Safety Evaluation Report for Amendment to Department of Energy Certificate of Compliance 9315 for the Model ES-3100 Package Design for Numerous Changes in Revision 2 of the Safety Analysis Report for Packaging

Docket No. 17-36-9315

Prepared by: James M. Shuler Date: 1/9/18

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Approved by: Joanne D. Lorence Date: 01/09/2018

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Department of Energy
Washington, DC 20585

April 26, 2018

MEMORANDUM FOR WILLIAM E. KILMARTIN
DIRECTOR, MATERIAL DISPOSITION PROGRAM
OFFICE OF FISSILE MATERIALS DISPOSITION
NATIONAL NUCLEAR SECURITY ADMINISTRATION

FROM: JOANNE D. LORENCE
HEADQUARTERS CERTIFYING OFFICIAL
DIRECTOR
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SUBJECT: Safety Evalution Report Page Correction for Revision 14 of Department of Energy Certificate of Compliance Number 9315

It has come to my attention that there were several typographical errors on page 8 of the Safety Evaluation Report (SER) issued with Department of Energy (DOE) Certificate of Compliance (CoC) Number 9315, Revision 14, for the Model ES-3100 package. These errors do not effect the CoC or safety basis for issuing the CoC. Attached is a corrected SER Page 8. Changes are indicated by vertical bars in the right page margin.

If you have any questions, please contact me or Dr. James M. Shuler of my staff at (301) 903-5513.

Attachment

cc: Virginia Kay, NA-233
Jeff Arbital, Y-12
Yung Liu, ANL
James Shuler, EM-4.24

EM Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

DOE Packaging Certification Program

Safety Evaluation Report for Amendment to Department of Energy Certificate of Compliance 9315 for the Model ES-3100 Package Design for Numerous Changes in Revision 2 of the Safety Analysis Report for Packaging

(Corrected Page 8)

Docket No. 17-36-9315

Prepared by: James M. Shuler Date: 4/26/18

James M. Shuler
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Approved by: Joanne D. Lorence Date: 04/26/2018

Joanne D. Lorence
Headquarters Certifying Official
Director
Office of Packaging and Transportation

This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent technical review and confirmatory analysis of the application submitted by the National Nuclear Security Administration (NNSA) Office of Material Management and Minimization (NA-23) to amend DOE Certificate of Compliance (CoC) Number 9315, based on numerous changes in Revision 2 of the Safety Analysis Report for Packaging (SARP).

Summary

By letter [1] dated September 8, 2016 and revised [2] May 25, 2017, NNSA NA-23 requested that the DOE PCP authorize numerous changes to the Model ES-3100 package design in amendment to DOE CoC Number 9315.

The applicant (NA-23) submitted Revision 2 of the ES-3100 Safety Analysis Report for Packaging (SARP) [3] in support of this request. The changes do not affect the safety features of the packaging design or operational features.

On the basis of the statements and representations in the SARP, Revision 2, and PCP staff's confirmatory evaluation as summarized in this SER, staff finds changes to the Model ES-3100 package design acceptable, and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

This SER will hereafter refer to SARP Revision 2 as the "SARP" as, unless otherwise specified.

Evaluation

SARP Revision 1 was revised to implement the following changes:

1. Revise maintenance interval on ethylene propylene diene monomer (EPDM) O-rings from one to two years;
2. Remove fluorocarbon elastomer (Viton) O-rings from the CoC;
3. Revise the density range authorized for oxide from 2.0 - 6.54 g/cc to 0.5 - 6.54 g/cc;
4. Remove the carbon limit of 921 g for all oxide types;
5. Increase the allowable enrichment for the material category – highly enriched uranium (HEU), "HEU metal or alloy turnings fines or powder" to 100% for ground transport;
6. Add an oxide loading of 12.323 kg U-235 with a criticality safety index (CSI) of 0.4;
7. Remove the requirement to include the mass of non-uranium metallic constituent and claddings in the calculation of U-235 mass when shipping alloys and research reactor fuel; and
8. Update the shielding evaluation presented in Chapter 5 of the SARP using the MCNP Monte Carlo radiation transport code. This code is up-to-date and more supported. This update does not change any technical parameters associated with the HEU shielding calculations.

