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DOE Packaging Certification Program

Safety Evaluation Report for Request for Content Amendment for Proposed Cobalt-60 Configuration in the 10-160B Package

Docket No. 15-28-9204

Prepared by: _____ Date: 9/13/16

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This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent technical review of the application submitted by Energy*Solutions* (ES) to request authorization to add a new Cobalt-60 (Co-60) configuration as authorized contents to DOE Certificate of Compliance (CoC) Number 9204, in the 10-160B packaging. This content addition is needed to support the mission of the Idaho National Laboratory Advanced Test Reactor (INL-ATR).

Summary

By letter [1] dated February 29, 2016, as supplemented [2] June 6, 2016, ES requested an amendment to DOE CoC 9204, Revision 9, for the Model 10-160B transportation package to include a packaging configuration consisting of Co-60 targets from the INL-ATR or commercially manufactured Co-60 sources, a U.S Department of Transportation (DOT) Specification 20WC-5 packaging to house the Co-60, and a wooden cribbing assembly to secure and support the 20WC-5 within the 10-160B package. The applicant prepared and submitted an addendum to the existing Consolidated Safety Analysis Report (CSAR) [3] for approval. In addition, the applicant prepared the addendum in the format of the Nuclear Regulatory Commission (NRC), *NRC Proposed Revision 2 to Regulatory Guide 7.9* (RG 7.9), rather than the current edition of RG 7.9, for consistency with the CSAR.

Based on the statements and representations in the application, as supplemented, and the conditions listed in the following SER chapters, PCP staff agrees that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71, *Packaging and Transportation of Radioactive Material.*

Evaluation

1.0 General Information

1.1 Introduction

The purpose of the application is clearly stated in the addendum. The applicant requested to use the 20WC-5 loaded with Co-60, and overpacked inside of the 10-160B. There are no design changes to the existing 10-160B packaging components to add this proposed Co-60 configuration.

The 20WC-5 is an expired DOT Specification Type B Packaging containing a DOT Specification 2R Serial No. INIS-2R-1 and the tungsten/lead shield insert referred to as the INIS-2 Isotope Transfer Container. The 20WC-5 package authorization expired October 1, 2008, when the Nuclear Regulatory Commission amended 10 CFR Part 71, for compatiblity with the 1996 edition of the International Atomic Energy Agency (IAEA), *Regulations for the Safe Transport of Radioactive Material* (TS-R-1, as amended in 2000). The 20WC-5 was also previously authorized as a Type B(U) package by DOE CoC 9856 and DOT Competent Authority Certificate USA/9856/B(U). The DOE CoC was terminated in 1988 because during the fire test, fire extinguishers were used to put out the fire (overpack) at the end of the test instead of being allowed to terminate naturally.[4] The applicant is using the 20WC-5 as a shielded insert in the 10-160B package.

1.2 Package Description

There are no changes to the existing 10-160B package design or package operational features. However, the packaging components identified in the following section are required for the proposed Co-60 configuration. These components and radioactive contents are assembled and loaded into the cavity (i.e., containment) of the 10-160B.

1.2.1 Packaging

The packaging components of the proposed Co-60 configuration consist of:

- Cask Cribbing Assembly: Drawing No. DWG-4182-ST-0001-01, Rev 2, *Transport of 20WC-5 Shield Insert in 10-160B Cask Cribbing Assembly and Details*
- 20WC-5 complete assembly:
    - Drawing No. INIS-DWG-0051, Rev A, *INIS-2/20WC-5 Overpack Drum and Assembly and Details OD 39.5 x51 H*
    - Drawing No. INIS-DWG-0007, Rev C, *INIS-2 Tungsten Shield Assembly and Details*, and
    - Drawing No. INIS-DWG-0019, Rev A, *INIS-2R-1 Transport Container Assembly and Details*
- Co-60 Target: Drawing No. 427648, Rev 7, *ATR High Specific Activity Cobalt Irradiation Capsule Assembly for "H" and Inboard "A" Hole*
- Co-60 Target Canister: Drawing No. DMP-CICC-100, Rev 0, *Cobalt Irradiation Capsule Canister Assembly*
- Co-60 Sources and Source Assembly: Drawing No. INIS-DWG-0049, Rev B, *INIS-SF01.6-13-I Cobalt 60 Calibration Capsule Assembly*

The applicant described these components in Section 1.1 of the addendum, and addressed the quality level classification (i.e., importance to safety) for each component in Section 9.3.2.2 and Table 9.2-2b of the addendum. The applicant provided drawings of these components in Appendix 1.3.1 of the addendum.

