UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 7, 2017

Ms. Lori Podolak
Regulatory Affairs Department
QSA Global, Inc.
40 North Avenue
Burlington, MA 01803

SUBJECT: REVISION NO. 6 OF CERTIFICATE OF COMPLIANCE NO. 9357 FOR THE MODEL NO. SENTRY TRANSPORTATION PACKAGE

Dear Ms. Podolak:

As requested by your application dated May 16, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16141B296); as supplemented on October 4, 2016 (ADAMS Accession No. ML16286A212), and August 10, 2017 (ADAMS Accession No. ML17227A132), enclosed is Certificate of Compliance No. 9357, Revision No. 6, for the Model No. SENTRY transportation package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's safety evaluation report is also enclosed.

This approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of Title 10 of the *Code of Federal Regulations* 71.17 or Title 49 of the *Code of Federal Regulations* 173.471.

If you have any questions regarding this certificate, you may contact me or Bernard White of my staff at 301-415-6577.

Sincerely,

/RA/

Meraj Rahimi, Acting Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9357
CAC No. L25122 and EPID No. L-2017-LLA-0063

Upon removal of Enclosure 3, this document is uncontrolled.

Enclosures:
1. Certificate of Compliance No. 9357, Rev. No. 6
2. Safety Evaluation Report
3. Registered Users

cc w/encls 1 and 2: R. Boyle, DOT
J. Shuler, DOE, c/o L. F. Gelder
Registered Users

REVISION NO. 6 OF CERTIFICATE OF COMPLIANCE NO. 9357 FOR THE MODEL NO. SENTRY TRANSPORTATION PACKAGE, DOCUMENT DATE: DECEMBER 7, 2017

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Closes EPID No. L-2017-LLA-0063

OFC:	NMSS/DSFM/SFLB	NMSS/DSFM/SFLB	NMSS/DSFM/CSRAB	NMSS/DSFM/RMB	NMSS/DSFM/CSTB
NAME:	BWhite	SFigueroa via email	DForsyth via email	DTarantino via email	ARigato via email
DATE:	11/29/17	12/4/17	11/29/17	12/1/17	12/1/17
OFC:	NMSS/DSFM/RMB	NMSS/DSFM/CSTB	NMSS/DSFM/CSRAB	NMSS/DSFM/SFLB	
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SAFETY EVALUATION REPORT
Docket No. 71-9357
Model No. SENTRY
Certificate of Compliance No. 9357
Revision No. 6

SUMMARY

By application dated May 16, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16141B296); as supplemented on October 4, 2016 (ADAMS Accession No. ML16286A212), and August 10, 2017 (ADAMS Accession No. ML17227A132), QSA Global (QSA or the applicant) requested an amendment to Certificate of Compliance (CoC) No. 9357, for the Model No. SENTRY transportation package, which includes the Model Nos. SENTRY 110, SENTRY 330, and SENTRY 867 packages. This safety evaluation report is based on review of the changes between Drawing No. R86000, Revision No. R and Revision No. U. QSA requested revisions to the CoC to allow increased manufacturing flexibility, to more accurately specify the package and to correct an error in the specification of the contents on the CoC. The use of "output" activity under ANSI N432-1980 and the U. S. Department of Transportation regulations only applies when you are transporting Ir-192, not Co-60.

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed these changes and concludes that they do not affect the ability of the package to meet the requirements of Title 10 of the *Code of Federal Regulation* (10 CFR) Part 71.

1.0 GENERAL EVALUATION

By application dated May 16, 2016; as supplemented on October 10, 2016, and August 10, 2017, QSA requested an amendment to CoC No. 9357, for the Model No. SENTRY transportation package. QSA requested revision to the certificate to include changes made to the drawings to remove the tolerances on the depleted uranium (DU) shield, reduce the material specifications for components that are not relied on to 10 CFR Part 71, and remove the specification that the activity of the contents are output curies instead of content curies.

2.0 STRUCTURAL EVALUATION

The applicant requested a total of 35 changes in this amendment. Most of the requested changes deal with flexibility in manufacturing such as tolerances and allowing for additional materials. Those that are structural in nature were examined in this portion of this safety evaluation report.

The applicant requested the use of ASTM International (ASTM) A182 304/304L in addition to the approved stainless steels for the shell of the welded body assembly. Staff evaluated the request and determined that the mechanical properties important to energy absorption (yield, rupture strain, and ultimate tensile stress) are equivalent to those materials that are already approved. Therefore, the staff finds that the requested material will not affect the structural performance of the package with respect to the tests and conditions in 10 CFR 71.71 and 10 CFR 71.73 related to drop, puncture, and penetration.

