SAFETY EVALUATION REPORT

Docket No. 71-9196
Model No. UX-30 Package
Certificate of Compliance No. 9196
Revision No. 24

SUMMARY

By application dated October 22, 2007, as supplemented September 25, and December 16, 2008, and February 24, March 9 and 27, 2009, Energy*Solutions* requested a revision to Certificate of Compliance (CoC) No. 9196 for the Model No. UX-30 package. Energy*Solutions* requested the contents be revised to include reprocessed uranium in the form of uranium hexafluoride (UF_6) in greater than Type A quantity. To qualify as a Type B(U)F packaging, Energy*Solutions* updated the application to classify the UX-30 as a Category II package, and specified enhanced leak testing for cylinders containing a Type B quantity of UF_6 contents.

NRC staff reviewed the application using the guidance in NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Material." Based on the statements and representations in the application, the staff agrees that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

1.0 GENERAL INFORMATION

1.1 Packaging

The UX-30 is an overpack designed to protect a standard ANSI N14.1 30B or 30C cylinder. The UX-30 is a horizontal right circular cylinder, 96 inches long by 43.5 inches in diameter. The exposed surface of the UX-30 is constructed of American Society for Testing and Materials (ASTM) 304 stainless steel. The space separating the inner and outer overpack shells is filled with an energy-absorbing closed-cell polyurethane foam material. No changes have been requested to the design or materials of construction of the UX-30 packaging in this application.

1.2 Contents

The changes requested in this application are primarily related to the addition of reprocessed uranium in the form of UF_6 enriched to a maximum of 5 weight percent U-235, in a standard ANSI N14.1 30B or 30C cylinder. Reprocessed UF_6 consists of uranium isotopes, primarily U-235 and U-238 which have unlimited A_2 values, however, the content includes small amounts of U-232, U-234, and U-236 and unquantifiable traces of transuranics (mainly Np and Pu), and fission products, primarily Ce-144, Cs-134, Cs-137, Nb-95, Ru-106, Tc-99, and Zr-95, which may be in greater than Type A quantities. As a result, the application requests the package to be redesignated as Type B(U)F-96.

The UX-30 was previously evaluated against the 2004, 10 CFR Part 71, final rule, 69 FR 3698, for a “-96” designation in the package identification number. However, the package was limited to Type A contents at that time. In evaluating the package for a Type B designation, the

applicant did not include an evaluation of the package against the requirements of 10 CFR 71.61 “Special requirements for Type B packages containing more than 10^5 A_2.” As a result, the maximum quantity of material per package has been limited to no more than 10^5 A_2.

A previous revision to the CoC revised the contents to include both natural and depleted UF_6. In this revision of the certificate, the Criticality Safety Index (CSI) is revised to clarify that the CSI is not applicable to non-fissile or fissile-excepted UF_6.

2.0 STRUCTURAL

The staff reviewed the application to verify the structural performance of the package design, and to confirm that the package has adequate structural integrity to meet the requirements of 10 CFR Part 71. The review included Energy*Solutions* revision of Chapter 2 of the safety analysis report to identify the UX-30 as a Category II package. Two weld symbols on Drawing No. C110-B-57922-002, sheet 2 (zones B/7 and C/7) were corrected. Additionally, staff reviewed clarification of the welding codes, and qualification of welding procedures and weld inspectors for UX-30 packagings fabricated after March 31, 2009. There have been no changes to the materials used in the construction of the UX-30.

The staff noted that UX-30 was previously approved by the NRC under the provision of 10 CFR Part 71 as a Type AF-96 package. Full scale tests were conducted in 1984, 1995, and in 2001, on the UX-30 (with ANSI N14.1, 30B or 30C cylinder), to demonstrate compliance with the applicable requirements of 10 CFR Part 71. Per Section 1.2.1.1 of the updated safety analysis report, the total maximum gross weight shall not exceed 8,270 pounds (lbs), including up to 5,020 lbs of UF_6.

2.1 Material Specifications, Fabrication and Examination

All exposed surfaces of the UX-30 are fabricated from ASTM 304 stainless steel, precluding ordinary atmospheric corrosion. The possibility of stress corrosion cracking is minimal, as the UX-30 is not expected to see exposure to chloride containing environments at elevated temperatures. In addition, the stainless steel inner and outer surfaces of the UX-30 are inspected every 6 months.

The applicant specified that welding for UX-30 fabrication after March 31, 2009, is performed in accordance with ASME Section III, Subsection NF or Section VIII-Division I, as appropriate. Visual inspection of accessible welds is performed in accordance with ASME Section V with acceptance criteria in accordance with ASME Section III, Subsection NF-5000, within in 12 months prior to shipment.