The Cask Cribbing Assembly is a two piece wooden design that fills the void space within the package and protects the 10-160B containment boundary interior surfaces from damage during normal conditions of transport (NCT), and eliminates the potential for a "piston effect" in the 10-160B from the 20WC-5 during hypothetical accident condition (HAC) tests. The 20WC-5 is secured to the lower cribbing assembly by Z-brackets that cinch the drum chime to the cribbing. The upper cribbing assembly is installed over the 20WC-5 and aligned with notches in lower cribbing assembly. Web-slings are fed through penetrations in the Cask Cribbing Assembly and used to lift it, with the 20WC-5, to load and unload in the 10-160B. The overall dimensions of the cribbing assembly are approximately 65 inches in diameter and 75-¼ inches in height.

The 20WC-5 complete assembly consists of: *INIS-2/20WC-5 Overpack Drum and Assembly*: overpack drum and internal cradle assemblies constructed from wood material (INIS-DWG-0051), *INIS-2 Tungsten Shield Assembly* (INIS-DWG-0007), and *INIS-2R-1 Transport Container*

Assembly (INIS-DW-0019). The overall dimensions of the 20WC-5 are approximately 39-½ inches in diameter and 51-$^{5}/_{16}$ inches in height.

The Co-60 Target Canister (DMP-CICC-100) or Basket Assembly (INIS-DWG-0049-4) is required for convenience handling the Co-60 contents. The canister is required for underwater loading of a Co-60 target canister in the *INIS-2 Tungsten Shield Assembly* at INL-ATR and for dry unloading at the receiving facility. The basket is required for dry loading and unloading of one International Isotopes Inc. Model INIS-SF-1.6-14-I capsule in the *INIS-2 Tungsten Shield Assembly*.

1.2.2 Contents

The applicant evaluated the three Co-60 payloads in the proposed configuration. The first and second payloads are Co-60 targets produced in the INL-ATR. These targets are identified in Table 1-1 of the addendum as Targets 482 and 488. The material form is solid metal pellets of Co-60, 1 mm in diameter by 1 mm in height. The pellets are doubly encapsulated in an assembly that consists of an aluminum alloy Pellet Holder and Housing (Drawing 427648). The assembly is welded and leak tested per the drawing notes, but was not qualified as special form radioactive material. The approximate outer dimensions of the encapsulation are 0.5 inches in diameter in 16 inches in length. Each target assembly has a nominal radioactivity of approximately 5,300 curies. For handling convenience, each target is loaded in a target canister (DMP-CICC-100), and only one canister can be loaded in the 20WC-5 (i.e., *INIS-2 Tungsten Shield Assembly*). The third payload is up to 10,000 Ci of Co-60, special form radioactive material, in the International Isotopes Inc. Model INIS-SF-1.6-14-I capsule design that is certified by IAEA Certificate of Competent Authority USA/0707/S-96. These sources that are identified in Table 1-1 as Sources 1, 2, and 3: up to three sources can be loaded in a basket assembly (INIS-DWG-0049-4) and only one basket assembly can be loaded in the 20WC-5. The maximum quantity of radioactive material per package for this proposed Co-60 configuration is 10,000 curies. The content decay heat is approximately 154 watts and was calculated by applicant in Table 1-2 of the addendum.

1.3 Evaluation Findings

Based on a review of the statements and representations in the application, PCP staff concludes that the package has been adequately described in the addendum to meet the requirements of 10 CFR Part 71.

2.0 Structural Evaluation

There are no changes to the existing 10-160B package design or structural evaluation of the package. The maximum weight of the proposed Co-60 configuration (4,869 lb.) will not exceed the maximum weight authorized in the CoC (14,250 lb.).

The applicant performed a structural evaluation of the cribbing assembly design, by calculation, CALC-4182-ST-0001, *Structural Evaluation of the 20WC-5 Shield Insert Wood Cribbing* [5], to confirm that it protects the 10-160B package interior and 20WC-5 from damage when subjected to Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC). In addition, the applicant evaluated the lifting arrangement to ensure the Co-60 configuration can be

safely lifted to insert and remove it from the package. The calculation results are summarized in Chapter 2 of the addendum. PCP staff confirmed the applicant's results by document review.