The applicant requested the use of other materials for components that are not important to safety or have no structural function. This includes collar roll pin, anti-rotation lug material, flat brass washer material, shaft spring material, lock cover set screw, plunger lock screw, lanyard screw, lanyard lock washer, large link, small link, lock extension, and lock cover roll pin. Staff agrees that these items have no structural importance and will not affect the performance of the package.

Based on review of the statements and representations in the application, the staff concludes that the SENTRY package meets the structural requirements in 10 CFR Part 71.

2.1 MATERIALS EVALUATION

The applicant requested an amendment to the materials of construction for the SENTRY package. The staff identifies the safety significant changes evaluated in Table 1 below:

The applicant stated that the material changes were made to provide accuracy and conformance to a consensus standard for safety-related materials. The staff reviewed the materials and associated standards detailed below and determined that they are acceptable and provide reasonable assurance that the package will continue to meet the requirements in 10 CFR Part 71. Specifications and temperature dependent mechanical properties conform to ASTM International standards and American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section II, Part D, for package components relied on to meet the package approval standards in 10 CFR Part 71. These material standards have been previously evaluated, accepted and used, without incident, other radioactive material transportation packages.

TABLE 1: Changes to Safety Significant Components Identified from on Drawing No. R86000, Revision R to Revision U

<table>
<tr><td>Component</td><td>Revision R</td><td>Revision U</td></tr>
<tr><td>Rivet, Open End/Name Plate</td><td>Any type 300 series stainless steel/Type 302, 303, 304, 304L, or 316 STN STL</td><td rowspan="3">Fireproof Stainless Steel</td></tr>
<tr><td>Large Set Screw</td><td>ASME B18.3 Type 302, 302HQ, 304, 304L, 305, 384 SS</td></tr>
<tr><td>Set Screw</td><td>ASME B18.3 Type 316 SS</td></tr>
<tr><td>Shield Assembly</td><td>Sheet 9, notes 1 - 6</td><td>Sheet 9, Added: Note 7 Shielding verified by shielding survey inspection</td></tr>
<tr><td>Welded Port Assembly</td><td>Sheet 3, Note 1: references 1999 Structural Welding Code of AWS D1.6</td><td>Sheet 3, Note 1, deleted: Year of Structural Welding Code (1999)</td></tr>
<tr><td>Shell Rivnut</td><td>No material specification referenced</td><td>Added: ASTM A276 or A493</td></tr>
</table>

Shield Disc	References copper material temper conditions H02 or H04	Deleted: conditions H02 and H04
Shell	References specifications ASTM A240, A272 or A666	Added: Shell also optionally per ASTM A182
Small Rivnut/Large Rivnut	Type 316/316L STN STL per ASTM A276	Deleted: Type 316/316L STN STL and Added “or A493”
Shield Bracket	Type C101 or C110 Copper Condition H02 or H04 per ASTM B152	Deleted: Condition H02 or H04
Shield Cup	Type C101 or C110 Copper Condition H02 or H04 per ASTM B152 or B187	
Hex Bolt	Type 17-4 PH SS	Added: ASTM F593
Rib Nut	Type 302, 303, 304, 304L or 316 STN STL	Type 304 stainless steel per ASTM A182, A276, or A479
Rib Bolt		Type 316 stainless steel per ASTM F593
Pin/Rib Link/Welded Rib Assembly	Type 17-4 PH SS	Added: Condition H900 or H1025 per ASTM A564, A693 or ASME SA-693
Fitting	Type C464 Brass Condition H02 or H04 per ASTM B21 or Type C360 Brass Condition H02 or H04 per ASTM B16 or Tungsten per ASTM B777 Class 1, 2, 3, or 4	Deleted: Type C464 Brass Condition H02 or H04 per ASTM B21 or Type C360 Brass Condition H02 or H04 per ASTM B16
Shield	Sheet 11, notes 1 - 8	Added: Note 9: Total supplemental shield weight shall not exceed 5% of maximum shield weight on Sheet 9

In addition, several safety components have been changed to “fireproof” stainless steel (SS). The applicant states failure of these components will not significantly reduce the package effectiveness or integrity during transport, however the nameplate is present to serve as a warning, and the set screws serve to plug bolt attachment holes, preventing air ingress to the package interior and all must remain during the thermal test required in 10 CFR 71.73(c)(4). The staff notes that SS can be found in applications where high temperature oxidation resistance and strength are required. The high chromium content which is essential to the wet corrosion resistance is also very beneficial to their high temperature strength and resistance to scaling at elevated temperatures. Therefore, the staff finds that stainless steel is acceptable for use as a nameplate and plugs to prevent air ingress into the package in fire events.