PCP assigned Docket 16-45-9315 to review these changes, which were implemented in Revision 2 of the SARP. The applicant subsequently requested PCP to prioritize review of the items and to first review item number 5 due to an immediate need for an international shipment of HEU metal turnings with an enrichment above 80%. Item 5 was completed under Docket 17-05-9315 and Revision 11 of the CoC was issued to authorize that content amendment for ground shipment (and later Docket 17-31-9315, Rev 12 of the CoC for air shipment).

The next set of priorities requested by the applicant was for items 3, 4, 6, 7, and 8; therefore, the scope of this SER is items 3, 4, 6, 7, and 8, but also includes item 2 under this docket (17-36-9315) for convenience. Item 1 is the applicant's final priority and will be reviewed by PCP staff at a later date.

1.0 General Information

1.1 Packaging Description

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 containment vessel (CV) inside the drum.

The applicant deleted Drawing M801580-0013, Revision 0, *Containment Vessel Viton O-ring Details* from the SARP to remove fluorocarbon elastomer (Viton) O-rings as an optional packaging component for the CV. The applicant revised the following additional drawings to update them for non-safety related changes.

Drawing No.	Revision	Title
M2E801580A037	G	Consolidated Assembly Drawing (3 sheets)
M2E801580A005	E	Misc. Details
M2E801580A011	G	Containment Vessel Assembly
M2E801580A023	E	Containment Vessel Leak Test Assemblies
M2E801580A043	B	Heavy Can Spacer Assembly (SST)

There are no additional changes to the existing Model ES-3100 packaging design or operational features authorized in the CoC.

1.2 Contents

Tables 1.3, 1.3a, and 1.3b in the SARP, which shows the authorized contents and fissile material loading limits for ground and air transport, have been updated for the content changes associated with the items 3, 4, 6, 7, and 8.

1.3 Criticality Safety Index

The CSI of the package ranges from 0 (zero) to 3.2, depending upon the radioactive contents (mass loading) of the package as shown in Tables 1.3, 1.3a, and 1.3b of the SARP. PCP staff confirmed the applicant's results, using the procedure in 10 CFR 71.59(b).

1.4 Radiation Level and Transport Index

PCP staff confirmed that the radiation transport indices (TIs) are less than 10, which is the TI limit in 10 CFR 71.47(a) for non-exclusive use shipment. The actual TI of the package will be determined by measurement prior to shipment.

1.5 Conclusion

Based on a review of the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff concludes that the package described in Chapter 1 of the SARP, has been adequately described in sufficient detail to provide an adequate basis for its evaluation under 10 CFR Part 71.

2.0 Structural Evaluation

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. These changes do not affect the structural evaluation.

2.1 Evaluation Findings

Based on review of the statements and representations in the SARP, and the PCP staff's confirmatory evaluation, staff finds the structural design and performance presented in Chapter 2 acceptable and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

3.0 Thermal Evaluation

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. These changes do not affect the thermal evaluation.

3.1 Evaluation Findings

Based on the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds the thermal design and performance presented in Chapter 3 acceptable and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

4.0 Containment

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. These changes do not affect the containment evaluation.

4.1 Evaluation Findings

Based on the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds the containment design and performance presented in Chapter 4 acceptable and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

5.0 Shielding Evaluation

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. Staff reviewed the updated shielding evaluation of the ES-3100 package as described in Chapter 5 of the SARP and the shielding calculations for shipment of up to 36 kg of HEU metal or 24 kg of HEU oxide in the ES-3100 package. Staff calculated the neutron and photon source terms using the ORIGEN of the SCALE 6.2.1 package and performed Monte Carlo analyses using MCNP5-1.6 to independently confirm the shielding calculations under both normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

5.1 Shielding Design

The ES-3100 package does not contain materials that are specifically for shielding gamma rays (photons) which are the primary contributor to the external package dose rates for the specified source configurations. For NCT and HAC shielding calculations, the packing materials inside the CV are conservatively are omitted from the models. It is assumed that the CV remains intact during HAC, but all the packaging materials external to the CV are removed (i.e., omitted). The geometry of the shielding analysis model is a conservative, cylindrical representation of the package.

