SAFETY EVALUATION REPORT

Docket No. 71-9185
Model No. OP-100
Certificate of Compliance No. 9185
Revision No. 10

SUMMARY

By letter dated July 21, 2015, as supplemented August 3, 13, and 17, September 22, 23, and 30, 2015, Industrial Nuclear submitted an amendment request to revise the certificate of compliance (CoC) for the Model No. OP-100 package. The applicant revised the shielding and thermal sections of the safety analysis report (SAR) to allow the use of Selenium-75 as a radiation source. In addition, the applicant reformatted the SAR in accordance with Regulatory Guide 7.9, Revision 2. 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, as supplemented, the staff agrees that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

1.0 GENERAL INFORMATION

1.1 Content Description

The applicant revised the SAR content description to allow transport of selenium-75 (Se-75), in a special form capsule, inside the authorized contents of the OP-100: either an IR-100 radiography device or an IR-50 source changer. The applicant identified the maximum amount of Se-75 to be loaded into the package as 120 Curies (Ci). Staff found this change acceptable since it adequately identified the maximum amount of radioactive material allowed in the package as well as the form of the material.

1.2 Findings

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

2.0 THERMAL EVALUATION

The applicant sought authorization to ship a special form Se-75 source capsule inside either an IR-100 exposure device or an IR-50 source changer using the OP-100 package. The objective of this review was to verify that the package design satisfies the thermal requirements of 10 CFR Part 71 under normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

2.1 Decay Heat

The OP-100 was previously approved for up to 120 Ci of Ir-192 in a special form capsule and the applicant sought approval for 120 Ci of Se-75 in a special form capsule as well. The applicant stated that the radiolytic decay heats of Ir-192 and Se-75 are 7.03×10^{-3} W/Ci and 2.41×10^{-3} W/Ci, respectively. The staff confirmed the heat load of Ir-192 bounds the heat load of Se-75. Therefore, the maximum heat load for the OP-100 is 0.84 watts. The staff reviewed the package description and evaluation relative to the changes associated with this request and concluded that they satisfy the thermal requirements of 10 CFR Part 71.

2.2 Material Properties and Component Specifications

The applicant described the OP-100 components and their material properties in SAR section 3.2. The applicant explained that the OP-100 package consists of a 10-gallon steel drum which houses a plywood support structure and either an IR-100 radiography device or an IR-50 source changer. The applicant further explained that the carbon steel drum consists of a body with a lid which is attached to the body using a carbon steel closure ring. The applicant stated both the IR-100 radiography device and the IR-50 source changer are constructed of a stainless steel outer skin surrounding polyurethane and a depleted uranium (DU) gamma shield. The applicant identified the melting temperatures for DU and stainless steel are 2,071°F and 2,800°F respectively.

The staff reviewed the material properties and component specifications provided in the SAR and confirmed that the thermal properties and component specifications for the OP-100 package are unchanged when loaded with Se-75. Therefore, the staff concluded that the material properties and component specifications, as described in the SAR, provide a sufficient basis for evaluation of the package against the thermal requirements of 10 CFR Part 71.

2.3 Thermal Evaluation Under NCT

The applicant stated in SAR section 3.3 that the calculated surface temperature is 137°F with a heat load of 0.84 watts, an ambient temperature of 100°F and maximum insolation under NCT. In addition, the applicant asserted that, with a heat load less than 1 watt, the peak internal temperatures will closely match the package surface temperatures. Similarly, the applicant asserted that the OP-100 surface temperature will be equal to ambient under the lower temperature conditions of -20°F and -40°F at which the DU and stainless steel have been tested. The applicant also stated in SAR 3.3 that the maximum temperature for all surfaces of the OP-100 in shade with an ambient temperature of 100°F is 100°F.

The applicant explained in SAR section 3.3.2 that containment for the OP-100 is provided by the special form capsule, and that gas can freely flow from the internal cavity to the environment. Consequently, the applicant claimed that there is neither a pressure boundary, nor a maximum normal operating pressure for the OP-100 package.