The internal, wooden cribbing design for the packaging the 20WC-5 is fully detailed in the applicant's structural calculation. The weights and center of gravity of the proposed Co-60 configuration were provided in Section 2.2 of the addendum and show that the combined weight of the proposed Co-60 configuration would be 4,869 lbs., which is significantly less than the weight limit of 14,250 lb. evaluated in the CSAR. Section 2.3 of the addendum provides the mechanical properties of all packaging materials for the proposed Co-60 configuration. The materials and associated properties, including Class or Grade, yield stress, ultimate stress are density are summarized in Table 2-1 of the addendum, with a comprehensive list provided in the drawings and Table 9.2-2b of the addendum. Materials of fabrication were evaluated in Section 2.4.1 of the addendum. The applicant concluded the materials and contents would not to cause significant chemical, galvanic, or other reactions with air, nitrogen, or water atmosphere. Section 2.4.3 of the addendum references the structural calculation to show the lifting arrangement of the proposed Co-60 configuration meets the load test requirement, that is, 125% of the rated load, in accordance with ASME B30.20, *Below-The-Hook Lifting Devices.* PCP staff confirmed the applicant's results by document review.

2.1 NCT

The applicant evaluated the proposed Co-60 configuration structure for NCT by comparison to previous 20WC-5 performance tests for NCT and the results of the structural calculation (CALC-4182-ST-0001) for HAC. The 20WC-5 was previously authorized as a Type B(U) package by DOE CoC 9856. In Section 2.6 of the addendum, the applicant references the previous Safety Analysis Report for Packaging (SARP), ORNL/TM-8347/R1 [6] supporting DOE CoC 9856 to demonstrate compliance for NCT. The applicant also references the results from the HAC structural calculation to demonstrate the results are bounding for NCT. PCP staff confirmed the applicant's results by document review.

2.2 HAC

The applicant evaluated the proposed Co-60 configuration structure for HAC by calculation (CALC-4182-ST-0001). The purpose of this calculation was to demonstrate the cribbing design has sufficient capacity to absorb the impact energy from HAC drops and still protect the 10-160B package. The 20WC-5 design was previously subjected to HAC performance tests at the Sandia National Laboratory and the package was certified by DOE as a Type B(U) package, so the applicant assumed the Co-60 contents were protected by the 20WC-5 from an HAC drop test, based on the Sandia's previous test results. The applicant determined from inspection of the cribbing design that the package drop orientations expected to cause the maximum damage to the cribbing were the end, side, and corner. The applicant used the Metz empirical formula to determine the depth of penetration (crush depth) to the cribbing from HAC drops to calculate the depth of crush (i.e., depth of penetration), and then estimate crushing strain. The crushing strain for the cribbing is 23.2%, whereas, the acceptance criteria is the maximum crushing strain must be less than 75%, which is when lock-up strain of softwood occurs. The applicant used a weight-scale factor to calculate deceleration forces, since the proposed Co-60 configuration weight (5,000 lb.) is less than the maximum payload weight (14,250 lb.) authorized in the CoC.

The impact force is calculated using the scaled decelerations multiplied by the weight of the contents. Table 4.2 of the calculation shows the results and comparison of the impact forces from end, side, and corner drops of proposed Co-60 configuration mass as compared with the forces on the package with the maximum payload weight authorized in the CoC. The applicant's crushing evaluation and the deceleration forces show the cribbing wood members have sufficient capacity to protect the interior cavity of the 10-160B package. PCP staff confirmed the applicant's results by document review.

2.3 Lifting Evaluation

The applicant evaluated the cribbing assembly design, by calculation (CALC-4182-ST-0001) to ensure it has the requisite strength and rigidity to the lift the Co-60 configuration mass. The criterion for the cribbing design is it must pass a load test of 125% of the rated load, per ASME B30.20. In this case the applicant evaluated a load of 6,250 lb. (5,000 lb. x 1.25). The applicant selected material properties from the 2012 edition of ANSI/AWC NDS, *National Design Specification for Wood Construction* and calculated the bending, shear, and compression load properties of the wood to compare them with the material specifications listed in Table 3.1 of the calculation. The applicant demonstrated that the calculated stresses are less than the allowable stresses, so the cribbing design is satisfactory. PCP staff confirmed the applicant's results by document review and agrees the cribbing design is satisfactory for the intended load.

