Safety Evaluation Report for the 10-160B Cask SAR Source Container Addendum

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Overview

This Safety Evaluation Report (SER) documents the technical review and analysis of the 10-160B Cask Consolidated Safety Analysis Report (SAR) Source Container Addendum, Docket # 11-36-9204, dated December 2011 [1], for compliance with 10 CFR Part 71 [2]. The Department of Energy (DOE) Packaging Certification Program (PCP) staff performed this review. The safety performance of the Argonne Source Container and Shoring, overpacked in the Model 10-160B Type B Radwaste Shipping Cask, with the intended contents, meets the applicable requirements of 10 CFR Part 71. The Addendum was prepared in the format of Nuclear Regulatory Commission (NRC) Proposed Revision 2 to Regulatory Guide 7.9 (May 1986) [3], rather than the current edition of NRC Regulation Guide 7.9, Revision 2 (March 2005), for consistency with the 10-160B SAR.

Background

The 10-160B is a reusable shipping package, designed to meet the applicable safety standards set forth in 10 CFR Part 71 and is used for transporting Type B fissile radioactive material and wastes in secondary containers.

This package design is certified by DOE, DOE Certificate # 9204 (Rev 2), Package ID Number USA/9204/B(U)F-96 (DOE). The safety basis for DOE certification is the SAR. [4]

This SAR Source Container Addendum provides the safety analysis to support a revision to DOE Certificate, #9204 for a one-time shipment from the Argonne National Laboratory (ANL) to the Nevada National Security Site (NNSS) for disposal. The radioactive contents are normal-form Co-60 and Ra-226 radioactive sources packaged in the Argonne Source Container Assembly. Only the source container and contents will be disposed at NNSS.

The DOE PCP has concluded the 10-160B package with the contents described in the Addendum meets the applicable safety standards set forth in 10 CFR Part 71. DOE PCP staff reviews of each Addendum chapter are documented below.

Regulatory Changes

The applicable safety standards for the 10-160B and the Addendum documents are the same, since both documents were prepared and evaluated for compliance to the "-96"regulations [2]. No further discussion is necessary.

The DOE PCP review for compliance with 10 CFR Part 71 was aided by consulting the US NRC Regulatory Guide 7.9, the Packaging Review Guide [5], and NUREG/CR-6407 [6].

1. General Information Review

The DOE PCP Staff performed a review and evaluation of the General Information in Chapter 1 of the Addendum for compliance with 10 CFR Part 71, and focused on the ANL Source Container, shoring, and contents in the 10-160B.

1.1 Areas of Review

The areas of review were limited to the information presented in the Addendum, Chapter 1, related texts, references, and drawings.

1.2 Review Procedures

Section 1, General Information, of the Addendum supplements Rev 3, of the SAR. No changes were made to the SAR. The Addendum addresses, ANL Source Container Assembly, Shoring, and the ANL contents (Cobalt-60 and Radium-226 sources), and how these contents affect the SAR analysis.

The purpose of the Applicant's submittal is clearly stated in the accompanying transmittal letter, that is, the ANL Source Container and Sources are proposed as authorized contents in the 10-160B.

The ANL Source Container is adequately described in Section 1.2.1 of the Addendum. A detailed description of the ANL Source Container structure and components is provided in Section 1.2.1. of the Addendum and is consistent with the drawings provided in Appendix 1.4 and the analyses contained within the Addendum. The shield container incorporates multiple vents to provide a large diffusion path for hydrogen to the 10-160B cavity. Large hydrogen diffusion paths like these are not a typical feature on lead shield containers. A detailed review of this feature is documented in Section 3 of this SER.

There are no special operational features of the ANL Source Container. The shoring is essential to the positioning of the ANL Source container within the 10-160B for transportation safety.

