

**Safety Evaluation Report for  
ES-3100 SARP Amendment 4,  
Phase III Topics**

**Docket No. 13-03-9315**

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## SUMMARY

The National Nuclear Security Administration (NNSA), Office of Defense Nuclear Nonproliferation (NA-20) submitted a letter<sup>1</sup> dated June 12, 2012, requesting that the Department of Energy (DOE) issue an amendment to the Certificate of Compliance (CoC) Number 9315, Package Identification No. USA/9315/B(U)F-96 (DOE), for the Model ES-3100.

In this letter, NA-20 requested that DOE conduct the regulatory review in three phases. Phase I changed the <sup>233</sup>U concentration limit in oxide contents from 200 ppm to 0.006 g/gU. DOE approved this change in Revision 4 of the CoC on August 2, 2012. Phase II initially included two topics: 1) add bulk highly enriched uranium (HEU) oxide as an authorized content for air transport and 2) add uranium silicide as an authorized content for ground transport. Two additional topics originally scheduled for Phase III review were added to the Phase II review: 3) increase the amount of <sup>235</sup>U reactor fuel and 4) add the option of applying a radio frequency identification (RFID) system to the ES-3100. DOE approved these changes in Revision 5 of the CoC issued on January 24, 2013. Phase III review was interrupted by NNSA for several higher-priority dockets. NNSA requested a letter amendment for a one-time shipment of up to eleven (11) ES-3100 packages containing U-Mo (<sup>235</sup>U enrichment < 20%) powdered metal alloy for air transport. The Letter Amendment to Revision 5 of the CoC was approved on September 26, 2013, and then implemented in Revision 6 of the CoC, which was issued on November 19, 2013. Revision 6 of the CoC was the basis for Department of Transportation Competent Authority Certification issued for a one-time shipment from Republic of Korea to United States. NNSA further requested a review of 1) HEU metal or alloy turnings, fines or powders for ground and air transport, 2) using aluminum convenience cans for HEU metal or alloy, and 3) changing the revision level of Drawing M2E801580A043 from "0" to "A" to make the "vibration absorbing silicone can pad" optional, which was originally an item of the Phase III review. These topics are included in Revision 7 of the CoC, issued on February 7, 2014.

The topics of the Phase III review are listed below and evaluated in this Safety Evaluation Report (SER).

1. (a) Addition of Viton GLT-S as an optional O-ring material and (b) extension of the periodic leak-test requirement from one year to two years, only if the Viton GLT-S is used. This request includes using the container continuously over the 2 year period. The basis for this request is lifetime performance data on Viton material performed by Savannah River National Laboratory (SRNL) and discussed in the ES-3100 Safety Analysis Reports for Packaging (SARP).
2. Allowance for convenience cans with diameters larger than 4.25 inches, along with potential off-gassing materials in the ES-3100 containment vessel (CV). This condition requires that a void volume limit be established, and was supported by analyses.
3. Removal of the requirement to place empty convenience cans on top of the loaded cans (i.e., to allow empty convenience cans to be placed above or below the loaded cans). This change will allow operators to load the container in the most efficient manner for each loading.
4. Revision of the wording on use of convenience cans to allow for contents that cannot fit

into a convenience can to be placed in a bag (i.e., allow use of bag in lieu of convenience can).

DOE Packaging Certification Program (PCP) staff reviewed the ES-3100 SARP Rev. 0, Page Change 5<sup>2</sup> for the above Phase III topics and generated five Q1 questions on the nine chapters. The Applicant responded to all the questions and implemented the changes in Page Change 6.<sup>3</sup> The changes in Page Change 6 to the SARP were acceptable to DOE, except the request to extend the periodic leak test requirement from 1 year to 2 years. The technical basis for rejecting this request is addressed in Sections 2, 4, and 8 of this SER. The Applicant may subsequently submit a request to extend the periodic leak testing, with additional information, in Phase IV.

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation as summarized in this SER, PCP finds that the information presented in the SARP is acceptable, except as noted, and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met, with the following conditions in the CoC:

- In situations where empty convenience cans are shipped in the package, they may be placed either above or below the loaded cans.
- If closed convenience cans with an outer diameter greater than 4.25 inches are used, the user shall verify that at least 55 cubic inches of free or void volume exists inside the containment vessel to allow for gas expansion and off-gassing of material at temperatures associated with normal conditions of transport (NCT) or hypothetical accident conditions (HAC).
- The extension of the periodic leak test interval to 2 years is still under review and is not authorized.