The ball-lock pins are checked before each use, and the pins are checked for proper operation annually. The applicant specified that the ball-lock pins are made of precipitation hardening stainless steels that meet the requirements set by Aerospace Materials Specification (AMS) 5643 or AMS A5657.

2.2 Evaluation Findings

Based on review of the statements and representations in the application, staff concludes that the applicant has provided reasonable assurance that the changes will not alter the existing structural safety of the package. Staff concludes that the structural design has been adequately

described and evaluated and that the package has adequate structural integrity to meet the requirements of 10 CFR Part 71.

3.0 THERMAL

The staff reviewed the application to verify that the thermal performance of the package design has been adequately evaluated for the thermal tests specified under NCT and HAC, and that the package design meets the thermal performance requirements of 10 CFR Part 71. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 3 (Thermal Review) of NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

The staff determined that the thermal analyses of this application were not changed and were bounded by the previously approved contents.

Based on the review of the statements and representation in the application, the staff found reasonable assurance that the applicant has demonstrated that the revision request is bounded by previously approved contents under NCT and HAC. The staff concludes that the thermal design has been adequately described and evaluated, and that the thermal performance of the package meets the thermal requirements of 10 CFR Part 71.

4.0 CONTAINMENT

The staff reviewed the UX-30 packaging system containment design and analyses. The purpose of this review is to verify that the package design has been described and evaluated to satisfy the containment requirements of 10 CFR Part 71 under NCT and HAC.

The UX-30 packaging system is designed to provide a reliable container for transporting standard 30-inch cylinders of uranium hexafluoride (UF_6) with a U-235 isotope concentration of not more than 5 weight percent (wt%). The UX-30 package was previously approved by the NRC as a Type AF-96 package. Testing of the UX-30 packaging was performed to the 10 CFR Part 71 requirements for a Type AF package. Staff reviewed the tests and test acceptance criteria for a Type B(U)F UF_6 package and for a Type AF UF_6 package, and found that these tests demonstrate that the UX-30 design complies with 10 CFR Part 71 Type B(U)F requirements, regardless of their initial designation as Type AF.

The UX-30 package utilizes the 30-inch cylinder to provide containment for the UF_6 payload. The maximum quantity of material per package of the UX-30 with the 30B cylinder or the 30C cylinder shall be up to 5020 pounds of UF_6 with a U-235 isotope concentration of not more than 5 wt%. The 30C cylinder is identical in dimensions and configuration to the standard 30B cylinder specified by ANSI N14.1, except that it is fitted with a Valve Protective Cover (VPC) that bolts over and protects the cylinder valve during transport.

For reprocessed UF_6, the fission product gamma activity shall not exceed 4.4×10^5 MeV Bq/kgU and the transuranic Alpha Activity shall be less than $3.3E \times 10^3$ Bq/kgU. The maximum H/U atomic ratio for UF_6 is 0.088.

4.1 Description of Containment System

The design features of UX-30 transportation packaging system meet the containment requirements of 10 CFR Part 71 under NCT and HAC. The UX-30 transportation package is

designed for use in conjunction with a standard 30-inch UF_6 cylinder such as a 30B or 30C as described in ANSI N14.1 (Reference 4.6.1). The cylinder provides the containment boundary for the package.

The design pressure of the containment cylinder is 25 psig external and 200 psig internal. The design temperature of the containment cylinder ranges from -40°F to 250°F.

The 30B and 30C cylinders are penetrated in two places: the fill valve on one end and a drain plug on the other end. The 30C cylinder has the VPC to provide additional assurance against water intrusion into the cylinder in two ways; however, the VPC is not part of the containment boundary for the package.

The drop testing of the UX-30 from 4 feet and 30 feet followed by drop from 40 inches onto a steel post resulted in no damage to the cylinder and none to the cylinder valve. The drop test assures protection of the cylinder valve during the NCT and HAC. For the 30C cylinder, this was confirmed by the VPC successfully passing its post-test acceptance leak test of 1×10^{-5} std-cm^3/sec, and with no damage to the cylinder valve upon examination after the VPC was removed. The cylinder VPC is itself a barrier against water intrusion. This was demonstrated by conducting a hydrostatic test on the cylinder VPC to a high pressure of 400 psig, which resulted in no leakage.

Welds on the containment vessel are shown in Figure 1.2-2 of the safety analysis report for the 30B, and in Figure 1.2-3 for the 30C cylinder. Pipe thread seals are provided around the valve and drain plug threads.