The radioactive contents and form (i.e., normal form solids) are adequately described in Section 1.2.3.1 of the Addendum. The radioactive material consists of Co-60 and Ra-226 sources with a maximum of 4030 curies of Co-60 and a maximum of 3.49 Ci of Radium 226. There are no fissile material constituents in the contents. The physical form of the material is described as dry normal for solids. The Co-60 sources are activated cobalt metal, enclosed in stainless steel and/or aluminum. No details are provided as to size or shape of the material, or the thickness of the sheathing. The radium-beryllium sources are described as $RaBr_2$ salt, mixed with metal beryllium powder, in a brass capsule sealed with soft solder. The chemical form of other sources described includes radium salts such as $RaBr_2$, $RaCl_2$, $RaSO_4$, which are sealed inside stainless steel, brass, monel or nickel tubes and sealed by welding, brazing or soft soldering, or in flame sealed glass vials. None of the sources are specified as special form and no credit for these tubes is taken in the Addendum analyses.

The bounding organic material within the ANL Source Container is specified as 5% of the maximum content mass of 7,500g. Addendum reference 3-4 calculates the resulting pressure and time required to produce a flammable gas mixture, assuming radiolysis of this material. Radiolysis of moisture is assumed to be insignificant in the Addendum

The SAR Addendum includes two new drawings, which are listed in Table 1 below.

Table 1- LIST OF SAR ADDENDUM DRAWINGS FOR SOURCE CONTAINER

Drawing	Sheet(s)	Rev.	Title
C-038-349097-001	3	1	ANL Source Container Assembly and Details
C-038-349097-005	1	0	ANL Shielded Source Container Shoring

1.3 Findings

Based on review of the statements and drawings given in the application, DOE PCP concludes the addition of the ANL Source Container, Shoring, and contents has no impact on the safety performance of the 10-160B shipping cask.

1.4 Conditions of Approval

The following conditions of approval are applicable to the 10-160B shipping cask, with the ANL Source Container contents:

- Maximum weight of the ANL Source Container, Shoring, and contents shall not exceed 14,500 lb. The maximum weight of the ANL Source Container, with contents, is 12,500 lb.
- Maximum normal operating pressure of (MNOP) of the ANL Source Container is the same as the 10-160B, which is 8.4 psig.
- Maximum quantity of radioactive material per package: 4030 Ci of Co-60 and 3.49 Ci of Ra-226 (as radium- beryllium sources) contained in a source container specified in Drawing C-038-349097-001.
- Radioactive sources in the source container have a maximum mass of 7.5 kg with not more than 5% by weight of organic material.
- The total decay heat shall not exceed 100 watts
- CSI = 0 (same as SAR)
- The Shoring design, fabricated and inspected per the drawing, is required for shipping the ANL Source Container in the 10-160B.

2. Structural Review

The DOE PCP Staff performed a review and evaluation of the Structural requirements in Chapter 2 of the Addendum for compliance with 10 CFR Part 71 and focused on the ANL Source Container, shoring, and contents in the 10-160B.

2.1 Areas of Review

Chapter 2 presented the structural impact evaluation of the ANL Source Container and Shoring on the 10-160B shipping cask during normal conditions of transport (NCT) and hypothetical accident conditions (HAC). Inputs from the existing SAR analysis were accepted as valid based on previous NRC review and were not part of the scope of this review.

The ANL Source Container design consists of a nested pair of shielded containers with the inner container composed of carbon steel encapsulated lead (gamma), and the outer container composed of carbon steel encapsulated SWX-237 neutron shield material. The ANL Source Container is held within the center of the 10-160 cavity by Shoring described in drawing C-038-349097-005.

The design criteria for the ANL Source Container included a combination of Regulatory Guide 7.6 [7], and ASME, Appendix F.

Although the Packaging Review Guide recommends shield components be fabricated in accordance with ASME Boiler & Pressure Vessel Code (ASME), Section VIII Division I or Section III, Division I, Subsection NF, the applicant selected the following alternate codes: ASTM materials were used for cost considerations, given that the ANL Source Container is a one-time use disposal. Most of the structure of the ANL Source Container Assembly consists of ASTM A516 Grade 70 carbon steel with a portion of the outer neutron shield composed of ASTM A53 Grade B carbon steel, and bolting is to SAE J429 specifications for both the inner and outer source container.

Non-destructive examination of welds was performed on the 10-160B to the requirements of ASME Section III, Division 1, Subsection NF-5000.

The ANL Source Container was evaluated to NCT and HAC by analysis only as detailed in Reference 2-4 of the Addendum.