Finally, the applicant clarified various components as “not important to safety,” and changed their designations to more generic material for manufacturing flexibility. The staff finds the generic material designations to be acceptable, since the components are not important to safety and therefore, will not affect the ability of the package to meet the requirements in 10 CFR Part 71.

2.3 Evaluation Findings

The staff finds that the QSA Global SENTRY transportation package meets the regulatory requirements for normal conditions of transport and hypothetical accident conditions temperatures; for ensuring that there will not be significant galvanic, chemical or other reactions; and the package is constructed with materials and using processes in accordance with acceptable industry codes and standards.

5.0 SHIELDING EVALUATION

QSA requested changes to the drawings to remove tolerances on the DU shield and revise the acceptance criteria, which specifies when supplemental shielding is required before final assembly of Model Numbers Sentry 110, 330, and 867. The objective of this review is to verify that the dose rates from the Model Numbers Sentry 110, 330, and 867 will continue to meet the shielding requirements in 10 CFR 71.

5.1 Description of Shielding Design

The applicant did not request changes to the actual design of any of the package models described in this application. The applicant made changes to the drawings to reflect some uncertainty in the exact fabrication since there is some inherent variability. Typically, per NUREG-5502, “Engineering Drawings for 10 CFR Part 71 Package Approvals,” and Spent Fuel Project Office Interim Staff Guidance No. 20 (ISG-20), “Transportation Package Design Changes Authorized Under 10 CFR Part 71 Without Prior NRC Approval,” these uncertainties are captured via tolerances or minimum design dimensions. NUREG-5502 and ISG-20 explain that these tolerances allow minor variations that do not affect the safe operation of the package while still complying with the CoC.

Furthermore, NUREG-1609 “Standard Review Plan for Transportation Packages for Radioactive Material” instructs the reviewer to “ensure that any changes in configuration (e.g., displacement of source or reduction in shielding) resulting under normal conditions of transport or hypothetical accident conditions have been included.” NUREG-1609 states that the reviewer may consider other factors in-lieu of a bounding analysis. Per ISG-20, demonstration of compliance should facilitate inspection activities. After review, staff finds that a specified, minimum DU thickness can only be determined by destroying the package, which facilitates neither safe operation nor inspection of the parameter.

NRC Regulatory Issue Summary 2013-04 “Content Specification and Shielding Evaluations for Type B Transportation Packages” (RIS 2013-04) includes a discussion on this issue. An example in the RIS allows for evaluation based on measurement when the certificate holder has well-defined, single-radionuclide sources that are special form material. The same example also utilizes a reference source of the same material as the production source within prototype packages, thus allowing a direct comparison of dose rates for the source material shipped. Prior staff review has found a methodology identical to the applicant’s to be acceptable.

Considering the example in RIS 2013-04 and the inability to inspect a minimum DU shield thickness, staff finds the applicant's changes to drawing R86000 Sheet 9 Rev. U in the application to be acceptable.

Since the applicant has provided enough information with the measured pre- and post-test dose rates to estimate the shielding effectiveness, staff finds there is enough information to perform a confirmatory analysis (Section 5.3.3 of this safety evaluation report). As a result, staff finds that there is sufficient information to perform an evaluation of the QSA Global Model Numbers Sentry 110, 330, and 867.

5.2 Radiation Source

The QSA Global Models Sentry 110, 330 and 867 all contain special form ^{60}Co sources. The maximum mass and activities are given in Table 1.2a of the application. QSA did not propose any change to these previously reviewed radiation sources.

5.3 Shielding Evaluation

5.3.1 Methods

The applicant did not perform any analysis on the design. Instead, the applicant conducted a series of tests with prototypes and measured the dose rates after each test. The applicant designed the tests to meet the criteria for normal conditions of transport (10 CFR 71.71) and hypothetical accident conditions per 10 CFR 71.73.

Prior to final fabrication, the applicant also conducts a thorough scan of the shield assembly to determine acceptability or whether additional shielding is needed to meet the dose rate requirements in 10 CFR 71.47 and 10 CFR 71.51. After final assembly, each package is measured to determine the package's dose rates. It is this acceptance test on the package that the applicant intends to provide reasonable assurance that the package meets the external radiation requirements of 10 CFR 71.47 and 71.51.

5.3.2 External Radiation Levels

The applicant provided a summary table of the maximum radiation levels observed post-testing from the prototypes in Tables 5.1a-g of the application. Staff noted that these are measurements taken from specific packages and, given the applicant's proposed changes to the acceptance criteria on Drawing R86000, Sheet 11, Rev. U, the dose rates the applicant presented may not be bounding.