2.4 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff concludes that the proposed changes do not affect the ability of the package structural design to meet the requirements of 10 CFR Part 71.

3.0 Thermal Evaluation

There were no changes to the 10-160B package design. The maximum decay heat load of the proposed Co-60 configuration (150 watts) will not exceed the maximum decay heat authorized in the CoC (200 watts).

The maximum decay heat of the Co-60 configuration is identified in Table 1.2 of the addendum as Shipment 3. PCP staff confirmed the applicant's results by document review.

Based on review of the statements and representations in the application, PCP staff concludes that the proposed changes do not affect the ability of the package thermal design to meet the requirements of 10 CFR Part 71.

4.0 Containment

There were no changes to the 10-160B package containment boundary. The maximum activity (9,750 Ci) and A_2 value (866.4) of the proposed Co-60 contents does not exceed the maximum contents for Co-60 authorized in the CoC (i.e., 10,000 Ci and 3,000 A_2). Note – for Co-60 the A_1 and A_2 values are the same.

The maximum activity and A_2 value of the Co-60 configuration is identified in Table 4.1 of the addendum. PCP staff confirmed the applicant's results by document review.

4.1 Combustible-Gas Generation

The applicant evaluated combustible-gas generation of the proposed Co-60 content configuration by calculation, CALC-4182-NS-0001, *Transport of the 20WC-5 Shield Insert in the 10-160B Cask Hydrogen Gas and Pressure Buildup Analysis*.[7]

The calculation assumptions and results are summarized in Sections 4.8.1 and 4.8.2 of the addendum. PCP staff concurs that the applicant's assumptions are reasonable and conservative.

The applicant identified the source of combustible-gas generation as hydrogen gas generated from gamma energy deposition in the packaging wooden material components, e.g., cribbing, 20WC-5 overpack and cradle assembly. Based on the calculation results, it would take approximately 571 years to reach 5% hydrogen, by volume, in the containment boundary. The results demonstrate that the Co-60 content configuration meets the requirements NUREG-1609, *Standard Review Plan for Transportation Packages for Radioactive Material*: hydrogen and other flammable gases are less than 5% by volume of the total gas inventory within any confined space (i.e., containment boundary). PCP staff reviewed the applicant's calculation and concurs with the results.

4.2 Pressure

The applicant evaluated maximum normal operating pressure (MNOP) and pressure from HAC of the proposed Co-60 configuration by calculation, CALC-4182-NS-0001, *Transport of the 20WC-5 Shield Insert in the 10-160B Cask Hydrogen Gas and Pressure Buildup Analysis*, and compared the result to the package MNOP and pressure from HAC. The package MNOP and HAC pressure are based on temperatures in the package interior of 188 °F (86.7 °C) and 290 °F (143 °C), respectively (Reference 8.5 of the CSAR) and resulting pressures of 31.2 and 94.2 psig, respectively.

The MNOP and HAC pressures for the Co-60 content configuration are summarized in Section 4.8.2.2 of the addendum, and are 3.6 and 5.8 psig respectively. These results are significantly below the CSAR results. PCP staff concurs with the applicant's calculation results.

4.3 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff concludes that the proposed changes do not affect the ability of the containment system design to meet the requirements of 10 CFR Part 71.

5.0 Shielding Evaluation

There were no changes to the existing 10-160B package radiation shield design. The maximum activity (9,750 Ci) and weight (4,869 lb.) of the proposed Co-60 configuration does not exceed the maximum contents for Co-60 and content weight authorized in the CoC (i.e., 10,000 Ci

14,250 lb.). Chapter 2 of the addendum demonstrates that NCT tests do not impact the geometry of the 10-160B packaging or the proposed Co-60 configuration and that no damage to the package shield design will occur as a result of HAC. The applicant performed computer modeling to evaluate the package with the proposed Co-60 configuration and demonstrate compliance with §71.47 for NCT and §71.51 for HAC.