The 10-160B MNOP remains unchanged by the addition of the ANL Source Container and shoring. Vents incorporated into the ANL Source Container equalize pressure within the 10-160B cavity, as well providing a diffusion path to prevent the accumulation of hydrogen in any gas space.

2.2 Review Procedures

The structural evaluation of the ANL Source Container used the peak g-loading from the 10-160B SAR in the end, side, and corner drop scenarios to evaluate worst case loads in Source Container components under HAC conditions. Simple ratios were used to demonstrate that comparable loads under NCT drop conditions are well within the lower allowable stresses for NCT conditions. Proper load combinations were also used in comparing to HAC allowable stresses. Stresses from punctures are not considered in the Source Container accident analysis because of protection provided by the 10-160B body.

The Shoring provides a path for inertial loads from the Source Container to the 10-160B structure. In a side drop, this inertial load is transferred to the 10-160B structure through a series of nine (minimum), one inch thick plywood disks. To show that these discrete load paths would not adversely affect the SAR analysis, the applicant performed a finite element analysis of the 10-160B inner shell as part of a sensitivity study. This ANSYS model analyzed two different loading conditions. In the first condition, a bounding 10-160B payload mass of the 14,500 lb. is distributed on the lower portion of the shell, uniformly along the length of the inner shell, and sinusoidally along the circumference of the shell. In the second condition, a 10-160B payload mass of 12,000 lb. is broken up with 11,000 lbs. distributed over the center 48-inches of cask wall and 1,000 lb. distributed over the remaining cask wall. Although the sensitivity study did not model the actual load path distribution, it demonstrated that the membrane stress intensity was more sensitive to total payload mass than the concentrated load case examined.

A lead slump analysis of inner gamma shield was performed in Addendum Reference 2-4, Section 6.4.1. The gamma shield contains a center hat which protrudes 2-inches above the main lid plate to provide shielding for the streaming path along the inner shell. The DOE PCP staff review determined that deformation of the gamma shield lid in Addendum, Reference 2-4; Section 6.2.2 (page 12) was incorrect based on the method used. However, the PCP staff performed a confirmatory calculation [8] and determined that the lid deformation in a top down drop is bounded by ½-inch.

Vibration loads are expected to be well bounded by inertia loads from the drop impact analysis. However, vibration could rotate the gamma shield in the ANL Source Container with respect to the neutron shield, resulting in misalignment of the vent path from the configuration shown on the drawings. This possibility is addressed in Section 3 of the SER.

2.3 Findings

Based on review of the statements and representations given in Chapter 2 of the 10-160B Addendum, the Staff concludes that the addition of the Source Container and contents has no impact on the safety performance of 10-160B shipping cask and that the requirements of 10 CFR 71 for NCT and HAC are satisfied.

2.4 Conditions of Approval

Approval of this application does not require special structural conditions in the CoC.

3. Thermal Review

The DOE PCP staff performed a review and evaluation of the Thermal requirements in Chapter 3 of the Addendum for compliance with 10 CFR Part 71, and focused on the ANL Source Container, Shoring, and contents in the 10-160B.

3.1 Areas of Review

The thermal analysis of Chapter 3 included the ANL Source Container, Shoring, and contents in the 10-160B.

3.2 Review Procedure

The radioactive content in the ANL Source Container generates less than 70 watts of total heat load. The Addendum uses 100 watts as the decay heat load in the thermal analysis. This heat load is bounded by the 200 Watt heat load limit of the 10-160B cask.

The thermal analyses of the ANL source container for the NCT and HAC fire test was performed using 2-d axisymmetric models that represent the gamma-source container accurately and neutron-shield container conservatively.

The amount of hydrogen generated in the ANL Source Container and the 10-160B was found to be less than 5% with a shipping window of more than 160 days. Since this shipping window is larger than the shipping window in the SAR (60 days), no change to the shipping window is required.

As noted in Section 2.3 of this SER, the possibility exists that vibration may cause the inner shield to rotate with respect to the outer shield container, resulting in a misalignment of the vent paths. The PCP staff does not consider this scenario significantly affect package safety for the following reasons:

a. Hydrogen from the encapsulated contents is extremely unlikely,
b. The vent path diffusivity assumption in Addendum, Reference 3-4 is very conservative, and
c. Rotation of the inner shield with respect to the outer shield is unlikely given weight of the containers involved.

