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**DOE Packaging Certification Program**

**Safety Evaluation Report for  
Certificate of Compliance No. 9228 Renewal and  
Amendment for the Model 2000 Package**

**Docket No. 19-02-9228**

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This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent document review of the consolidated Safety Analysis Report for Packaging (CSARP) submitted by the DOE Oak Ridge National Laboratory Site Office (OSO) for renewal and amendment of DOE Certificate of Compliance (CoC) Number 9228 for the Model 2000 Serial Number 2003 package design (a.k.a., GE-2000).

## Summary

By email <sup>[1]</sup> dated October 9, 2018, as supplemented <sup>[2, 3, 4]</sup> December 12, 2019, March 9, 2020, and June 4, 2020, the certificate holder, OSO, requested renewal and amendment of DOE CoC 9228 for the Model 2000 Serial Number 2003 package design as required by DOE Order 460.1D, *Hazardous Materials Packaging and Transportation Safety*, and in response to Condition 15 of DOE CoC Rev. 0, which requires a CSARP for renewal of the CoC.

The initial DOE CoC (Rev 0) was based on Nuclear Regulatory Commission (NRC) CoC No. 9228, Rev. 26, and its two Safety Analysis Reports (SARs): NEDO-31581<sup>[5]</sup> and NEDO-32229<sup>[6]</sup> and their supplements. The NRC CoC and its SARs include the DOE High Flux Isotope Reactor (HFIR) fuel configuration as authorized contents and many NRC-licensed material content configurations that are not applicable to DOE.

The Oak Ridge National Laboratory (ORNL) developed and submitted a CSARP as the safety basis document in support of this renewal and amendment of the DOE CoC, by extracting the relevant packaging, content configuration, and compliance evaluations related to the HFIR fuel configuration from the SARs and their supplements, and by adding a Quality Assurance (QA) chapter for the packaging specific QA requirements for the HFIR fuel configuration.

OSO did not request any changes to the package design, but the CSARP includes minor improvements to the operating procedures, acceptance tests, and maintenance program of the package to incorporate the current leakage test standard, ANSI N14.5-2014, *American National Standard For Radioactive Materials — Leakage Tests on Packages for Shipment*.

Based on the statements and representations in the final CSARP <sup>[8]</sup> and conditions listed in the following SER chapters, DOE PCP staff independently confirmed that the package design has been adequately described and evaluated in the CSARP for the HFIR fuel configuration. Therefore, staff has reasonable assurance that the regulatory requirements of Part 71 have been met and recommends renewal and amendment of the CoC by the DOE Headquarters Certifying Official.

## Evaluation

By email dated October 9, 2018, as supplemented December 12, 2019, March 9, 2020, and June 4, 2020, the certificate holder, OSO requested renewal and amendment of DOE CoC 9228 for the Model 2000 Serial Number 2003 package design as required by DOE Order 460.1D, and in response to Condition 15 of DOE CoC Rev. 0, which requires a CSARP for renewal of the CoC.

The initial DOE CoC (Rev 0) was based on Nuclear Regulatory Commission (NRC) CoC No. 9228, Rev. 26, and its two Safety Analysis Reports (SARs) and their supplements: NEDO-31581 and NEDO-32229 and their supplements. The NRC CoC and its SARs include the DOE High Flux Isotope Reactor (HFIR) fuel configuration as authorized contents and many NRC-licensed material content configurations that are not applicable to DOE.

The Oak Ridge National Laboratory (ORNL) developed and submitted a CSARP as the safety basis document in support of this renewal and amendment of the DOE CoC by extracting the relevant packaging, content configuration, and compliance evaluations related to the HFIR fuel configuration from the two SARs and supplements and by adding a Quality Assurance (QA) chapter for the packaging specific QA requirements for the HFIR fuel configuration.

OSO did not request any changes to the package design, but the CSARP does include minor improvements to the operating procedures and acceptance tests and maintenance program of the package to incorporate the current leakage test standard, ANSI N14.5-2014.