5.2 Source Specification

The isotopic content used for the shielding calculations is shown in Table 5.3 of the SARP. The staff calculated the neutron and the photon source terms using the ORIGEN module of the Standardized Computer Analysis for Licensing Evaluation package (SCALE version 6.2.1) and the ENDF/B-VII.1 decay data.

The photon spectrum after 10.5 years of decay time provides the maximum dose rate. The principal photon emitter was confirmed to be Tl-208.

The neutron spectrum after 50 years of decay time provides the maximum neutron dose rates.

5.3 Shielding Model

The NCT and HAC calculations performed by the applicant were based on MCNP5 models of the ES-3100 package using the ENDF/B-VII.0 nuclear data library. The analyzed package contents are (a) 36 kg of HEU metal and (b) 24 kg of HEU oxide. The 36 kg of HEU metal analyzed are in the form of a solid cylinder, cylindrical shell, vertical plate, cylindrical

hemi-shell, single solid rod and cylindrical segment. The HEU metal in the form of a cylinder with the same radius as the CV is moved to the bottom and top of the CV for the maximum bottom and top dose rate configurations.

PCP staff concurred that the shielding analysis model in the SARP is conservative because no packing material except the radioactive contents are included in the model.

5.4 Shielding Analysis Results

MCNP5 was used for the shielding analyses in the SARP and the confirmatory evaluation by the staff. The cross section library used in the evaluations was based on ENDF/B-VII. ANSI/ANS-6.1.1-1977 Neutron and Gamma-Ray Flux-to-Dose-Rate Factors was used to calculate personnel doses. A comparison the applicant's (SARP) and PCP staff's calculated total dose rates for NCT and HAC are shown in Tables 5.1 and 5.2 below for 36kg of HEU Metal and 24kg of HEU Oxide per package.

Table 5.1 - Maximum Total Dose Rates Calculated for the ES-3100 Package with 36kg of HEU Metal under NCT and HAC

	Maximum Dose Location	SARP (mSv/h)	Staff (mSv/h)	10 CFR 71 Limits (mSv/h)
NCT	Side surface of the package	0.9738	1.0104	2
NCT	1 m from the side surface of the package	0.06121	0.06315	0.1
HAC	1 m from the side surface of the CV	0.12942	0.13476	10

Table 5.2 - Maximum Total Dose Rates Calculated for the ES-3100 Package 24kg of HEU Oxide under NCT and HAC

	Maximum Dose Location	SARP (mSv/h)	Staff (mSv/h)	10 CFR 71 Limits (mSv/h)
NCT	Side surface of the package	0.7987	0.8128	2
NCT	1 m from the side surface of the package	0.05024	0.05582	0.1
HAC	1 m from the side surface of the CV	0.10691	0.11983	10

5.5 Evaluation Findings

Based on the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds the shielding design and performed presented in Chapter 5 acceptable and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

6.0 Criticality Evaluation

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. PCP staff reviewed the criticality safety design and performance of the package described in Chapter 6 and Appendices 6.9.9 and 6.9.11 of the SARP. Staff also performed independent Monte Carlo confirmatory analyses for criticality safety under the most reactive conditions.

6.1 Criticality Evaluation

The Model ES-3100 package design includes a stainless steel CV inside a 30 gallon outer drum (See Figures 1.1 and 1.2 of the SARP). The contents are placed in convenience cans or bottles or otherwise protected to prevent contamination of the interior surface of the CV. The package includes two features intended for criticality control: a neutron absorber that surrounds the CV and can spacers placed between convenience cans; both the neutron absorber and the can spacers are filled with alumina borated cement. The SARP drawings provide the dimensions of the relevant packaging components. Chapter 2 of the SARP provides material specifications for the packaging components.

Descriptions of the package design features include identification of packaging materials, densities and compositions of packaging materials, and the fissile/fissionable material forms, masses, and isotopic compositions of the payloads. PCP staff confirmed that criticality-related information in the SARP is complete and representative of the actual materials specified for the package.