3.3 Findings

Based on review of the statements and thermal models and results presented in Chapter 3 of the Addendum, DOE PCP concludes that the addition of the Source Container, Shoring and contents, has no impact on the safety performance of 10-160B, and that the requirements of 10 CFR 71 for NCT and HAC are satisfied.

3.4 Conditions of Approval

The maximum total heat load for the contents of the ANL Source Container is 100W. The shipping window is 60 days (based on the SAR).

4. Containment Review

The DOE PCP staff performed a review and evaluation of the Containment requirements in Chapter 4 of the Addendum for compliance with 10 CFR Part 71, and focused on the ANL Source Container, Shoring, and contents in the 10-160B.

4.1 Areas of Review

The review of Chapter 4 included the addition of the ANL Source Container, Shoring, and the radioactive contents.

4.2 Review Procedures

There is no need to specify review procedures for the current review.

4.3 Findings

Based on review of the statements and representations given in Chapter 4 of the Addendum, DOE PCP concludes that the addition of the ANL Source Container, Shoring, and contents has no impact on the safety performance of 10-160B and that the requirements of 10 CFR 71 for NCT and HAC are satisfied.

The A_2 value of ANL Source Container radioactive contents is <500, which is much less than the A_2 value used in the containment evaluation (i.e., 3000) of the 10-160B. Therefore, the applicant did not perform a containment analysis in the Addendum.

4.4 Conditions of Approval

The ANL Source Container does not include a containment system.

5. Shielding Review

The DOE PCP staff performed a review and evaluation of the Shielding requirements in Chapter 5 of the Addendum for compliance with 10 CFR Part 71, and focused on the ANL Source Container, Shoring, and contents in the 10-160B.

5.1 Areas of Review

The shielding analysis focused a one-time shipment, for disposal, of normal-form Co-60 and Ra-226 radioactive sources in the Argonne Source Container Assembly.

5.2 Review Procedures

There is no need to specify review procedures for the current review.

5.3 Findings

Based on review of the statements and evaluations presented in Chapter 5 of the Addendum, DOE PC concludes that the evaluation of the normal-form Co-60 and Ra-226 radioactive sources in the Argonne Source Container Assembly has been described adequately and conservatively and has no impact on the safety performance of 10-160B. The dose rate requirements of 10 CFR 71 for exclusive use transport and HAC are satisfied.

5.4 Conditions of Approval

The Certificate of Compliance (CoC) shall limit the quantities to the normal-form Co-60 and Ra-226 radioactive sources in the Argonne Source Container Assembly as identified and limited in Chapter 1 of the Addendum.

The 10-160B with the contents described in the Addendum may be shipped under exclusive use conditions.

6. Criticality Review

Since there is no fissile material in the contents addressed by this addendum, a review and evaluation of the Chapter 6 of the Addendum is not applicable.

7. Package Operations Review

The DOE PCP staff performed a review and evaluation of the Operating Procedure Requirements in Chapter 7 the Addendum for compliance with 10 CFR Part 71, and focused on the ANL Source Container, Shoring, and contents in the 10-160B.

7.1 Areas of Review

The review of Chapter 7 focused on the operating procedures for loading ANL contents into the Source Container and the loading and unloading the Source Container into the 10-160B shipping cask.

7.2 Review Procedures

There is no need to specify review procedures for the current review.

7.3 Findings

Based on the review of the statements and representations presented in the SAR Addendum, DOE PCP concludes that 10-160B operating procedures meet the requirements of 10 CFR 71 and that the procedures are adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

7.4 Conditions of Approval

The procedural steps for operating the 10-160B are specified in Chapter 7 of the SAR and shall be incorporated in their entirety into the CoC as a condition of package approval. In addition, the procedure for loading the ANL Source Container is specified in Section 7.1 of the Addendum. Finally, the Shoring shall be fabricated and inspected per the Drawing specified in Chapter 1 of the Addendum.