DOE PCP staff performed a document review of the CSARP by comparison with the SARs and their supplements to confirm that:

- The package description and evaluation for HFIR fuel configuration was consistent with respect to the NRC CoC approval and complete with respect to the current NRC Regulatory Guide 7.9 (RG 7.9), *Standard Format and Content of Part 71 Applications for Approval of Packages for Radioactive Material* and
- The new Quality Assurance (QA) Chapter for HFIR fuel configuration was consistent with respect to the NRC CoC approval and complete with respect to the current NRC Regulatory Guide 7.10 (RG 7.10), *Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material*.

ORNL submitted CSARP Chapters 1 and 9 for staff review on August 30, 2019. DOE PCP issued regulatory comments/questions (Qs) for clarification to OSO on November 12, 2019. OSO submitted proposed responses to the Qs on December 12, 2019, which were dispositioned by staff and accepted December 17, 2019, pending review of the response implementation in the full CSARP submittal.

ORNL submitted the full CSARP for staff review on February 17, 2020. DOE PCP issued a second round of regulatory Qs for clarification to OSO on May 5, 2020. OSO submitted proposed responses on June 8, 2020, which were dispositioned by staff and accepted on June 9, 2020, pending review of the response implementation in the final CSARP resubmittal.

The final CSARP was submitted by ORNL for staff review on June 11, 2020. Staff verified all the agreed-upon responses to Qs were accurately implemented in the final CSARP.

This SER documents the independent document review by DOE PCP staff to confirm the final CSARP contains the safety basis for NRC approval of the package design to the requirements of 10 CFR Part 71.

## **1.0 General Information**

Each Chapter of the CSARP begins with a table of the detailed change description and basis for implementing the HFIR fuel configuration information from the SARs and supplements or responses to DOE PCP staff's questions or comments for clarification.

The General Information Chapter of the CSARP includes background and certification history for the Model 2000 Serial Number 2003 package (a.k.a., GE-2000). Packaging serial number 2003 is owned by DOE and the certificate holder is OSO.

CSARP Chapter 1 is the packaging and content description for the HFIR fuel configuration extracted from NEDO-31581 and NEDO-32229 and their supplements (henceforth referred to as "SARs" in this SER, unless otherwise stated). There were no changes to the packaging design or contents for the HFIR fuel configuration.

DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 packaging for the HFIR fuel configuration was accurately implemented and complete, including ORNL's responses to staff's eight General Information questions or comments.

The Model 2000 is a Type B fissile, B(U)F-96, package designed for shipping radioactive and fissile materials in solid form, including byproduct, source, and special nuclear materials. The HFIR fuel configuration evaluated in the CSARP consists of one HFIR irradiated fuel assembly (inner and outer elements) in the HFIR Fuel Liner and Basket (Drawing GE105E9523 Rev. 501) per package. The weight of the HFIR fuel configuration is not to exceed 5,450 lbs. per package, including the weight of the fuel liner and basket.

The HFIR fuel assembly is composed of one inner fuel element, with up to 2628 grams U-235, and one outer fuel element, with up to 6872 grams U-235. The maximum uranium enrichment is 93.2 weight percent U-235. The maximum burnup per assembly is 2300 MWd and minimum cool time is two years. Decay heat is not to exceed 600 watts per package. The Criticality Safety Index (CSI) for the HFIR fuel configuration is 100.

CSARP Chapter 1, Appendix 1.4, includes new tables for the packaging component quality categories. These tables address the quality categories of all packaging components based their importance to safety. The information in tables is based on the packaging drawings, operating procedures, and maintenance program.

Based on a review of the statements and representations in the CSARP, DOE PCP staff concludes that the packaging and contents for the HFIR fuel configuration have been described in sufficient detail to provide an adequate basis for the package evaluation under 10 CFR Part 71.

## **2.0 Structural Evaluation**

CSARP Chapter 2 is essentially a verbatim copy of NEDO-32229, with minor editorial changes, corrections, and clarifications. There were no changes to the structural design or contents for the HFIR fuel configuration. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 structural evaluation for the HFIR fuel configuration was accurately implemented and complete in the CSAR Chapter 2 and its appendix, including ORNL's responses to staff's three Structural Evaluation questions or comments.

Based on review of the statements and representations in the CSARP, DOE PCP staff has reasonable assurance that the structural design for HFIR fuel configuration meets the requirements of 10 CFR Part 71.