5.3.3 Confirmatory Analysis

Staff performed confirmatory analysis with MAVRIC, a fixed-source, Monte-Carlo particle transport code that is part of the SCALE 6.2.1 software package. Staff used a 19-group photon cross-section library based on ENDF/B-VII nuclear data. Since this analysis was comparative, staff used a simplified model consisting of spherical shells comprised of the same materials as the source tube, DU shield, and steel shell. Staff modeled the shell thicknesses to match the reference dimensions provided by the applicant and modeled the space between the DU sphere and the steel shell sphere as void. Staff modeled the source as a point-source at the origin, with point detectors at the DU surface, the steel shell surface, and at 1 m. Staff varied the density of the DU shield in 1% increments from 90% to 100%. Staff also modeled spherical voids at various locations in the DU shield between source and detector. Staff varied the radius of the spherical voids (roughly from 0.09 to 0.9 cm), and staff included cases that offset the voided region from the direct path between the source and detectors. Based on the results of these analyses, staff also evaluated the relative reduction in observed dose rates in selected cases at the surface and at 1 meter from the package with a 0.5-inch thick DU cylinder with the same diameter as the supplemental shielding discs attached to the outside of the DU sphere. Staff results showed that minor changes to density will result in significant increase in surface dose rate (e.g., the dose rate more than doubles with a 5% reduction in overall density). Staff analysis showed that small voids will result in significant increase in observed dose rate at the surface nearest the void space (e.g., dose rates may increase by a factor of 4 with a 0.53 cm radius void). Staff analysis also showed that voiding near the inner and outer surface of the DU component was more limiting than voiding toward the middle.

Staff analysis used a point detector to evaluate the change in dose rate. However, as indicated by the surface correction factor on the sample Shielding Profile and Inspection Form, previously submitted by QSA, the detector used by the applicant is not a single point and interacts with photons over a finite volume. As a result, the staff's calculated surface dose rates will show an overly conservative angular sensitivity. Staff's results from dose rates at 1 m showed much less sensitivity to the void shifting one or two diameters off the direct line between source and detector. In Section 8.1.6 of the application, the applicant describes the measurement as a "slow scan survey." Considering the void size necessary to exceed the remediation capability of the maximum allowed supplemental shielding, the speed of the survey, and the size of the sensitive volume of the probe, staff finds that the applicant's acceptance procedures will detect significant deficiencies in shielding performance.

Casting of DU, like all heavy metal casting, results in the creation of small voids and some amount of porosity is expected. The applicant has shown a long operational history of casting DU shield assemblies and has observed that defects rarely result in subtle changes to the dose rates observed during acceptance testing. The applicant provided information showing that none of the previously accepted shielding assemblies have ever failed a subsequent pre-shipment measurement. Staff results, discussed above, showed that even with small voids or an overall reduction in density, deficiencies in the shielding performance are likely to be detected during acceptance. Staff analysis showed that supplemental shielding up to 0.5 inches would suffice except in cases of extreme shield-assembly deficiency that would not pass the applicant's acceptance criteria. For these reasons, staff finds with reasonable assurance the package meets the requirements of 10 CFR Part 71 with supplemental shielding.

5.4 Summary

For reasons discussed in Sections 5.3 of this safety evaluation report, given a maximum of 0.5 inches of stacked supplemental shielding, staff finds the applicant's acceptance tests and supplemental shielding sufficient to detect and compensate for minor deficiencies in the shield assembly. Thus staff finds the applicant's proposed changes to drawing R86000 Rev. U will not adversely affect the safe operation of the package and the staff has reasonable assurance that the package will meet the shielding requirements in 10 CFR Part 71.

CONDITIONS

The package description in Condition 5(a) was edited to state that “the primary components of the SENTRY packages” instead of “the Model No. SENTRY package.”

Condition No. 5(a)(3) was revised to include Drawing No. R86000, Rev. U, sheets 1-11.

The Condition 5(c)(2) was revised to remove the specification that the package contents can be measured in output curies instead of content curies.

Condition No. 10 was added to authorize continued use of the previous revision for up to 1 year and previous Condition Nos. 10 and 11 were renumbered accordingly.

The references section has been updated to include this application and its supplements.

CONCLUSION

Based on the statements and representations in the application, as supplemented, and with the conditions listed above, the staff agrees that, with these changes, the package continues to meet the requirements of 10 CFR Part 71.

Issued with CoC No. 9357, Revision No. 6,
on December 7, 2017.