8. Acceptance Tests and Maintenance Program Review

The DOE PCP Staff performed a review and evaluation of the Acceptance Tests and Maintenance requirements in Chapter 8 the Addendum for compliance with 10 CFR Part 71, and focused on the ANL Source Container, shoring, and contents in the 10-160B.

8.1 Areas of Review

The review focused on the acceptance tests for the ANL Source Container prior to first use and the maintenance program requirements. There are no changes to the acceptance test or maintenance instruction found in Chapter 8 of the SAR for the 10-160B.

8.2 Review Procedures

There is no need to specify review procedures for the current review.

8.3 Findings

Based on the DOE PCP Staff's review of the statements and representations given in the application, DOE PCP concludes that the Acceptance Tests for the ANL Source Container and contents meet the requirements of 10 CFR 71. Since the ANL Source Container is a single-use disposal container, there are no routine or periodic maintenance activities.

DOE PCP also concludes that the information provided Section 8.1 of the Addendum for the Acceptance Tests is adequate.

8.4 Conditions of Approval

The Acceptance Tests requirements of Section 8.1 of the Addendum shall be incorporated into the CoC as a condition of package approval with respect to the shipment of the ANL Source Container and the contents specified in Section 1.2.3.1 of the Addendum, in the 10-160B.

9.0 Quality Assurance Review

The DOE PCP staff performed a review and evaluation of the Quality Assurance (QA) requirements in Chapter 9 the Addendum [9-1] for compliance with 10 CFR 71 Subpart H [9-2], and focused on the ANL Source Container, Shoring, and contents in the 10-160B.

9.1 Area Reviewed

The focus areas of the PCP review were Chapter 9 of the Addendum, the ANL Source Container and Shoring drawings, select fabrication, inspection, testing, and implementing procedures.

9.2 Review Procedures

The applicant, Energy*Solutions*, LLC (ES) QA program responsibilities, documentation, and approvals were adequately identified in the SAR Addendum. The ES Quality Assurance Program (QAP) is described in Chapter 9, Appendix 9.0A. The ES QAP is based on the requirements provided in ASME NQA-1, and 10 CFR 830 Subpart A. Chapter 9 of the SAR Addendum also meets the requirements of, and is organized in accordance with the 18 criteria of 10 CFR 71, Subpart H, as presented in Sections 9.3.1 through 9.3.18. In addition, ES has a NRC approved QAP for radioactive material packages, approval number 0935 (Docket No. 71-0935), authorizing it to design, procure, fabricate, assemble, test, modify, maintain, repair and use radioactive material transportation packaging systems. All activities conducted by ES regarding radioactive material transportation packaging are executed in full compliance with 10 CFR 71, Subpart H.

For this one-time shipment of sources from the ANL to the NNSS in the 10-160B, ANL contracted with ES to provide the packaging, including the design and fabrication of the ANL Source Container and Shoring, the development of the SAR Addendum, and technical and logistics services for the safe transport of the sources.

Packaging specific QA requirements for the ANL Source Container and Shoring are summarized in the following Chapter 9 References and Tables:

- The ES roles and responsibilities associated with the preparation and shipping of Argonne sources in the ANL source container is shown in Figure 9.3-1. ES will provide training for the loading and closure of the ANL source container and for the loading and closure of the 10-160 B Cask (Section 9.3.2.2).
- Table 9-3-2a, provides the matrix of the 10 CFR 71 Subpart H requirements to the ES implementing procedure for quality system elements.
- Table 9.3-2b, contains the list of quality levels for the ANL Source Container components and Shoring. This list was developed with the aid of NUREG/CR 6407. The PCP agrees with the Quality Levels assigned to these components by the applicant. In particular, the neutron shielding was identified as Category B, only because the 10-160B is shipped exclusive use; otherwise, it would need to be Category A).
- Section 9.3.3, Design Control - The design criteria used for the ANL source container is the same as that for the 10-160B cask, as described in SAR Section 2.1.2.