## **3.0 Thermal Evaluation**

CSARP Chapter 3 is essentially a verbatim copy of NEDO-32229, with minor editorial changes, corrections, and clarifications. There were no changes to the thermal design or contents for the HFIR fuel configuration. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 thermal evaluation for the HFIR fuel configuration was accurately implemented and complete in the CSAR Chapter 3 and its appendix, including ORNL's responses to staff's two Thermal Evaluation questions or comments.

Based on review of the statements and representations in the CSARP, DOE PCP staff has reasonable assurance that the thermal design for the HFIR fuel configuration meets the requirements of 10 CFR Part 71.

## **4.0 Containment**

CSARP Chapter 4 is based on the text from NEDO-31581 with results from the thermal and containment evaluation from NEDO-32229, with minor editorial changes, corrections, and clarifications. There were no changes to the containment system design or contents for the HFIR fuel configuration. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 containment evaluation for the HFIR fuel configuration was accurately implemented and complete in the CSAR Chapter 4 and its appendix. There were no questions or comments from staff's review of CSARP Chapter 4 and its appendix.

The package containment system (i.e., boundary) is formed by the cask inner wall, the top and bottom forgings, vent and drain port plugs, cask seal inner ring, and lid.

The maximum normal operating pressure, 20.2 psia at temperature of 253F, and dry helium in the cask cavity are consistent with the CSARP Chapter 3, *Thermal Evaluation*, and NEDO-32229, for the HFIR fuel configuration.

CSARP Chapter 4 updated ANSI N14.5-1997 to -2014 in Sections 4.1.2, 4.2.3, 4.3.3, and 4.4. Reference to ANSI N14.5-1977 in CSARP Appendix 4.6.1 was not changed because it was the

standard of record when the package prototype tests were performed. The criteria for “leak tightness” is the same in both the -1997 and -2014 versions of the standard.

Based on review of the statements and representations in the CSARP, DOE PCP staff has reasonable assurance that the containment system design for the HFIR fuel configuration meets the requirements of 10 CFR Part 71.

## **5.0 Shielding Evaluation**

CSARP Chapter 5 is essentially a verbatim copy of NEDO-32229, with minor editorial changes, corrections, and clarifications. There were no changes to the shielding design or contents for the HFIR fuel configuration. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 shielding evaluation for the HFIR fuel configuration was accurately implemented and complete in the CSAR Chapter 5 and its appendix, including ORNL’s responses to staff’s four Shielding Evaluation questions or comments.

Based on CSARP Table 5-1, the calculated transport index exceeds 10, so the package must be shipped by exclusive use.

Based on review of the statements and representations in the CSARP, DOE PCP staff has reasonable assurance that the package shielding design for the HFIR fuel configuration meets the external radiation requirements of 10 CFR Part 71.

## **6.0 Criticality Evaluation**

CSARP Chapter 6 is essentially a verbatim copy of NEDO-32229, with minor editorial changes, corrections, and clarifications. There were no changes to the criticality design or contents for the HFIR fuel configuration. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 criticality evaluation for the HFIR fuel configuration was accurately implemented and complete in the CSAR Chapter 6 and its appendix, including ORNL’s responses to staff’s two Criticality Evaluation questions or comments.

Based on CSARP Section 6.1, the value for  $N = 0.5$ , so the calculated criticality safety index value (CSI) equals 100 ( $CSI = 50/N$ ); consequently, the package must be shipped by exclusive use.

Based on review of the statements and representations in the application, DOE PCP staff has reasonable assurance that the package nuclear criticality safety design for the HFIR fuel configuration has been adequately described and evaluated and that the package meets the sub-criticality requirements of 10 CFR Part 71.

## **7.0 Operating Procedures**

CSARP Chapter 7 is based on NEDO-31581, with minor editorial changes, corrections, improvements, and clarifications for the HFIR fuel configuration. There were no significant

changes to the package operating procedures for the HFIR fuel configuration. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 operations procedures for the HFIR fuel configuration was accurately implemented and complete in the CSAR Chapter 7. There were no questions or comments from staff's review of CSARP Chapter 7.