The fill valve and drain plug are used as the closure devices on the cylinder. They shall be installed per ANSI N14.1 using 200 – 400 ft-lbs of torque. The valve shall have 7 – 12 threads engaged, and the plugs shall have 5 – 8 threads engaged.

4.2 Containment Under Normal Conditions of Transport

The UX-30 package contents consists of unirradiated uranium or reprocessed/recycled uranium in the form of UF_6, enriched to a maximum of 5 wt% U-235, in standard ANSI N14.1 30B or 30C cylinder. Recycled UF_6 consists of uranium isotopes, primarily U-235 and U-238 which have unlimited A_2 values. The contents includes small amounts of U-232, U-234, and U-236 and unquantifiable traces of transuranics (mainly Np and Pu), and fission products (primarily Ce-144, Cs-134, Cs-137, Nb-95, Ru-106, Tc-99, and Zr-95), which may be in greater than Type A quantities.

The maximum allowable leak rate for the UX-30 shipment is leaktight based on the methodology described in ANSI N14.5 – 1997 (Reference 4.6.2). To preclude water from leaking into the containment to prevent criticality, the cylinder must have a tested leak rate less than 1×10^{-7} cm^3/sec. The structural evaluation shows that the cylinders are capable of maintaining this condition under both NCT and HAC.

Containment for UX-30 package is provided by both 30B and 30C cylinders. The cylinders are filled with liquid UF_6, then cooled to solidify the contents prior to transport. The internal pressure of the cylinders under NCT is less than 11 psia.

The package shall undergo proper maintenance, periodic inspections, and pre-shipment inspections. For Type B contents, the cylinder shall have a measured leak rate less than

1 x 10^{-7} cm^3/sec with test sensitivity of 5 x 10^{-8} ref-cm^3/sec prior to the first shipment, after maintenance, repair or replacement of the containment system, and periodically within the 12 months prior to shipment. Pre-shipment leak tests shall show no detectable leakage when performed using a leak test with a sensitivity of at least 1 x 10^{-3} ref-cm^3/sec per ANSI N14.5 - 1997. Details of these tests are described in Section 4.4 below.

4.3 Containment Under Hypothetical Accident Conditions

For Type B contents, the package shall have a leak rate less than 1 x 10^{-7} cm^3/sec. The internal pressure of a cylinder, under hypothetical conditions is dependent on the temperature of the UF_6 in the cylinder. The thermal analysis shows that most of the UF_6 is at 117°F while a portion of the UF_6 is assumed to be 200°F or less. For the leak rate evaluation, the UF_6 temperature will be assumed to be 200°F. The resulting internal pressure is 51 psia.

4.4 Acceptance Tests, Maintenance Programs and Leakage Rate Tests

The applicant stated that the 30B cylinder is designed and manufactured per ANSI N14.1. The applicant also indicated that the acceptance tests performed for UX-30 package shall be in accordance with ANSI N 14.1.

The 30C cylinder is designed and manufactured in accordance with Addendum 2-2004 to ANSI N14.1. The acceptance tests are performed per Addendum 2-2004 to ANSI N14.1.

In addition to the acceptance tests for the 30B or 30C cylinder listed above, when the cylinders are used for UF_6 in a Type B quantity, the cylinder must have a leak rate less than 1 x 10^{-7} cm^3/sec. The acceptance leak test of the 30B or 30C cylinder used for contents in Type B quantity, shall be performed using Method A.5.4, Evacuated Envelope of ANSI N14.5 - 1997. The cylinder is evacuated to a 90% vacuum and then pressurized with helium to approximately 1 psig. The pressurized cylinder is placed in a sealed container connected to a helium mass spectrometer leak detector. The container is sealed and evacuated until the vacuum is sufficient to operate the helium mass spectrometer leak detector. The helium concentration in the container void is monitored for leakage. The acceptance criterion is 1 x 10^{7} atm-cm^3/sec of air. The detector sensitivity achieved shall be 5.0 x 10^{-8} atm-cm^3/sec.

Maintenance program for the 30B cylinders shall be in accordance with ANSI N14.1. For those 30 B cylinders manufactured in accordance with ANSI N14.1 and ISO 7195:1993(F) (Ref. 4.6.3), the maintenance program shall be in accordance with ANSI N14.1 and ISO 7195:1993(F).

Maintenance of the 30C cylinder shall be performed in accordance with Addendum 2-2004 to ANSI N14.1-2001.