6.2 Contents

The contents of the ES-3100 package will be bulk HEU in the form of oxide (UO_2, UO_3, U_3O_8, U_3O_8-Al, UO_2-Mg and UO_2-ZrO_2), uranium metal and alloy in the form of solid geometric shapes or broken pieces, uranium compounds, uranyl nitrate crystals (UNX), fuel elements from TRIGA reactors, and research reactor fuel elements or fuel components. Content limits and special conditions (i.e., package loading limits) are listed Tables 1.3, 1.3a, and 1.3b of the SARP.

The following sections of the SER summarize and compare the applicant's and PCP staff's nuclear criticality calculation results for items 3, 4, 6, and 7.

6.2.1 Item 3: Revise the density range authorized for oxide <u>from</u> 2.0 - 6.54 g/cc <u>to</u> 0.5 - 6.54 g/cc

For any bulk density evaluated, down to 0.5g/cm^3, with dry and flooded CV, the $k_{eff} + 2\sigma$ is still below k_{safe}, the upper subcritical limit (USL). Table 6-1 below compares the applicant's $k_{eff} + 2\sigma$ listed in Table 6.9.11.12 of the SARP and PCP staff's confirmatory analyses for the reflected CV cases containing HEU oxide at a bulk densities of 1.75, 1.5, and 1.25 g/cm^3 at 100% enrichment for a flooded CV and moisture fraction inside the containment vessel (MOCFR) of 1.0.

Table 6-1 - SARP and Staff's Criticality Analysis Results for UO_2 at bulk densities of 1.75, 1.5 and 1.25 g/cm^3, reflected CV, flooded CV (MOCFR of 1.0)

UO_2 mass (g)	Maximum $k_{eff} + 2\sigma$ [a]					
	1.75 g/cm^3		1.50 g/cm^3		1.25 g/cm^3	
	SARP (SCALE 5.0)	Staff (MCNP5)	SARP (SCALE 5.0)	Staff (MCNP5)	SARP (SCALE 5.0)	Staff (MCNP5)
16000	0.9196	0.9169	[b]	[b]	[b]	[b]
14000	0.9152	0.9133	0.9154	0.9182	[b]	[b]
12000	0.9089	0.9079	0.9133	0.9129	0.9205	0.9165
10000	[c]	[c]	0.9066	0.9066	0.9109	0.9116
8000	[c]	[c]	[c]	[c]	0.9018	0.9032

[a] Upper subcritical limit (USL) k_{safe} value is 0.924
[b] Masses that would not fit inside the CV at that density.
[c] Additional calculations are not necessary

Table 6-2 below compares the applicant's $k_{eff} + 2\sigma$ listed in Table 6.9.11.14 of the SARP and staff's confirmatory analyses for the reflected CV cases containing HEU oxide at a bulk densities of 1.0, 0.75, and 0.5 g/cm^3 at 100% enrichment for a flooded CV (MOCFR of 1.0).

Table 6-2 - SARP and Staff's Criticality Analysis Results for UO_2 at bulk densities of 1.00, 0.75, and 0.50 g/cm^3, reflected CV, flooded CV (MOCFR of 1.0)

UO_2 mass (g)	Maximum $k_{eff} + 2\sigma$ [a]					
	1.00 g/cm^3		0.75 g/cm^3		0.50 g/cm^3	
	SARP (SCALE 5.0)	Staff (MCNP5)	SARP (SCALE 5.0)	Staff (MCNP5)	SARP (SCALE 5.0)	Staff (MCNP5)
9000	0.9124	0.9139	[b]	[b]	[b]	[b]
7000	0.9057	0.9028	0.9101	0.9092	[b]	[b]
5000	0.8846	0.8856	0.8979	0.8963	[b]	[b]
4000	[c]	[c]	0.8824	0.8827	0.8905	[c]
3500	[c]	[c]	[c]	[c]	0.8841	0.8820
3000	[c]	[c]	[c]	[c]	0.8759	0.8747

[a] Upper subcritical limit (USL) k_{safe} value is 0.924
[b] Masses that would not fit inside the CV at that density.
[c] Additional calculations are not necessary

6.2.2 Item 4: Remove the Carbon Limit of 921 g for all oxide types

Substituting carbon for oxide and adding carbon to a fixed amount of oxide results in a decrease of reactivity. The substitution of carbon for oxide results in the highest decrease in reactivity as opposed to adding carbon to a fixed amount of oxide.

