U (g) | Fuel OD <sup>2</sup> (in.) | Rod OD (in.) | Cladding Thickness (in.) | H/Zr | Overall Length <sup>3</sup> (in.) | Erbium (wt. %) |
|--------------------------------------------------|-----------------|-----------------|-------------------|----------------|--------------------------|-------|----------------------|----------------------------|--------------|--------------------------|------|-----------------------------------|----------------|
| Standard 100 series                              | 101             | Aluminum        | 14                | 8.0            | 20                       | 166   | 32                   | 1.41                       | 1.48         | 0.03                     | 1.0  | 28.62                             | 0              |
|                                                  | 101             | Aluminum        | 15                | 8.5            | 20                       | 189   | 37                   | 1.41                       | 1.48         | 0.03                     | 1.6  | 28.62                             | 0              |
|                                                  | 103             | Stainless Steel | 15                | 8.5            | 20                       | 197   | 39                   | 1.44                       | 1.48         | 0.02                     | 1.6  | 29.15                             | 0              |
|                                                  | 105             |                 | 15                | 12             | 20                       | 285   | 56                   | 1.44                       | 1.48         | 0.02                     | 1.6  | 29.15                             | 0              |
|                                                  | 107             |                 | 15                | 12             | 20                       | 271   | 53                   | 1.4                        | 1.48         | 0.02                     | 1.6  | 30.14                             | 0              |
|                                                  | 109             |                 | 15                | 8.5            | 70                       | 194   | 136                  | 1.44                       | 1.48         | 0.02                     | 1.6  | 29.15                             | 1.2            |
|                                                  | 117             |                 | 15                | 20             | 20                       | 503   | 99                   | 1.44                       | 1.48         | 0.02                     | 1.6  | 29.93                             | 0.5            |
|                                                  | 119             |                 | 15                | 30             | 20                       | 825   | 163                  | 1.44                       | 1.48         | 0.02                     | 1.6  | 29.93                             | 0.9            |
| Instrumented 200 series                          | 201             | Aluminum        | 15                | 8.5            | 20                       | 189   | 37                   | 1.41                       | 1.48         | 0.03                     | 1.6  | 28.78                             | 0              |
|                                                  | 203             | Stainless Steel | 15                | 8.5            | 20                       | 197   | 39                   | 1.44                       | 1.48         | 0.02                     | 1.6  | 45.5                              | 0              |
|                                                  | 205             |                 | 15                | 12             | 20                       | 285   | 56                   | 1.44                       | 1.48         | 0.02                     | 1.6  | 45.5                              | 0              |
|                                                  | 207             |                 | 15                | 12             | 20                       | 271   | 53                   | 1.4                        | 1.48         | 0.02                     | 1.6  | 45.5                              | 0              |
|                                                  | 217             |                 | 15                | 20             | 20                       | 503   | 99                   | 1.44                       | 1.48         | 0.02                     | 1.6  | 40.35                             | 0.5            |
|                                                  | 219             |                 | 15                | 30             | 20                       | 825   | 163                  | 1.44                       | 1.48         | 0.02                     | 1.6  | 40.35                             | 0.9            |
| Fueled Follower Control Rods (FFCR) (300 series) | 303             | Stainless Steel | 15                | 8.5            | 20                       | 163   | 32                   | 1.31                       | 1.35         | 0.02                     | 1.6  | 44                                | 0              |
|                                                  | 305             |                 | 15                | 12             | 20                       | 237   | 47                   | 1.31                       | 1.35         | 0.02                     | 1.6  | 44                                | 0              |
|                                                  | 317             |                 | 15                | 20             | 20                       | 418   | 82                   | 1.31                       | 1.35         | 0.02                     | 1.6  | 44                                | 0.5            |
|                                                  | 319             |                 | 15                | 30             | 20                       | 685   | 135                  | 1.31                       | 1.35         | 0.02                     | 1.6  | 44                                | 0.9            |
| Cluster rods (400 series)                        | 403             | Stainless Steel | 15                | 8.5            | 20                       | 166   | 33                   | 1.37                       | 1.41         | 0.02                     | 1.6  | 30.38                             | 0              |
|                                                  | 405             |                 | 15                | 12             | 20                       | 243   | 48                   | 1.37                       | 1.41         | 0.02                     | 1.6  | 30.38                             | 0              |
|                                                  | 417             |                 | 15                | 20             | 20                       | 427   | 85                   | 1.37                       | 1.41         | 0.02                     | 1.6  | 30.38                             | 0.5            |
|                                                  | 419             |                 | 15                | 30             | 20                       | 710   | 141                  | 1.37                       | 1.41         | 0.02                     | 1.6  | 30.38                             | 0.9            |
| Instrumented cluster rods (500 series)           | 503             | Stainless Steel | 15                | 8.5            | 20                       | 166   | 33                   | 1.34                       | 1.41         | 0.02                     | 1.6  | 45.5                              | 0              |
|                                                  | 505             |                 | 15                | 12             | 20                       | 243   | 48                   | 1.34                       | 1.41         | 0.02                     | 1.6  | 45.5                              | 0              |
|                                                  | 517             |                 | 15                | 20             | 20                       | 427   | 85                   | 1.34                       | 1.41         | 0.02                     | 1.6  | 45.5                              | 0.5            |
|                                                  | 519             |                 | 15                | 30             | 20                       | 710   | 141                  | 1.34                       | 1.41         | 0.02                     | 1.6  | 45.5                              | 0.9            |