- The construction materials of the ANL source container were procured as ASTM standard materials for non-bolting items and SAE standard materials for the bolting items.
- Section 9.3.5, Instructions, Procedures, Drawings - ES cask handling procedures will be used for the transport of ANL sources in the ANL source container.
- Section 9.3.6 Document Control - As a "Package user" for the 10 -160B cask ES will maintain current copies of the 10-160B Cask SAR chapters applicable (e.g. Chapter 1, 7, 8, 9), applicable drawings, and the CoC authorizing the ANL payload.
- Section 9.3.9, Control of Special Processes - Procedures for gamma shield installation and verification were reviewed and approved by ES prior to acceptance of the ANL Source Container. Procedures for neutron shield installation and verification were prepared and approved by ES prior to acceptance of the Source Container. Welding of the ANL Source Container was performed in accordance with ASME Code Section IX, as specified by drawing C-038-349097-001 Rev. 1.
- Section 9.3.10, Internal Inspection - Two critical inspections were performed during the fabrication of the lead shielding and neutron shielding processes to verify cavity dimension, including minimum dimensions of the vertical (container wall) lead column prior to starting the installation of the lead in the horizontal (container base) cavity.
- Sections 9.3.11, Test Control - Functional test requirements for the ANL Source Container are defined in Equipment Data Sheet ES-C-001-387. Independent gamma scans were also performed after lead was installed into the Inner Container Wall to ensure that shielding meets performance requirements. The effectiveness of the neutron shield was performed by sample mass measurements, visual inspection, and field measurements. The field measurements were taken after the container was loaded.
- Section 9.12, Control of M&TE - ES will be using calibrated M&TE for the load testing the rigging, torquing the cask lid and port cover bolts; and leak testing of the 10-160B cask containment boundary. Non-destructive examination, structural tests, load tests, and shielding integrity tests for the ANL Source Container were performed by qualified personnel and/or approved suppliers using calibrated M&TE.
- Section 9.15, Control of Nonconforming Items – The reporting requirement to the DOE Headquarters Certifying Official (HCO) within 30 days, for significant package or certificate noncompliance, are included in this Section, per DOE Order 460.1C. [9]
- ES will provide Argonne a certificate of conformance or compliance stating that the 10-160B Casks delivered have been fabricated and tested in accordance with the requirements of the applicable license drawings, and that the casks supplied have been maintained in accordance with the Maintenance and Operations sections of the SAR.

9.3 Findings

Based on review of the statements and representations in the Addendum, DOE PCP concludes that the ES QAP has been adequately described in the Addendum and meets the QA requirements of 10 CFR 71 Subpart H. Package-specific QA requirements in Chapter 9 assure that the ANL Source Container package is designed, fabricated, assembled, tested, used, maintained, modified, and repaired in a manner consistent with its evaluation.

9.4 Conditions of Approval

Any organization involved in the design, procurement, fabrication, handling, shipping, storage, cleaning, assembly, operation, inspection, testing, maintenance, repair, modification, and use of the 10-160B with ANL Source Container, Shoring, and contents shall maintain and follow an appropriate QA program that is compliant with the requirements specified in 10 CFR 71, Subpart H.

References

[1] 10-160B Cask SAR Source Container Addendum, Docket # 11-36-9204, dated December 2011

[2] Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), Packaging and Transportation of Radioactive Materials.

[3] U.S. Nuclear Regulatory Commission, Proposed Revision 2 to Regulatory Guide 7.9, Standard Format and Content of Part 71 Applications for Approval of Packaging for Radioactive Materials, Washington, DC (May 1986).

[4] Consolidated Safety Analysis Report for Model 10-160B Type B RADWASTE Shipping Cask, Energy Solutions Revision 3, January 2011.

[5] A.A. DiSabatino, et al., Packaging Review Guide for Reviewing Safety Analysis Reports for Packagings, UCID-21218, Revision 3, Lawrence Livermore National Laboratory (February 2008).

[6] U.S. Nuclear Regulatory Commission, Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety, NUREG/CR-6407, Washington, DC (February 1996).

[7] U.S. Nuclear Regulatory Commission, Regulatory Guide 7.6, Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels, Revision 1, Washington, DC (March 1978).

[8] McKeel, C.A., *ANL Gamma Shield Body Lead Lid Deformation During Drop of 10-160B Package*, M-CLC-G-00402, Savannah River Site, February 2012.

[9] U.S. Department of Energy, Packaging and Transportation Safety, DOE O 460.1C, Washington, DC (April 2010).