Table 6-3 below shows the applicant's $k_{eff} + 2\sigma$ listed in Table 6.9.11.8 of the SARP and the staff's confirmatory analyses for a single-unit case for both NCT containing HEU oxide at a bulk density of 2 g/cm^3 mixed with 500g of polyethylene and with 0.0 and 5000g of carbon.

Table 6.3 - SARP and Staff's Criticality Analysis Results for UO_2 at a bulk density of 2 g/cm^3, reflected CV, 0.0 and 5000 g of Carbon, CV fully flooded

			Maximum $k_{eff} + 2\sigma$ [a]	
	Oxide (g)	Carbon (g)	SARP (SCALE 5.0)	Staff (MCNP5)
NCT	19000	0.0	0.8143	0.8131
	13000	0.0	0.8011	0.8030
	19000	5000	[b]	[b]
	14000	5000	0.7142	0.7145
	12000	5000	0.7048	0.7060
HAC	19000	0.0	0.8126	0.8138
	13000	0.0	0.8048	0.8023
	19000	5000	[b]	[b]
	13000	5000	0.7119	0.7136
	14000	5000	0.7066	0.7085

[a] Upper subcritical limit (USL) k_{safe} value is 0.924
[b] Masses that would not fit inside the CV at that density.

6.2.3 Item 6: Add an oxide loading of 12.323 kg U-235 with a CSI of 0.4

The mass limit for the HEU oxide content having a bulk density ≥2.0g/cm^3 is increased from 9,682g U-235 to 12,323g U-235 with a CSI = 0.4. Table 6-4 below shows the applicant's k_{eff} + 2σ listed in Table 6.9.9.8-4 of the SARP and the staff's confirmatory analyses for the 13×13×6 array of NCT packages and for the 9×9×4 HAC packages. These calculations support the assignment of a CSI=0.4.

Table 6.4 - SARP and Staff's Criticality Analysis Results for HEU oxide content for 13×13×6 array under NCT and the 9×9×4 array under HAC with an CSI=0.4

		Maximum $k_{eff} + 2\sigma$ [a]			
		NCT Array (13×13×6)		HAC Array (9×9×4)	
U-235 (g)	Oxide density (g/cm^3)	SARP (SCALE 5.0)	Staff (MCNP5)	SARP (SCALE 5.0)	Staff (MCNP5)
12,323	2.00	0.91539	0.91773	0.90474	0.89698
	3.00	0.85925	0.86131	0.85558	0.84494
	4.00	0.82279	0.82619	0.82142	0.81188
	5.00	0.80027	0.80201	0.79752	0.78954
	6.54	0.76954	0.77467	0.76848	0.76352

[a] Upper subcritical limit (USL) k_{safe} value is 0.924

6.2.4 Item 7: Cladding for broken metal

For a fully reflected and flooded CV, it was found that the most reactive cases are those with no cladding material either surrounding the broken metal or intermixed with the broken metal. Reactivity of the system decreases as the amount of cladding to the broken metal increases. This conclusion also applies to the cladding for U_3O_8-Al oxides of U-Zr and UO_2-Mg reactor fuel

elements and components and to the cladding for fuel pellets. Table 6-5 shows the applicant's $k_{eff} + 2\sigma$ listed in Table 6.9.11.20 of the SARP and the staff's confirmatory analyses for the reflected and flooded CV cases containing broken homogeneously mixed within the rectangular lattices formed by the unit cells of the small cubes.

Table 6.5 - SARP and Staff's Criticality Analysis Results for broken metal mixed with various amount of cladding with the CV fully reflected and flooded containing 27,743.2g U-235

	Maximum $k_{eff} + 2\sigma$ [a]	
Aluminum Clad Thickness (cm)	**SARP (SCALE 5.0)**	**Staff (MCNP5)**
0.0	0.84431	0.84555
0.0506	0.83728	0.83827
0.1016	0.82932	0.83045
0.1508	0.82152	0.82353
0.2032	0.81376	0.81404
0.2446	0.80727	0.80860

[a] Upper subcritical limit (USL) k_{safe} value is 0.924

6.3 Evaluation Findings

Based on the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds that the criticality safety design and performance presented in Chapter 6 acceptable, and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

7.0 Package Operations

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. These changes do not affect package operations.