Table 1.4 Notes:

- General Atomics catalog numbers are not necessarily unique. TRIGA elements with the same ID could have different fuel parameters. Table 1.4 includes two variants of the Type 101 element.
- Outer Diameter.
- Overall length includes 0.25 inches for irradiation growth.

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(iv) *Irradiated TRIGA fuel elements (continued)*. The maximum length of a TRIGA fuel element, including irradiation growth, is 45.50 inches. For all fuel elements, stainless steel spacers are utilized within the TRIGA baskets. The bounding weight of any TRIGA fuel element is 10 lb. The maximum decay heat per element is 20 W. The number of TRIGA rods per element is 1. Table 1.5 includes parameters for irradiated TRIGA fuel.

**Table 1.5 Maximum Burnup and Minimum Cooling Time for TRIGA Fuel Elements<sup>1</sup>**

| TRIGA Fuel Type<br>(Enrichment) | Maximum Burnup<br>(MWD) | Minimum Cooling Time<br>(days) |
|---------------------------------|-------------------------|--------------------------------|
| 101 (8.0%)                      | 23                      | 90                             |
| 201/101 (8.5%)                  | 26                      | 90                             |
| 109                             | 88                      | 350                            |
|                                 | 70                      | 250                            |
|                                 | 52                      | 170                            |
|                                 | 34                      | 90                             |
| 203/103                         | 27                      | 90                             |
| 205/105                         | 39                      | 120                            |
|                                 | 33                      | 90                             |
| 207/107                         | 38                      | 120                            |
|                                 | 33                      | 90                             |
| 217/117                         | 71                      | 280                            |
|                                 | 52                      | 180                            |
|                                 | 34                      | 90                             |
| 219/119                         | 122                     | 600                            |
|                                 | 91                      | 370                            |
|                                 | 63                      | 220                            |
|                                 | 34                      | 90                             |
| 303                             | 22                      | 90                             |
| 305                             | 32                      | 90                             |
| 317                             | 58                      | 210                            |
|                                 | 46                      | 150                            |
|                                 | 34                      | 90                             |
| 319                             | 97                      | 420                            |
|                                 | 76                      | 290                            |
|                                 | 55                      | 180                            |
|                                 | 34                      | 90                             |
| 503/403                         | 23                      | 90                             |
| 505/405                         | 33                      | 90                             |
| 517/417                         | 60                      | 220                            |
|                                 | 47                      | 150                            |
|                                 | 34                      | 90                             |
| 519/419                         | 101                     | 430                            |
|                                 | 79                      | 290                            |
|                                 | 56                      | 180                            |
|                                 | 34                      | 90                             |

Table 1.5 Note:

1. Based on an in-core residence time of 4 years resulting on a decay heat less than or equal to 20 W. Not applicable to fuel with an in-core residence time less than 4 years with a decay heat greater than 20 W.