5.1 Description of the Shielding Design

The additional packaging components for the proposed Co-60 configuration are internal to the 10-160B packaging and include:

- Cask Cribbing Assembly – Drawing *Transport of 20WC-5 Shield Insert in 10-160B Cask Cribbing Assembly and Details,* DWG-4182-ST-0001-01, Rev 2
- 20WC-5 complete assembly: *INIS-2/20WC-5 Overpack Drum and Assembly*, *INIS-2 Tungsten Shield Assembly,* and *INIS-2R-1 Transport Container Assembly;*
- Co-60 Target: *ATR High Specific Activity Cobalt Irradiation Capsule Assembly for "H" and Inboard "A" Hole*
- Co-60 Target Canister: *Cobalt Irradiation Capsule Canister Assembly*
- Co-60 Sources and Source Assembly: *INIS-SF01.6-13-I Cobalt 60 Calibration Capsule Assembly*

These components are nested in the 10-160B and provide radial and axial shielding of the contents for NCT. The *INIS-2 Tungsten Shield Assembly* is designed to transport one Co-60 Target that is loaded in a Co-60 Target Canister, or three Co-60 Sources that are loaded in a Source Assembly. The *INIS-2R-1 Transport Container Assembly* is designed to transport one shield assembly. The *INIS-2/20WC-5 Overpack Drum and Assembly* are designed to cradle and transport one transport container assembly. And finally, the Cask Cribbing Assembly is designed to envelop one 20WC-5 overpack and fit in the package with minimal clearance. The applicant describes these components in Section 5.1.1 of the addendum, which includes descriptive drawings and photographs in Figures 5.1 through 5.9, and component material descriptions, dimensions and specifications in Tables 5-1a through 5-1e.

The only packaging components that provide radial and axial shielding for HAC are the 10-160B package shield and the *INIS-2 Tungsten Shield Assembly*.

PCP staff reviewed the applicant's shielding design and concurs that it has been adequately described in the addendum.

5.2 Summary Tables of Maximum Radiation Levels

The applicant performed the shielding evaluation using the MCNP6 computer code and calculated NCT and HAC dose rates with a 10,000 Ci of Co-60, distributed source (15 inches). The distributed source is located in the center of the 20WC-5 for NCT and is positioned at various locations within the 10-160B containment system for HAC.

The maximum package dose rates with the proposed Co-60 configuration are listed in Tables 5-2 through 5-5 of the addendum and compared with exclusive use limits from §§71.47(b) and 71.52(a)(2) for NCT and HAC respectively. The maximum NCT dose rate is less than 0.3 mrem/hr., at contact with the package and 0.013 mrem/hr., at 2 meters from the package, as compared with the regulatory limits of 200 mrem/hr., at contact and 10 mrem/hr., at 2 meters. The maximum HAC dose rate at 1 meter from the package is less than are 38 mrem/hr., as compared to the regulatory limit of 1,000 mrem/hr. at 1 meter.

PCP staff reviewed the applicant's shielding evaluation, including the methodology, model, and results as presented in Tables 5-2 through 5-5 of the addendum, to ensure that the package with the proposed Co-60 configuration met the requirements in §71.47 and §71.51.

5.3 Radiation Source

The maximum quantity of radioactive material offered for shipment in the proposed Co-60 configuration is 10,000 Ci of Co-60. Table 5-5 of the addendum lists the photon emission probability for Co-60 as a function of energy. The source region composition is modeled as air, so self-shielding of the source material is not a factor in the shielding evaluation. Co-60 emits two photons per disintegration (1.176 and 1.333 MeV) with abundance of 100%. The applicant used Equation 1 of the addendum to calculate a photon source activity for Co-60 of 7.4E+14 photons/second.

The source term of the proposed Co-60 configuration contains no neutron emitting radioisotopes.

PCP staff independently confirmed the applicant's source term.

5.4 Shielding Models

The applicant modeled the 10-160B with the proposed Co-60 configuration using MCNP Version 6, Release 1.0.

The radioactive source is modeled as air in the form of an annular cylinder with a minimum outside diameter of 0.417 inches, a minimum wall thickness of 0.055 inches. This model is conservative in that it reduces the amount of self-shielding and concentrates the source activity into a smaller annular volume. The source is distributed over a length of 15 inches.

The NCT model is described in Section 5.3.1.1 of the addendum and is used to calculate package dose rates and gamma energy deposition rates in the wood components of the proposed Co-60 configuration. The gamma energy deposition rate is an important variable for calculating flammable gas generation and pressure in the 10-160B containment by radiolysis of water in the wood components. In the NCT model, the cribbing assembly positions the 20WC-5 approximately 16.75 inches above the bottom of the 10-160B containment and centers it radially in the package. The clearance between the cribbing and the 10-160B containment boundary is approximately 5/16 of an inch. NCT models are represented in Figures 5-10 through 5-12 of the addendum.