The detailed steps for the pre-shipment leakage rate test from the SAR were replaced in the CSAR with a requirement that the pre-shipment leakage rate test must be performed with a procedure developed by an American Society for Nondestructive Testing (ASNT) Level III examiner. This change is consistent with ANSI N14.5-2014, Section 8.8, *Quality Assurance*.

Based on review of the statements and representations in the CSAR, DOE PCP staff has reasonable assurance that the package operating procedures for the HFIR fuel configuration meet the requirements of 10 CFR Part 71 and that these procedures are adequate to assure the package will continue to be operated in a manner consistent with its evaluation for approval.

## **8.0 Acceptance Tests and Maintenance Program**

CSARP Chapter 8 is based on NEDO-31581, with minor editorial changes, corrections, improvements, and clarifications for the HFIR fuel configuration. There were no changes to the acceptance tests of the packaging for the HFIR fuel configuration, and no significant changes to the maintenance program. DOE PCP staff performed a document review by comparing the CSARP and SARs and supplements to verify the Model 2000 acceptance tests and maintenance program for the HFIR fuel configuration were accurately implemented and complete in the CSAR Chapter 8. There were no questions or comments from staff's review of CSARP Chapter 8.

The detailed steps for the pre-shipment leakage rate test from the SAR were replaced in the CSAR maintenance program section with a requirement that the pre-shipment leakage rate test must be performed with a procedure developed by an American Society for Nondestructive Testing (ASNT) Level III examiner. This change is consistent with ANSI N14.5-2014, Section 8.8, *Quality Assurance*.

Based on review of the statements and representations in the CSAR, DOE PCP staff has reasonable assurance that the packaging acceptance tests and maintenance program meet the requirements of 10 CFR Part 71 and are adequate to assure packaging performance during its service life.

## **9.0 QUALITY ASSURANCE**

The Model 2000, serial number 2003, was originally designed, constructed, and certified under the previous certificate holder's (General Electric) Subpart H Quality Assurance Program (QAP) approved by NRC.

Chapter 9 of the CSARP was developed to address package specific QAP requirements for DOE's use of the package. DOE PCP staff performed a document review by comparing the CSARP and SARs to verify the Model 2000 quality assurance program for the HFIR fuel configuration was accurately implemented and complete, including ORNL's responses to staff's five Quality Assurance questions or comments, with respect to the current NRC Regulatory Guide 7.10 (RG 7.10), *Establishing Quality Assurance Programs for Packaging used in Transport of Radioactive Material*, in the CSARP Chapter 9.

ORNL's 10 CFR 71 Subpart H Quality Assurance Program, *Packaging Quality Assurance Program Description Applicable to Type B or Fissile Packaging (PQPD)*, is approved by the DOE Headquarters Certifying Official ([https://rampac.energy.gov/docs/default-source/qa/approval\\_0012\\_r3.pdf](https://rampac.energy.gov/docs/default-source/qa/approval_0012_r3.pdf)).

CSARP Chapter 9 integrates the applicable quality assurance requirements from the SARs within the ORNL PQPD.

CSARP Table 9-2 correlates the RG 7.10 quality assurance categories (e.g., Q-Cat A, B, & C) for important-to-safety packaging components with ORNL's safety classifications for nuclear facilities (e.g., Safety Class, Safety Significant, & Defense-in-Depth). CSARP Chapter 1 Appendix 1.4 includes new tables to address the quality categories of all packaging components based their importance to safety.

Based on review of the statements and representations in the CSARP, DOE PCP staff has reasonable assurance that the package-specific requirements for the HFIR fuel configuration are consistent with their DOE approved PQPD, meet the requirements of 10 CFR 71 Subpart H, and are therefore adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

### Conditions of Approval

The following changes to the CoC are required to implement the modifications evaluated in this SER.