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- (v) *PULSTAR Fuel*. Table 1.6 includes the characteristics of the pulsed training assembled reactor (PULSTAR) fuel. A 5×5 array of fuel rods enclosed within a rectangular can. Each fuel rod contains cylindrical uranium oxide fuel pellets. The weight of a PULSTAR element is 48 lb., including a spacer pedestal. The maximum heat load of the square fuel basket per compartment is 30 W.

**Table 1.6 Characteristics of PULSTAR Fuel**

| Parameter                                    | Value           |
|----------------------------------------------|-----------------|
| Nominal <sup>235</sup> U Enrichment (%)      | 4.0/6.0         |
| Fuel matrix                                  | UO <sub>2</sub> |
| Maximum burnup (MWD/MTU)                     | 20,000          |
| Decay time (years)                           | 1.5             |
| Maximum fuel pellet diameter (inch)          | 0.423           |
| Minimum cladding thickness (inch)            | 0.0185          |
| Cladding material                            | Zirconium alloy |
| Maximum cladding OD (inch)                   | 0.474           |
| Maximum active fuel length (inches)          | 24.1            |
| Fuel rod pitch X (inch)                      | 0.607           |
| Fuel rod pitch Y (inch)                      | 0.525           |
| Box outer dimensions (inches)                | 3.15 x 2.74     |
| Box thickness (inch)                         | 0.06            |
| Box material                                 | Zirconium alloy |
| Maximum overall length (inches) <sup>1</sup> | 38.23           |

Table 1.6 Note:

1. Includes 0.25 inch for irradiation growth.

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(vi) *Square Fuel and Loose Plates (excluding PULSTAR)*. Table 1.7 includes the main characteristics of square fuel and square-loose-plate fuel. These types of fuel have a square, or nearly square-rectangular cross section. The flat type fuels consist of either a uranium-oxide dispersion or uranium-silicide dispersion meat in an aluminum matrix, bonded with an aluminum alloy cladding. The maximum heat load of the square fuel basket per compartment is 30 W.