Multiple HAC models and modeling assumptions are described in Section 5.3.1.2 of the addendum and identify the configurations resulting in the maximum HAC dose rate, i.e., the location of the *INIS-2 Tungsten Shield Assembly* within the 10-160B containment following an accident. HAC models are represented in Figures 5-13 through 5-15 of the addendum. Material properties used by the applicant in the shielding evaluation are summarized in Section 5.3.2 and Table 5-8 of the addendum.

PCP staff reviewed the applicant's model configurations and materials and concurs they are consistent with the package design, with the proposed Co-60 configuration, and result in maximum external radiation.

5.4 Shielding Evaluation

The general steps the applicant used to perform the shielding evaluation are listed in Section 5.4.1 of the addendum. The discussion in this section addressed the method of variance reduction (geometrical importance weighing) and sufficient run time to obtain relative error, and estimated the dose rates to three standard deviations (Equation 2). Sample input data files are listed in Appendix 5.5.2 of the addendum.

PCP reviewed the applicant inputs and assumptions associated with the NCT and HAC shielding model and evaluation. MCNP results were independently validated by staff and are consistent with the text in the addendum. In addition, staff compared the inputs and results with Co-60 contents configuration (Docket No. 14-11-9204), with adjustments made for differences, including density.

5.5 Computer Code

The applicant used MCNP Version 6, Release 1.0 computer code to perform the shielding evaluation and described the computer system used to run MCNP.

5.6 Flux-To-Dose-Rate Conversion

PCP staff confirmed that the applicant used the ANSI/ANS 6.1.1-1977, *Neutron and Gamma-Ray Flux-to-Dose-Rate Factors* standard and finds this acceptable. Table 5-9 of the addendum summarized photon flux-to-dose-rate conversion.

5.7 NCT and HAC Results

Table 5-2 of the addendum lists the contact dose rates, with tally, segment, and relative error at the top, side, and base of the package; and the contact dose rate, with tally, segment, and relative error 2 meters from the top of the package. Table 5-3 of the addendum lists the maximum and maximum plus-3-sigma dose rates, respectively, for NCT. The maximum dose rates for NCT are 0.0028 mSv/hr. (0.28 mrem/hr.) on contact with the 10-160B secondary lid and 0.0013 mSv/hr. (0.013 mrem/hr.) at 2 meters from the secondary lid. The relative error of the maximum the contact dose rate is 0.75% and at 2 meters is 1.78%. The maximum dose rate plus-3-sigma is less than 0.0030 mSv/hr. (< 0.30 mrem/h) on contact and less than 0.0002 mSv/hr. (<0.02 mrem/h) at 2 meters.

Table 5-4 of the addendum lists the 1-meter dose rates, with tally and relative error, at the top, side, and base of the package. Table 5-5 of the addendum lists the maximum and maximum plus-3-sigma dose rates, respectively, for HAC, for Cases 2 (side), 5 (base) and 6 (top). These cases are illustrated in Figures 5-14 and 5-15 of the addendum. The maximum HAC dose rate is less than 0.37 mSv/hr. (< 37 mrem/hr.) at 1-meter from the package (Figure 5-15, Case 5), with a relative error of 0.57%. The maximum dose rate plus-3-sigma is less than 0.38 mSv/hr. (< 38 mrem/hr.) at this location.

5.3 Evaluation Findings

Based on the information provided by the applicant and the staff's confirmatory calculations, PCP staff has reasonable assurance that the applicant's shielding analyses demonstrate that the package design meets the requirements of 10 CFR Part 71.

6.0 Criticality Evaluation

There were no changes to the fissile material limits in the certificate of compliance and the proposed Co-60 configuration is not fissile, so a criticality evaluation was not necessary.

7.0 Operating Procedures

There were no changes to the existing 10-160B package operating procedures. The applicant added supplementary operating procedure requirements to prepare, load, and unload the proposed Co-60 configuration in the package.