For 30B or 30C cylinder used for transport of UF_6 in Type B quantities, the cylinder shall be tested to demonstrate a leak rate less than 1 x 10^{-7} cm^3/sec, within the 12 months prior to shipment. The acceptance leak test for 30B or 30C cylinder with UF_6 contents in a Type B quantity shall be performed using the method A.5.4 of ANSI N14.5 – 1997. The acceptance criterion is 1.0 x 10^{7} atm-cm^3/sec of air. The detector sensitivity must be less than or equal to 5.0 x 10^{-8} atm-cm^3/sec.

The staff reviewed the leakage tests for acceptance and maintenance and found them acceptable. These leak test requirements are included in the revised CoC, as appropriate.

4.5 Evaluation Findings

Based on the staff's review of the statements and representations in the application, the staff concludes that the containment design has been adequately described and evaluated and that the package design meets the containment requirements of 10 CFR Part 71.

4.6 References

4.6.1 ANSI N14.1 -2001 Addendum 1, "American National Standard for Nuclear Materials – Uranium Hexafluoride –Packaging for Transport," April 2002.

4.6.2 ANSI N14.5 – 1997, "American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment," ANSI, February 1998.

4.6.3 ISO-7195(F), "Nuclear Energy – Packaging of Uranium Hexafluoride (UF_6) for Transport," International Organization for Standardization, 1993.

5.0 SHIELDING EVALUATION

The staff reviewed the package design for shielding to verify that the changes made to the package design, as part of this amendment, meet the external radiation requirements of 10 CFR Part 71 under normal conditions of transport and hypothetical accident conditions.

As part of this revision, the applicant is proposing to add reprocessed UF_6 as authorized content, and is proposing to change the classification of the transportation package from Type AF to a Type B(U)F.

5.1 Description of Shielding Design

The UX-30 is an overpack designed to protect a standard ANSI N14.1 30B or 30C cylinder. The UX-30 is a horizontal right circular cylinder, 96 inches long by 43.5 inches in diameter. The exposed surface of the UX-30 is constructed of ASTM 304 stainless steel. The space separating the inner and outer overpack shells is filled with an energy-absorbing closed-cell polyurethane foam material.

The UX-30 is authorized to contain a 30-inch cylinder with 5020 lbs of UF_6. During transportation, UF_6 is transported as a solid with a density of 5.09 g/cc. This amendment request is being issued to allow proposed shipment of a Type B quantity which may result from the inclusion of recycled UF_6 contents. The reason for this is because recycled UF_6 has the potential for increased radioactivity over time while being contained within the 30B or 30C cylinders.

The gamma source from fission products is limited to 4.4×10^5 MeV Bq/kgU, per ASTM C996-04, "Standard Specification for Uranium Hexafluoride Enriched to Less Than 5% ^{235}U," published July 2004. The fission products are primarily Ce-144, Cs-134, Cs-137, Nb-95, Ru-103, Ru-106, Tc-99, and Zr-95. The gamma energy range of the nuclides listed range from 0.5 to 0.795 MeV. However, the gamma source in this evaluation was assumed to be at an energy of 1 MeV; having an activity of 6.789×10^8 photons/sec. This is conservative because the gammas being emitted are at higher energies than the actual UF_6 contents.

Neutrons can often be emitted from UF_6 cylinders carrying enriched or depleted uranium. However, the neutron source is not significant for recycled UF_6 quantities in the UX-30 transportation package.

The shielding model was generated using Microshield, a point-kernel calculational shielding code. The UF_6 in the UX-30 is transported as a solid inside of the 30-inch cylinder at a density of 5.09 g/cc. As part of the Microshield model, it is assumed that the UF_6 uniformly fills the cylinder at a volume of 2.77 g/cc. The density was conservatively reduced in the model to take less credit for any self absorption.

The cylinder cavity was modeled as 29 in x 76 in. For the NCT model, the UX-30 was modeled as a cylindrical stainless steel shell filled with polyurethane. The evaluation of the HAC conservatively ignored the overpack container as part of the model. This is conservative because the applicant assumed gammas being emitted were at 1 MeV, which was above the energy range specified in Chapter 5 of the safety analysis report.

5.2 Staff Evaluation

The methodology used by the applicant to evaluate the shielding aspects of the UX-30 transportation package was adequate. Since the primary concern involving the recycled UF_6 is gamma radiation, the use of Microshield point kernel code is adequate for calculating potential dose rates. The two conservatisms outlined in the safety analysis report are adequately applied. First, the gammas being emitted were assumed to be at 1 MeV. This is conservative because this assumes a higher energy than the range for primary radionuclides listed in the safety analysis report. Secondly, the shielding model used by the applicant assumed that the entire cylinder was uniformly filled with UF_6 having a density of 2.77 g/cc. This is conservative because it takes less credit for any self absorption from the UF_6. The dose rates calculated using Microshield were shown to be well below the limits found in 10 CFR Part 71.