**Table 1.7 Square Plate Fuel Characteristics**

| Parameter                                 | RINSC                              | Ohio State                         | Miss. S&T                          | U-Florida                          | Purdue                             | U-Mass (Al)      | U-Mass (Si)                        |
|-------------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------|------------------------------------|
| <sup>235</sup> U loading (g)              | 275±7.7                            | 200±5.6                            | 225±6.3                            | 175±4.9                            | 129.92±2.52                        | 167±3.3          | 200±5.6                            |
| Nominal <sup>235</sup> U enrichment (%)   | 19.75                              | 19.75                              | 19.75                              | 19.75                              | 19.75                              | 19.75            | 19.75                              |
| Fuel matrix                               | U <sub>3</sub> Si <sub>2</sub> +Al | U <sub>3</sub> Si <sub>2</sub> +Al | U <sub>3</sub> Si <sub>2</sub> +Al | U <sub>3</sub> Si <sub>2</sub> +Al | U <sub>3</sub> Si <sub>2</sub> +Al | UAl <sub>x</sub> | U <sub>3</sub> Si <sub>2</sub> +Al |
| Maximum burnup per fuel element (MWD)     | 52.5                               | 64.0                               | 74.0                               | 87.0                               | 0.57                               | 9.7              | 9.7                                |
| Minimum decay time (D)                    | 120                                | 120                                | 365                                | 120                                | 120                                | 1,000            | 1,000                              |
| Nominal fuel meat width (in.)             | 2.395                              | 2.395                              | 2.395                              | 2.395                              | 2.395                              | 2.320            | 2.395                              |
| Nominal fuel meat thickness (in.)         | 0.02                               | 0.02                               | 0.02                               | 0.02                               | 0.02                               | 0.03             | 0.02                               |
| Nominal fuel plate thickness (in.)        | 0.05                               | 0.05                               | 0.05                               | 0.05                               | 0.05                               | 0.06             | 0.05                               |
| Nominal active fuel length (in.)          | 23.25                              | 23.25                              | 23.25                              | 23.25                              | 23.25                              | 23.25            | 23.25                              |
| Number of fuel plates                     | 22                                 | 16                                 | 18                                 | 14                                 | 14                                 | 18               | 16                                 |
| Maximum channel spacing (in.)             | 0.099                              | 0.127                              | 0.139                              | 0.117                              | 0.175                              | 0.119            | 0.122                              |
| Weight (lb.)                              | 14                                 | 12                                 | 14                                 | 10                                 | 10                                 | 12               | 12                                 |
| Maximum overall length (in.) <sup>1</sup> | 39.75                              | 35.25                              | 34.50                              | 27.38                              | 32.49                              | 39.75            | 39.75                              |
| Maximum cross section (in.)               | 3.097×3.097                        | 3.05×3.05                          | 3.036×3.212                        | 2.9×2.424                          | 3.011×3.011                        | 3.097×3.097      | 3.097×3.097                        |
| Loose plate <sup>1-2</sup>                | no                                 | no                                 | no                                 | Yes <sup>3</sup>                   | Yes <sup>4</sup>                   | Yes <sup>5</sup> | no                                 |

**Table 1.7 Notes:**

1. Maximum length includes 0.25 inches for irradiation growth.
2. Loose plates shall be extracted from fuel elements that meet the per-element burnup limits provided in this table.
3. U-Florida loose plates have a <sup>235</sup>U loading of 12.5 ± 0.35g and dimensions of 2.85 inches wide by 25.88 inches long.
4. Purdue loose plates have a <sup>235</sup>U loading of 9.28 ± 0.18g and dimensions of 2.85 inches wide by 25.88 inches long.
5. U-Mass (Al) loose plates have a <sup>235</sup>U loading of 9.28 ± 0.18g and dimensions of 2.78 inches wide by 24.88 inches long.

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(vii) *Isotope Production Targets*. Targets are irradiated in nuclear reactors to produce  $^{60}\text{Co}$  and may be made of aluminum and contain a large quantity of small pellets, or they may consist of a cylindrical rod of cobalt material inside a stainless steel tube. All targets must be placed into target holders prior to loading into the basket. There are two different payload types:

1. *Payload Type 1*. Type 1 consists primarily of higher-activity targets of a newer design, which may also include lower-activity targets as described under Payload Type 2. The pellets are arranged in several stacks in an annular configuration within the target body. Payload Type 1 consists of up to 10 targets, which must be loaded in the inner row of basket holes, and be arranged using a loading plan into five zones of two holes each. The maximum activity in any zone is 22,000 Ci. A loading collar must be installed to block access to the outer row of holes before loading payload Type 1 targets. Table 1.8 includes the characteristics of Payload Type 1 isotope production targets.

**Table 1.8 Characteristics of Isotope Production Targets, Payload Type 1**

| Parameter                              | Value                  |
|----------------------------------------|------------------------|
| Target Diameter (inch)                 | 1/2                    |
| Target Length (inches)                 | 16                     |
| Cladding Material                      | 6061-T6 aluminum alloy |
| Target Contents (pellets)              | 6,000 (approximately)  |
| Pellet Size Diameter (mm)              | 1                      |
| Pellet Size Thickness (mm)             | 1                      |
| Maximum $^{60}\text{Co}$ Activity (Ci) | 14,100                 |
| Payload Quantity (targets)             | 10                     |
| Maximum Total Activity (Ci)            | 82,000                 |

2. *Payload Type 2*: Type 2 consists of lower-activity targets of an older design, which include: a) Design in which an aluminum core rod holds pellets placed in dimples on the outer surface and which are retained by a close-fitting outer sleeve, welded to the core rod on each end and b) Design using a solid rod of cobalt inside a stainless steel tube with welded ends. Table 1.9 includes the characteristics of Payload Type 2 isotope production targets.