The applicant provided detailed procedures with illustrations in Section 7 of the addendum, the procedures address the requirement for:

- Wet loading operations at INL - loading a Co-60 target in the *Cobalt Irradiation Capsule Canister Assembly*,
- Dry loading operations at International Isotopes – loading Co-60 sources in the *INIS-SF01.6-13-I Cobalt 60 Calibration Capsule Assembly*,
- Loading a target canister or source assembly into the *INIS-2 Tungsten Shield Assembly*,
- Loading the *INIS-2 Tungsten Shield Assembly* in the *INIS-2R-1 Transport Container Assembly*. Note - The open *INIS-2R-1 Transport Container Assembly* and open *INIS-2/20WC-5 Overpack Drum and Assembly* are staged for this operation. Also the *INIS-2/20WC-5 Overpack Drum and Assembly* is secured by Z-brackets in the lower *Cask Cribbing Assembly* for this operation,
- Closing the *INIS-2R-1 Transport Container Assembly* and *INIS 2/20WC-5 Overpack Drum and Assembly*,
- Installing the upper *Cask Cribbing Assembly* on the lower *Cask Cribbing Assembly*,
- Loading the *Cask Cribbing Assembly*, with payload, into the 10-160B packaging,
- Performing the page pre-shipment leakage test (incorporated by reference to the CSAR),
- Unloading the 10-160B at INL or International Isotopes and steps for removing the Co-60 contents, and

- Preparing the empty 10-160B and the 20WC-5 complete assembly for shipment.

The applicant omitted, from the loading procedures in Section 7.1 of the addendum, the requirement to perform a pre-shipment gamma survey of the 20WC-5 after the contents are loaded, per Section 8.1.5 of the addendum. However the survey step is included as Step 4 in Figure 7-1b of the addendum. PCP staff will include this survey step as a condition of the approval in the certificate.

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

8.0 Acceptance Tests and Maintenance Program

There are no changes to the existing 10-160B package acceptance tests or maintenance program. The applicant added supplemental acceptance testing and maintenance program requirements in the addendum for the proposed Co-60 configuration.

8.1 Acceptance Tests

The 20WC-5 is not a pressure containing vessel, so pressure testing was not required for acceptance.

The applicant required visual examination per Section 8.1.1 of the addendum for acceptance of the following components, prior to first use, for adverse conditions in materials or fabrication:

- 20WC-5 compete assembly: *INIS-2/20WC-5 Overpack Drum and Assembly*, *INIS-2 Tungsten Shield Assembly*, and *INIS-2R-1 Transport Container Assembly*, and
- Cask Cribbing Assembly

The applicant required load testing of the lifting lugs and lid fasteners to 150% of the maximum service load per 8.1.2 of the Addendum for acceptance of load carrying components, and proof testing of the Cask Cribbing Assembly at 125% of the proposed payload, to meet proof-testing requirements of ASME B30.20, *Below-the-Hook Lifting Devices*, to assure the cribbing will function prior to its use with the payload at INL-ATR.

Prior to each use of the 20WC-5, the applicant requires a gamma scan to verify shielding integrity of the 20WC-5.

8.2 Maintenance Program

Maintenance of the 20WC-5 is performed by the owner, International Isotopes, Inc. using company-specific procedures.

Based on review of the statements and representations in the addendum , PCP staff concludes that the acceptance tests for the new packaging components meet the requirements of

10 CFR Part 71 and that the maintenance program is adequate to assure packaging performance during its service life.

9.0 QUALITY ASSURANCE

The applicant's Quality Assurance Program (QAP) is approved by DOE and the Nuclear Regulatory Commission (NRC). The applicant identified and evaluated package-specific quality requirements for the proposed Co-60 configuration in Chapter 9 of the addendum in accordance with their DOE approved QAP and 10 CFR 71 Subpart H.

The applicant addressed the quality levels for the additional packaging components required for this proposed Co-60 content configuration in Section 9.3.2.2 of the Addendum, based on their importance to safety. The applicant identified the following components as important to safety (*drawing title (*drawing number)/Quality Category (Q-Cat) :