Based on the review of the statements and representations in the application, the staff concludes that the package shielding design, with the proposed contents, meets the external radiation requirements of 10 CFR Part 71.

6.0 CRITICALITY EVALUATION

The staff reviewed the changes made to the package design and contents as part of this application, to verify that the package meets the criticality safety requirements of 10 CFR Part 71 under normal conditions of transport and hypothetical accident conditions.

6.1 Description of Criticality Design

Proposed authorized contents in the UX-30 include UF_6 with a maximum U-235 enrichment of 5.0 wt%. As covered in Revision 0 of the safety analysis report, criticality control is maintained by limiting absorption into the 30B and 30C UF_6 cylinders (H/U ratio) and maintaining the structural integrity of the cylinders (thermal protection, the VPC on the 30C cylinder, etc.).

6.2 Staff Evaluation

The criticality evaluation that was presented in Revision 0 of the safety analysis report is not changed in the applicant's revision. The criticality evaluation presented in the safety analysis report accounted for the possibility of damage to the cylinder valve, a concern with past performance of UF_6 cylinders.

The criticality evaluation outlines the criticality controls incorporated to preclude water in-leakage. In addition, a series of drop and thermal tests performed on the UX-30 overpack containing a 30-inch cylinder showed that the UX-30 provided adequate protection to the 30-inch cylinder.

Based on the review of the statements and representations in the application, the staff concludes that the package design with the proposed contents meets the subcriticality requirements of 10 CFR Part 71.

7.0 PACKAGE OPERATIONS

Staff reviewed the operating controls and procedures to determine if they are adequate to ensure the package will be operated in a manner consistent with the evaluation and requirement of 10 CFR Part 71. Chapter 7 of the safety analysis report includes instructions for loading, for receipt of the package, and preparation of an empty package for transport. Specific requirements for leak testing of cylinders containing a Type B quantity of UF_6 have been added to the loading instructions.

Based on the statements and representations in the application, the staff concludes that the operating procedures provide adequate measures and reasonable assurance for safe operation of the UX-30 package with a Type B quantity of UF_6 contents in accordance with 10 CFR Part 71. Compliance with Chapter 7 is a specific condition of the CoC No. 9196 for the UX-30.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The staff reviewed the revisions to Chapter 8 of the safety analysis report to verify that the revised acceptance tests for the packaging meet the requirements of 10 CFR Part 71.

To support this revision request, Sections 8.1 and 8.2 were revised to describe the requirements for acceptance testing and maintenance of the UF_6 cylinders with Type B quantity contents.

Based on the statements and representations in the application, the staff concludes that the revised acceptance tests for the packaging meet the requirements of 10 CFR Part 71. Further, the CoC is conditioned to specify that each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.

CONDITIONS

The following changes were made to the CoC:

Condition No. 1(d) was revised to reflect the updated package identification as a Type B(U)-96.

Condition No. 5(a)(3)(i) was updated to reflect the revised drawings submitted in this application, Energy*Solutions* Drawing No. C-110-B-57922-0002, sheets 1 through 3, Revision 4.

Condition No. 5(b)(1) was revised to add the details for reprocessed uranium as evaluated in this application to the authorized contents.

Condition No. 5(b)(2) was revised to limit the maximum activity in the package to 10^5 A_2.

Condition No. 5(c) was revised by the addition of a statement clarifying the applicability of the CSI to non-fissile and fissile-excepted UF_6.

Condition No. 9(d) was revised to specifically call out the ball-lock pins in the existing requirement to visually inspect all stainless steel components of the packaging prior to each shipment.

Condition No. 12 was added to allow the package to be marked with the previous package identification number, USA/9196/AF-96, until February 28, 2011. This is to allow time to replace the packaging nameplate showing the revised package identification number, USA/9196/B(U)F-96. However, any package transporting Type B quantities of UF_6 must be marked with the revised package identification number.

Condition No. 14 was updated to authorize use of the previous revision of the certificate for a period of approximately one year.

As a consequence of the inclusion of the new Condition No. 12, the previous Conditions No. 12 through 14 have been renumbered to Conditions No. 13 through 15.

CONCLUSION

Based on the statements and representations in the application, as supplemented, and the conditions listed above, the staff concludes that the Model No. UX-30 package design has been adequately described and evaluated and that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9196, Revision No. 24,
on April 14, 2009.