**Table 1.9 Characteristics of Isotope Production Targets, Payload Type 2**

| Parameter                              | Value (pellet design)  | Value (rod design)                       |
|----------------------------------------|------------------------|------------------------------------------|
| Target Diameter (inch)                 | 5/8                    | 5/16                                     |
| Maximum Target Length (inches)         | 16.5                   | 16.5                                     |
| Cladding Material                      | 6061-T6 aluminum alloy | Stainless steel                          |
| Target Contents (pellets/rods)         | 5,500 (approximately)  | 1 solid or segmented rod of cobalt metal |
| Pellet Size Diameter (mm)              | 1                      |                                          |
| Pellet Size Thickness (mm)             | 1                      |                                          |
| Maximum $^{60}\text{Co}$ Activity (Ci) | 4,000                  |                                          |
| Payload Quantity (targets)             | 20                     |                                          |
| Maximum Total Activity (Ci)            | 80,000                 |                                          |

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(viii) *Pu-238 Production Targets.* Pu-238 production targets contain Np-237 which is irradiated in a nuclear reactor to produce Pu-238 heat source material. Two different targets will be transported: the HFIR Gen II target (a.k.a., HFIR) and the ATR target. Both targets are of similar design and both will be irradiated in the ATR located at the Idaho National Laboratory. Both unirradiated or irradiated targets can be shipped. Both targets are approximately 0.4 inch in diameter and consist of a stack of NpO<sub>2</sub> cermet pellets clad in aluminum. The end structures include a plenum and may be made from aluminum or stainless steel. The HFIR target is 33.6 inches long with a pellet stack length of 19.7 inches, and the ATR target length is bounded by 33.6 inches with a bounding pellet stack length of 23 inches. Up to 16 targets can be placed into each target rack, and up to six target racks can be placed into the outer tubes of the square fuel basket (Drawing 3022948, Assembly A5) for a maximum payload quantity of 96 targets. When transporting Pu-238 targets, the center two square holes are not used. The personnel barrier does not need to be used with Pu-238 production targets.

Table 1.10 below assumes full complement of 96 targets and maximum pellet stack length of 23.0 inches. The isotopic distribution and activity limits for unirradiated targets is Appendix E of SARP Section 1.3.1 Reference 3 and for irradiated targets Table 6 of SARP Section 1.3.1 Reference 3.

**Table 1.10 Characteristics of Pu-238 Production Targets**

| Item                                      | Characteristic/Limit                                                           |
|-------------------------------------------|--------------------------------------------------------------------------------|
| Unirradiated targets                      | 3.5 kg (max) of Np-237                                                         |
| Irradiated targets (cooling and activity) | 180 days (min) cooling prior to shipment and 50,122 Ci (max per package)       |
| Irradiated targets (fissile mass)         | 64 g (max per package)                                                         |
| Irradiated targets (decay heat)           | 5.32 W (max target, 511 W per package)                                         |
| Pellet cermet composition                 | 65% aluminum (min), 10% void (approximately), and the balance NpO <sub>2</sub> |
| Nominal Cladding thickness                | Wall thickness is 0.035 inches (minimum between ribs)                          |

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(b) Contents (cont.)

(2) Maximum Quantity of Radioactive Material per Package:

See Table 1.11.