- 20WC-5: The complete assembly includes
  - *INIS-2/20WC-5 Overpack Drum and Assembly and Details OD 39.5 x51 H* (INIS-DWG-0051, Rev A)/Q-Cat C,
  - *INIS-2 Tungsten Shield Assembly and Details* (INIS-DWG-0007, Rev C))/Q-Cat B, and
  - *INIS-2R-1 Transport Container Assembly and Details* (INIS-DWG-0019, Rev A)/Q-Cat C
- Cask Cribbing Assembly: *Transport of 20WC-5 Shield Insert in 10-160B Cask Cribbing Assembly and Details* (DWG-4182-ST-0001-01, Rev 2)/Q-Cat C
- Co-60 Target: *ATR High Specific Activity Cobalt Irradiation Capsule Assembly for "H" and Inboard "A" Hole* (427648, Rev 7)/Q-Cat B
- Co-60 Target Canister: *Cobalt Irradiation Capsule Canister Assembly* (DMP-CICC-100, Rev 0)/Q-Cat C
- Co-60 Sources and Source Assembly: *INIS-SF01.6-13-I Cobalt 60 Calibration Capsule Assembly* (INIS-DWG-0049, Rev B)/Q-Cat B

PCP staff reviewed the applicant's evaluation and concurs with the applicant's assignment of quality significance for these components.

Based on the review of the statements and representations presented in Chapter 9 of the addendum, PCP staff concludes the quality requirements in the addendum are consistent with their DOE approved QAP, meet the requirements of 10 CFR 71 Subpart H, and are therefore adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

Conditions of Approval

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

- Packaging Description 5.(a)(2) was revised to add the 20WC-5 Shield Insert configuration.
- Drawings 5.(a)(3) was revised to add the six, 20WC-5 Shield Insert configuration drawings.
- Contents 5.(b)(1)(vi)-(viv) were revised to add "or" at the end of the condition.
- Contents 5.(b)(1)(vv) was added for the new contents "For a shipment in the 20WC-5, Co-60 pellets, solid metal, or nickel alloy (plated)."
- Condition 5.(b)(2)(xiv) was added for the new contents "Each 20WC-5 shall contain no more than 10,000 Ci of Co-60."
- Condition 5.(d)(10) was revised to allow the use of Revisions 8 and 9 of the certificate until May 31.2017.
- Condition 5.(d)(18) was added "The cribbing design for the 20WC-5 shall be fabricated and inspected per the drawings specified in Reference 7 (Addendum)."
- Condition 5.(d)(19) was added "The 20WC-5 shall be prepared, loaded, and closed as specified in Reference 7 (Addendum). The user must perform a radiation survey of the 20WC-5 after the contents are loaded, prior to loading the 20WC-5 in the 10-160B (Reference 7, Addendum, Section 8.1.5)."
- Conditions 5.(d)(20)-(22) were added to clarify the basis for the DOE CoC and user restrictions.
- Supplement 5.(e)(7) was added for this application, "20WC-5 Shield Insert Shipping Addendum for Model 10-160B Type B RADWASTE Shipping Cask, Revision 1, June 6, 2016."

Conclusion

Based on the statements and representations contained in the addendum , as supplemented, and the conditions listed above, the PCP staff concludes that the design has been adequately described and evaluated, and the Model 10-160B package meets the requirements of 10 CFR Part 71.

References

[1] *Amendment Request for the 10-160B, Certificate No. USA/9204/B(U)F-96 (DOE), Docket No. 15-28-9204*, Letter# ES/DOE 16-001, Letter to Shuler, February 29, 2016, with enclosure.

[2] *Transmittal of Q1 Responses and Final SARP Addendum for the 10-160B, USA/9204/B(U)F-96(DOE), Docket No. 15-28-9204, and notification of name change from EnergySolutions Government Group, Inc. to EnergySolutions Performance Strategies, Inc. (an Atkins Company)*, Letter# ATKINS/DOE 16-001, Letter to Shuler, June 6, 2016, with enclosure.

[3] *Consolidated Safety Analysis Report for Model 10-160B Type B RADWASTE Shipping Cask*, Energy Solutions, Revision 4, July 2012

[4] *Certificate of Compliance 9856*, Memorandum from Charles J. Mauck, Chief - Packaging Certification Staff, February 26, 1988, DP-4.1

[5] *Transport of the 20WC-5 Shield Insert in the 10-160B Type B Radwaste Shipping Container-Structural Evaluation of the 20WC-5 Shield Insert Wood Cribbing*, CALC-4182-ST-001, Revision 3, May 31, 2016

[6] *Safety Analysis Report for Packaging: The ORNL DOT Specification 20WC-5 Special Form Packaging Report*, ORNL/TM-8347/R1, March 1983.

[7] *Transport of the 20WC-5 Shield Insert in the 10-160B-Cask-Hydrogen Gas and Pressure Buildup Analysis*, CALC-4182-NS-001, Rev. A, February 16, 2016