## 1. GENERAL INFORMATION AND DRAWINGS

Detailed packaging descriptions, drawings and contents can be found in the SARP. The components of the packaging include a drum enhanced by impact-limiting and thermal-insulating materials, neutron-absorbing materials, and a CV inside the drum. The payload in the CV is contained in content containers and bags.

### Radiation Level and Transport Index

PCP staff has confirmed that the radiation transport index (TI) is below 5.8, which is less than 10, the TI limit specified in 10 CFR 71.47(a) for non-exclusive use shipment. The actual TI of the ES-3100 package will be determined by measurement prior to shipment.

### Criticality Safety Index

On the basis of the results of the criticality safety analysis presented in Chapter 6 of the SARP, the PCP staff has confirmed, using the procedure in 10 CFR 71.59(b), that the Criticality Safety Index (CSI) for the package is less than 3.2.

On the basis of the statements and representations in SARP Rev 0, Page Change 6, and the PCP staff's confirmatory evaluation, PCP finds that the general information and drawings of the

ES-3100 package are acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

Evaluations of design and performance of the package for safety and regulatory compliance in structural, thermal, containment, shielding, criticality safety, operating procedures, acceptance tests and maintenance, and quality assurance are given in the remaining sections of this SER.

## 2. STRUCTURAL

### 2.1 Discussion

PCP staff reviewed Chapter 2 of the ES-3100 SARP for the Phase III topics. PCP evaluated the adequacy of the structural design and performance of the package described in Chapter 2 of the SARP during NCT and HAC.

One topic (two parts) in the Phase III review is a request to “*Add Viton GLT-S as an optional O-ring material in addition to [ethylene propylene diene monomer] EPDM. Along with this request is an extension of the periodic leak test requirement from one year to two years, only if the Viton GLT-S is used. This request includes using the container continuously over the 2-year period. The basis for this request is lifetime performance data on Viton material performed by SRNL and discussed in the ES-3100 SARP.*”

### 2.2 Structural Evaluation

The use of Viton GLT-S O-rings does not change the structural performance of the package for packaging and transportation safety; however, the acceptance criterion for extended maintenance in Page Change 6 is not acceptable to PCP due to the differences in the closure design features. Regarding the issues of applicability of the SRNL test data for the ES-3100 CV, Page Change 6 (pg. 2-28, 2-40, and 4-6) states:

*O-rings are captured inside the containment vessel of the ES-3100 in a static face seal (axial) method as opposed to the conical (radial) mating surfaces of the 9975 containment vessel. Both designs (ES-3100 and 9975) use the same cross-sectional diameter and durometer O-rings. The half-dovetail O-ring groove design of the ES-3100 provides a nominal 18% compression when metal-to-metal contact of the body and lid is achieved at closure (Parker O-Ring Handbook, Design Chart 4-5). The basic design of the ES-3100 O-ring groove detail requires no stretching of the O-ring unlike the requirement of the conical sealing surfaces for the 9965, 9975, and 9977 containment vessels. Assuming the conical surfaces react like an industrial static seal, the nominal stretch required for this design will provide ~16 to 23% compression of the O-ring. As shown in SRNS-TR-2009-00259, Table 1, the percent compression of the 9975 O-ring may vary from 8 to 23.4% under various stretch, size, and gap conditions. Whereas, the ES-3100 design provides a range of 15 to 21% based on O-ring size and groove depth variations. Because the O-ring compressions are similar between designs and the O-ring compounds and sizes are comparable, the surveillance program data (See Sect. 2.2.2) should be applicable for Viton GLT-S O-ring use in the ES-3100 containment vessel.*

However, because of the difference in O-ring groove designs between the 9975 primary containment vessel (PCV) and the ES-3100 CV, the long-term lifetime data obtained from the 9975 PCV test fixtures are not sufficient for the requested extension of the periodic leakage rate test from 1 year to 2 years; therefore, test data are needed for the ES-3100 package. Page Change 6 (pg. 2-40) also states:

*Constant ambient temperature monitoring will be conducted by placing a temperature-indicating patch next to the O-ring flange on each containment vessel. The temperature range for this patch will be 88 to 138°C (190 to 280°F). When the temperature of an indicator is reached, the patch color will change to black (i.e., blackout temperature). For O-rings in service > 12 months (i.e., during the extended periodic maintenance interval), if the 93°C (200°F) patch on the containment vessel flange has turned black, then the O-rings must be replaced as discussed in Sect. 7.4.3. Therefore, for the ES-3100 package equipped with Viton O-rings and temperature monitoring, it should be acceptable to extend the periodic maintenance interval from 12 months to 2 years.*

PCP does not concur with this statement because the temperature-indicating patch does not provide continuous temperature monitoring and is not visible when placed next to the O-ring flange on the CV.

The other Phase III topics (i.e., the use of convenience cans with diameters larger than 4.25 inches along with potential off-gassing materials in the ES-3100 CV, the configuration change of loaded cans and empty cans, and the change of wording to allow the contents that cannot fit into a convenience can to be bagged only) do not affect the structural performance because the existing structural evaluation does not take credit for the convenience cans and plastic bags.

### 2.3 Conclusion

On the basis of the statements and representations in the SARP Rev. 0 Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the structural design and performance of the ES-3100 package are acceptable, and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71. Because of the lack of 2 years of specific leak testing data for this packaging, the 2 year extension for extended maintenance is denied.

## **3. THERMAL**

### 3.1 Discussion

PCP staff reviewed Chapter 3 of the ES-3100 SARP for the Phase III topics. PCP evaluated the adequacy of the thermal design and performance of the package described in Chapter 3 of the SARP during Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC).

### 3.2 Thermal Evaluation

PCP reviewed the thermal calculations and Viton GLT-S O-ring thermal specification and confirmed that the working temperature of the O-ring is within its allowable temperature limit. Also, the use of Viton GLT O-rings in the ES-3100 CV does not change the thermal performance of the package; therefore, it is acceptable to use these O-rings in the ES-3100.

Since there is no heat generated from empty convenience cans, placing the empty can above or below the loaded can does not change the thermal performance of this package. Thermal performance of the package does not take any credit for convenience cans; therefore, for contents that cannot fit into a convenience can, the use of a bag to confine the contents in lieu of a convenience can is acceptable.

In order to make allowance for convenience cans with diameters larger than 4.25 inches, along with potential off-gassing materials in the CV, a void volume minimum limit of 54.25 cubic inches (rounded to 55 cubic inches) in the CV has been established to make sure the system pressure does not exceed the design limit. PCP's confirmative calculation of CV pressures concurs with this limit reported in the SARP.

### 3.3 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the thermal design and performance of the ES-3100 package are acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **4. CONTAINMENT**

### 4.1 Discussion

PCP staff reviewed Chapter 4 of the ES-3100 SARP for the Phase III topics. PCP evaluated the adequacy of the containment design and performance of the package described in Chapter 4 of the SARP during NCT and HAC.

### 4.2 Containment Evaluation

#### Use of Viton GLT-S

The ES-3100 containment boundary consists of the CV body, lid assembly, and inner O-ring (Fig. 1.3 of the SARP). A summary of the containment boundary design and acceptance basis is given in Table 4.2 of the SARP. The CV O-rings (Drawings M2E801580A013 and M-801580-0013, Appendix 1.3.7) are manufactured from either ethylene propylene diene monomer (EPDM) in accordance with Equipment Specification SPC-M801580-0002 (Appendix 1.3.10) or a fluorocarbon elastomer (Viton GLT-S) in accordance with Equipment Specification SPC-M801580-0001 (Appendix 1.3.9). The SARP describes tests in which a full-scale prototype ES-3100 package with GLT-S O-rings was chilled to  $\leq -40^{\circ}\text{C}$  and subjected to an NCT drop test and the entire HAC test battery. The CV was leak tested and found to be leaktight. The SARP states that the continuous service temperature rating of the fluorocarbon elastomer O-rings in the ES-3100 containment vessel has been verified by similarity and actual compliance testing. PCP agrees with this assessment only for packaging and transportation safety; therefore, Viton GLT-S is an acceptable O-ring material in addition to EPDM.

#### Extended Maintenance

See Section 2.2 of this SER.