**Table 1.11 Radioactive Material Package Limits**

| <b>Content Type &amp; Form</b>                          | <b>Item</b>                                   | <b>Package Limit</b> | <b>Loading Condition</b>                                                                                                                                                                        |
|---------------------------------------------------------|-----------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>MURR</b>                                             | Irradiated fuel elements                      | 8                    | Only one fuel element is allowed per basket location.                                                                                                                                           |
| <b>MITR-II</b>                                          | Irradiated fuels elements                     | 8                    | Only one fuel element is allowed per basket location.                                                                                                                                           |
| <b>ATR</b>                                              | Irradiated fuels elements                     | 8                    | Only one fuel element is allowed per basket location.                                                                                                                                           |
| <b>TRIGA (26 Types)</b>                                 | Irradiated fuel elements                      | 19                   | Only one fuel element is allowed per basket location.                                                                                                                                           |
| <b>PULSTAR</b>                                          | Irradiated fuel elements                      | 8                    | Only one fuel element is allowed per basket location.                                                                                                                                           |
| <b>Square Fuel and Loose Plates (excluding PULSTAR)</b> | Irradiated fuel elements or loose plate boxes | 8                    | Only one fuel element or loose plate box is allowed per basket location (i.e., compartment). Up to 31 loose plates may be placed in each loose plate box.                                       |
| <b>Isotope Production Targets Payload Type 1</b>        | Target holders                                | 10                   | Up to 10 target holders may be placed into the inner row of holes in the isotope basket                                                                                                         |
| <b>Isotope Production Targets Payload Type 2</b>        | Target holders                                | 20                   | Up to 20 target holders may be placed into any of the 20 holes in the isotope basket                                                                                                            |
| <b>Pu-238 Production Targets</b>                        | Irradiated or unirradiated targets            | 96                   | Up to 16 targets can be placed into each target rack, and up to six target racks can be placed into the outer tubes of the square fuel basket, except the center two square holes are not used. |
| <b>Pu-238 Production Targets</b>                        | Plutonium (Ci)                                | 11,010               | Package limit is based on SARP Table 6.10-1                                                                                                                                                     |
| <b>All (others)</b>                                     | Plutonium (Ci)                                | 6,500                | Package limit is based on 4% <sup>235</sup> U enrichment of PULSTAR fuel                                                                                                                        |

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(c) Criticality Safety Index

The Criticality Safety Index CSI is 0.0

(d) Conditions

- (1) In addition to the requirements of Subpart G of 10 CFR Part 71, the package must be prepared for shipment and operated in accordance with Chapter 7 of the Safety Analysis Report (SAR), as supplemented by 5.(e) of this certificate.
- (2) Each packaging must be acceptance tested and maintained in accordance with Chapter 8 of the SAR, as supplemented.
- (3) For TRIGA fuel, spacer pedestals must be used as described in Table 7.1-2 of the SAR, as supplemented.
- (4) For PULSTAR fuel, square fuel, or loose plates, spacer pedestals must be used as described in Table 7.1-1 of the SAR, as supplemented.
- (5) For Square Fuel and Loose Plates, spacer pedestals must be used as described in Table 7.1-1 of the SAR, as supplemented.
- (6) For Loose Plates, use aluminum dunnage sheets to reduce the free space between the flat face of the loose plates and the box opening to a value of ¼ inches or less. The dimensions of the dunnage sheets shall be as shown in Figure 7.1-1 of the SAR, as supplemented.
- (7) For Isotope Production Targets, a personnel barrier must be used as described in Section 7.1.4 of the SAR, as supplemented.
- (8) Transport by air of fissile material is not authorized.
- (9) Each DOE consignor or consignee of the package must have a 10 CFR 71 Subpart H Quality Assurance Program approved by the DOE Headquarters Certifying Official.
- (10) Only Departmental elements or persons working under contract to Departmental elements shall consign the package for domestic transport.
- (11) Nuclear Regulatory Commission or Agreement State licensees shall not consign a DOE certified package for domestic transport but can transfer the material on-site to DOE elements or persons working under contract to DOE elements for consignment of the package.
- (12) Revision 1 of this certificate may be used until January 31, 2025.

(e) Supplements

- (1) *RE: DOE CoC 9341 BRR Package Renewal*, email, McBride, N. to Shenk, J., October 24, 2024