7.1 Evaluation Findings

Based on the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds the package operations presented in Chapter 7 acceptable, and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

8.0 Acceptance Tests and Maintenance Program

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. These changes do not affect the acceptance tests and maintenance program.

8.1 Evaluation Findings

Based on the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds the acceptance tests and maintenance program presented in Chapter 8

acceptable, and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

9.0 Quality Assurance

PCP staff reviewed the SARP for changes requested by the applicant for items 2, 3, 4, 6, 7, and 8. These changes do not affect the quality assurance program.

9.1 Evaluation Findings

On the basis of the statements and representations in the SARP and PCP staff's confirmatory evaluation, staff finds the quality assurance program presented in Chapter 9 acceptable, and will provide reasonable assurance that the regulatory requirements in 10 CFR 71 have been met.

Conditions of Approval

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

- Section 5(a)(2) – revise "…The O rings are ethylene propylene diene monomer (EPDM) fabricated to ASTM D 2000, M3BA712A14B13F17. " to remove the reference to Viton GLT-S O-rings.
- Section 5(a)(3) – update the following drawings to their latest revision and delete M801580 0013.

Drawing No.	Revision	Title
M2E801580A037	G	Consolidated Assembly Drawing (3 sheets)
M2E801580A005	E	Misc. Details
M2E801580A011	G	Containment Vessel Assembly
M2E801580A023	E	Containment Vessel Leak Test Assemblies
M2E801580A043	B	Heavy Can Spacer Assembly (SST)
~~M801580 0013~~	~~0~~	~~Containment Vessel Viton O-ring Details~~

- Section 5(b) Weights and Content Description – remove the reference to the revision for M2E801580A043; it is addressed by Condition 15 of the certificate.
- Table 1.3 for Broken Metal – delete the reference to Table Note "g".
- Table 1.3 for HEU metal or alloy turnings, fines, or powders – delete the reference to Table Note "p".
- Table 1.3 for HEU Oxide – add CSI and loading limits for HEU oxide bulk densities from 0.5 to 6.54 g/cc and remove the carbon limit.
- Table 1.3 for Research reactor fuel elements and components:
    - UZrHx (TRIGA) & UZrHx (SNAP) – revise Table Note "i" to "l", and move footnote "k" to the 2nd column to the applicable contents: UZrHx (TRIGA) & UZrHx (SNAP), for clarity.

- U_3O_8-Al, Oxides of U-Zr, and UO_2-Mg – remove the carbon limit and add a content loading for 12.323 kg U-235 with CSI of 0.4, and
- U_3Si_2-Al – revise Table Note "o" to "n";