### 4.3 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the containment design and performance of the ES-3100 package are acceptable, except for extended maintenance, and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **5. SHIELDING**

### 5.1 Discussion

PCP staff reviewed Chapter 5 of the ES-3100 SARP for the Phase III topics. The staff evaluated the adequacy of the shielding design and performance of the package as described in Chapter 5 of the SARP during NCT and HAC.

### 5.2 Shielding Evaluation

The use of Viton GLT-S O-rings does not change the shielding performance of the ES-3100 package. The use of convenience cans with diameters larger than 4.25 inches along with potential off-gassing materials in the ES-3100 CV, the configuration change of loaded cans and empty cans, and the revised wording on use of convenience cans to allow for contents that cannot fit into a convenience can to be bagged only (no convenience can) do not affect shielding because the existing shielding evaluation does not take credit for the convenience cans and plastic bags.

### 5.3 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the shielding design and performance of the ES-3100 package are acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **6. CRITICALITY**

### 6.1 Discussion

PCP staff reviewed Chapter 6 of the ES-3100 SARP for the Phase III topics. PCP evaluated the adequacy of the criticality design and performance of the package as described in Chapter 6 of the SARP during NCT and HAC.

### 6.2 Criticality Evaluation

The use of Viton GLT-S O-rings does not change the criticality performance of the ES-3100 package. The criticality safety evaluation in the SARP does not take any credit for the presence of the convenience cans. PCP concurs that removal of the requirement to place empty convenience cans on top of the loaded cans does not have any criticality safety significance. PCP also concurs that revising the wording on the use of convenience cans in the SARP to allow for contents that cannot fit into a convenience can to be bagged only is an administrative change that does not have any criticality safety significance.

### 6.3 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the nuclear criticality safety design of the ES-3100 package is acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **7. PACKAGE OPERATIONS**

### 7.1 Discussion

PCP staff reviewed Chapter 7 of the ES-3100 SARP for the Phase III topics. There is no change required in Chapter 7 of the SARP for the Phase III topics.

### 7.3 Package Operations Evaluation

Since PCP rejected the Applicant's evaluation for extended maintenance, the use of temperature indicating labels on the CV is not required.

### 7.3 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the package operations of the ES-3100 package are acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **8. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM**

### 8.1 Discussion

PCP staff reviewed Chapter 8 of the ES-3100 SARP for the Phase III topics. There is no change required in Chapter 8 of the SARP for the Phase III topics.

### 8.2 Acceptance Test and Maintenance Program Evaluation

Since PCP rejected the Applicant's evaluation for extended maintenance, the references to extended maintenance in this Chapter of Page Change 6 (pp. 8-9 and 8-10) are not applicable.

### 8.2 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and the PCP staff's confirmatory evaluation, PCP finds that the acceptance tests and maintenance program of the ES-3100 package are acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **9. QUALITY ASSURANCE**

### 9.1 Discussion

PCP staff reviewed Chapter 9 of the ES-3100 SARP for the Phase III topics. There is no change required in Chapter 9 of the SARP for the Phase III topics.

## 9.2 Conclusion

On the basis of the statements and representations in SARP Rev 0, Page Change 6 and PCP staff's confirmatory evaluation, PCP finds that the quality assurance program of the ES-3100 package is acceptable and will provide reasonable assurance that the package meets the regulatory requirements of 10 CFR Part 71.

## **REFERENCES**

1. *Request for Amendment 4 of USA/9315/B(U)F-96(DOE)*, submitted to James M. Shuler, Manager of Packaging Certification Program, Office of Packaging and Transportation of Department of Energy, by the National Nuclear Security Administration (NNSA), Office of Defense Nuclear Nonproliferation (NA-20), June 12, 2012.
2. *Safety Analysis Report for Packaging for Model ES-3100 Package with Bulk HEU Contents*, SP-PKG-801940-A001, Rev. 0, Page Change 5, Babcock & Wilcox Technical Services Y-12, LLC, Y-12 National Security Complex, September 30, 2013
3. *Safety Analysis Report for Packaging for Model ES-3100 Package with Bulk HEU Contents*, SP-PKG-801940-A001, Rev. 0, Page Change 6, Babcock & Wilcox Technical Services Y-12, LLC, Y-12 National Security Complex, February 27, 2014