- Section 3, Block (2) – The safety basis document is the CSARP: *Safety Analysis Report for Packaging: GE-2000 HFIR Irradiated Fuel Element Transport*, ORNL/RRD/INT-161, Rev. 0, May 2020.
- Section 5(a)(2), Packaging Description – Add description of the containment system (missing from NRC & DOE CoCs): The containment system consists of the cask cavity shell, bottom forging with drain port plug; cask lid top forging with vent port plug; and cask lid seal inner O-rings. The cask lid seal is an aluminum retainer, placed between the cask body flange and lid, with four O-rings, two on each side of the retainer: the two inner rings are part of the containment system and the outer two rings are test seals.
- Section 5(a)(3), Drawings – Replace with Table 1 below:

**Table 1 - Packaging Design Drawings**

Drawing No.	Rev.	Title
GE129D4946	501	<i>Model 2000 Transport Container Assembly FMF Certification Drawing</i>
M-11494-OH-134	3	<i>GE 2000 Cask Packaging Nameplate</i>
105E9520	9	<i>Model 2000 Shipping Cask All S/Ns Except 2001</i>
105E9521	7	<i>Model 2000 Cask Overpack All S/N's Except S/N 2001</i>
GE105E9523	501	<i>HFIR Fuel Liner and Basket FMF Certification Drawing</i>

- Section 5(b)(1), Type and form of material – Replace with info below:
  - (i) Irradiated High Flux Isotope Reactor (HFIR) fuel assembly, positioned within the HFIR fuel basket and liner (Drawing GE105E9523). The HFIR fuel assembly is fabricated in accordance with Oak Ridge National Laboratory Drawings: *HFIR Fuel Inner Element*, M 11524 OH 101 D, Rev. 0, and *HFIR Fuel Outer Element*, M 11524 OH 102 D, Rev. 0.
- Section 5(b)(2), Maximum quantity of material per package – Replace with info below:
  - (i) Contents not to exceed 5,450 lbs., including the required HFIR fuel liner and basket.
  - (ii) One HFIR fuel assembly per package, limits as follows in Table 2:

**Table 2 – HFIR Fuel Assembly Limits**

<b>Item or assembly parameter</b>	<b>Maximum/(Minimum)</b>
Inner fuel element (unirradiated)	2628 grams U-235
Outer fuel element (unirradiated)	6872 grams U-235
Uranium enrichment (unirradiated)	93.2 wt. % U-235
Fuel assembly burnup	2300 MWd
Decay (cooling) time to shipment	2 years (minimum)
Decay heat	600 watts

- Section 5(c), CSI – Replace with: Criticality Safety Index (CSI): 100.
- Section 5(d), Conditions – Replace with:
  - (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 the Operating Procedures of Chapter 7 of the SARP, as supplemented, and the package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the SARP, as supplemented.
  - (2) The package shall be shipped in a vertical configuration.
  - (3) Air transport is prohibited.
  - (4) Only DOE or persons working under contract to DOE shall consign the package for shipment.
  - (5) NRC or Agreement State licensees shall not consign a DOE certified package for shipment, but can transfer the material on-site to DOE or persons working under contract to DOE, for consignment of the package.
  - (6) Revision 0 of this certificate may be used until August 31, 2021.
- Section 5(e), Supplements – Replace with: None.

## **Conclusion**

Based on the statements and representations contained in the CSARP and the conditions listed above, DOE PCP staff concludes that the package design has been adequately described and evaluated for the HFIR fuel configuration, and the Model 2000 package meets the requirements of 10 CFR Part 71.

## References

- [1] *Request for consolidation of DOE packaging certificate USA/9228/B(U)F-96* , Email James C. Barnard, Jr. to Shuler, October 9, 2018.
- [2] *ORNL GE-2000 SARP* , Email James C. Barnard, Jr. to Shuler, December 12, 2019, with attachment *GE-2000 SARP.pdf*.
- [3] *GE-2000 Consolidated SARP*, Email James C. Barnard, Jr. to Shuler, March 9, 2020.
- [4] *Certificate Number 9228*, Email James C. Barnard, Jr. to Shuler, June 4, 2020, with attachment *GE-2000 SARP.pdf*.
- [5] *Model 2000 Radioactive Material Transport Package Safety Analysis Report*, NEDO-31581, October 2000, GE Nuclear Energy, as supplemented (see NRC CoC 9228 Rev 26)
- [6] *Model 2000 Radioactive Material Transport Package, HFIR Fuel Basket and Liner Safety Analysis Report*, NEDO-32229, August 2000, GE Nuclear Energy.
- [7] *Safety Analysis Report for Packaging: GE-2000 HFIR Irradiated Fuel Element Transport Package*, ORNL/RRD/INT-161, Rev. 0, May 2020.