- Table 1.3 for Uranium compounds:
  - UF_4 – add a content loading for 24.0 kg UF_4, 18.136 kg U-235, and CSI of 2.0 (previously authorized by Letter Amendment dated 9/16/2016) and
  - U_3Si_2 – revise Table Note "o" to "n".
- Table 1.3 Notes – revise as follows:
  - g – If the mass of metal or alloy turnings, fines, or powders is ≤ 50 g, then it may be shipped as the parent form (e.g., broken metal, reactor fuel, etc.),
  - h – Seal time must be 12 months or less. Seal time is the length of time after the ES-3100 containment vessel is sealed that the shipment must be complete,
  - i – Allowable HEU oxide bulk densities are 0.5–6.54 g/cm^3 and the total mass of oxide in all cases is limited to 15.13 kg. Moisture content in oxide is limited to 3 wt. % water,
  - j – UO_2-Mg will be shipped in a glass bottle inside a metal convenience can under an inert cover gas,
  - k – For SNAP $UZrH_x$, $x \leq 2$. For TRIGA $UZrH_x$, $x \leq 1.6$,
  - l – Evaluation limit based on specific fuel type as opposed to a maximum calculated limit for $UZrH_x$,
  - m – Oxides of U-Zr are UO_2-Zr and UO_2-ZrO_2,
  - n – The maximum impurities in uranium silicide are shown in Table 1.2a. of the SARP and this certificate, and
  - o, p – delete.
- Table 1.3a Notes – revise as follows (for consistency with the SARP Table 1.3a. Notes):
  - e – add new Note "e" reference to the Loading Limits column, "Loading limits for uranyl nitrate crystals are based on hydrogen generation calculations presented in Appendix 3.5.4 of the SARP."
  - f – replace old Note "e", with "f" reference in the U Content column.
- Table 1.3b for all contents – revise the CSI reference from Table Note "g" to "d".
- Table 1.3b for HEU metal or alloy – delete Table Note reference "d".
- Table 1.3b for HEU metal or alloy turnings, fines, or powder – revise Table Note reference from "d, k" to "e".
- Table 1.3b for Research reactor fuel elements and components $UZrH_x$ and U-Zr – revise Table Notes "e" to "f" and "f" to "g" respectively.
- Table 1.3b Notes – revise as follows:
  - c – Add "… of the SARP and this certificate)."
  - d – CSI and spacer use are governed by ground transport mode,
  - e – If the mass of metal or alloy turnings, fines, or powders is ≤ 50 g, then it may be shipped as the parent form (e.g., broken metal, reactor fuel, etc.),
  - f – For SNAP $UZrH_x$, $x \leq 2$. For TRIGA $UZrH_x$, $x \leq 1.6$,
  - g – Oxides of U-Zr are UO_2-Zr and UO_2-ZrO_2,

  - h – Seal time must be 12 months or less. Seal time is the length of time after the ES-3100 containment vessel is sealed that the shipment must be complete,
  - i – Allowable uranium oxide bulk densities are 2.0–6.54 g/cm^3. Moisture content in oxide is limited to 3 wt. % water,
  - j – UO_2-Mg will be shipped in a glass bottle inside a metal convenience can under an inert cover gas, and
  - k – delete.
- Condition 5.(d)(12) revise to "… Chapter 9 of the SARP, Revision 1, as supplemented."
- Condition 5.(d)(13) revise to "For domestic shipments under this DOE certificate Revisions 10 and 11 may be used until June 30, 2018, and Revisions 12 and 13 may be used until December 31, 2018. For export or import use of the package under a Department of Transportation Competent Authority Certification (CAC), previous revisions of this certificate may continue to be used until their expiration date, unless otherwise specified in the CAC."
- Condition 5.(d)(14) revise to "…Periodic maintenance of the packaging shall be performed on a 1-year basis."
- Condition 5.(d)(19) revise to "HEU oxide with residual particles of metallic uranium (a.k.a., clinkers and screenings) and meeting the requirements of footnote "i" of Table 1.3 (for ground transport) and Table 1.3b (for air transport) of this certificate must be prepared for shipment in accordance with the authorized content and loading limits for "Broken HEU metal or alloy" in Table 1.3 (for ground transport) or Table 1.3b (for air transport) and Condition (4) of this certificate, and must be shipped within the seal time per footnote "h" of the aforementioned tables."
- Supplement 5.(e)(4) add for this application, "Revised Request for Amendment to ES-3100, Certificate of Compliance (CoC) USA/9315/B(U)F-96 (DOE), Revision 10, Docket 16-45-9315, Letter Kilmartin to Shuler, May 25, 2017."

Conclusion

On the basis of the statements and representations in the SARP, Revision 2, and PCP staff's confirmatory evaluation as summarized in this SER and the conditions listed above, staff finds changes to the Model ES-3100 package design acceptable, and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

References

[1] Request for Amendment to ES-3100 Certification of Compliance (CoC) USA/9315/B(U)F-96 (DOE), Revision 10, Docket No. 16-45-9315, from W. E. Kilmartin to James M. Shuler, September 8, 2016.

[2] Revised Request for Amendment to ES-3100, Certificate of Compliance (CoC) USA/9315/B(U)F-96 (DOE), Revision 10, Docket 16-45-9315, Letter Kilmartin to Shuler, May 25, 2017

[3] Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG-801940-A001 Revision 2, Consolidated Nuclear Security, LLC, September 8, 2016.