The staff reviewed the changes in the SAR and confirmed that the thermal design and features of the OP-100 package are unchanged by the proposed amendment. The staff also confirmed that the maximum allowable service temperatures of all components remain unchanged and the minimum allowable service temperature of all components is still -40°F, in compliance with 10 CFR 71.71. The staff also determined that the OP-100 package has neither a pressure boundary nor a maximum normal operating pressure. The staff found that the OP-100 material

and component temperatures will not exceed the specified allowable limits (melting points) during NCT for shipment with Se-75 and are consistent with the tests specified in 10 CFR 71.71.

2.4 Thermal Evaluation Under HAC

The applicant performed the HAC 30-minute thermal test in an oven, as described in SAR section 3.4, with a minimum temperature of 1,475°F at the package surface. During heat up, burning of the polyurethane foam was observed. Following the 30-minute fire test, the package was removed from the oven and cooled in air, in compliance with 10 CFR 71.73. After completion of the test, the applicant examined the package and found that both the plywood support structure and polyurethane foam were completely consumed by the fire, adding their combustion energy to the package. However, the depleted uranium shielding and the outer stainless steel skin of the payload (either the IR-100 radiography device or the IR-50 source changer) were neither compromised nor appreciably oxidized. The peak temperatures in the test were still well below the melting temperatures of stainless steel (2,800°F) and DU (2,071°F).

The staff reviewed the HAC thermal evaluation in SAR section 3.4 and inquired of the applicant if the HAC test procedures had been changed. The applicant responded that both the fire test procedures and conditions had not changed (Agencywide Documents Access and Management System (ADAMS) accession number ML15226A470). Therefore, staff accepted the test procedures and conditions for shipment of Se-75 in the OP-100 package. The staff reviewed the thermal features of OP-100 and confirmed that both the stainless steel and the DU, enclosing the Se-75 capsule, have melting points of 2,800°F and 2,071°F, respectively. Since these temperatures are greater than the fire temperature of 1,475°F, the staff determined that neither the stainless steel nor the DU will significantly degrade in a HAC fire. The staff also confirmed that the thermal features and test conditions for the OP-100 package with Se-75 remain unchanged from the previously approved conditions.

The staff reviewed the package design and evaluation. Staff concluded that the package material and component temperatures will not degrade in the HAC fire test because the melting points of stainless steel and DU are much higher than the 1475°F fire temperature. The staff also confirmed that the thermal evaluation and the fire test, described in SAR 3.4 for the OP-100 package with Se-75 payload, meet the thermal requirements specified in 10 CFR 71.73.

2.5 Evaluation Findings

Based on review of statements and representations in the proposed amendment, the staff determined that the thermal design and features of the OP-100 package are unchanged from the conditions previously approved by the NRC and meet the thermal requirements of 10 CFR Part 71 for shipment of special form Se-75.

3.0 SHIELDING EVALUATION

The objective of this evaluation was to verify that the OP-100 package, with either an IR-100 radiography device or an IR-50 source changer containing 120 Ci of Se-75 in special form, meets the regulatory requirements of 10 CFR 71.47 and 71.51 for external dose rate limits of radioactive materials transportation packages under NCT and HAC.

3.1 Shielding Design Description

The OP-100 transportation package was previously approved for transporting either an IR-100 radiography device or an IR-50 source changer containing a maximum of 120 Ci of Ir-192 in special form. This amendment requested adding 120 Ci of Se-75 in special form contained in either an IR-100 or an IR-50 as allowable content for the OP-100.

The applicant described the OP-100 packaging as consisting of a 10-gallon steel drum with a plywood supporting structure inside to house either one Industrial Nuclear Co., Model No. IR-100 (NRC Docket No. 71-9157) radiography device or one Industrial Nuclear Co. Model No., IR-50 source changer. The applicant explained that either the IR-100 radiography device or the IR-50 source changer would be centered within the OP-100 overpack by the plywood structure inside the 10-gallon drum. The applicant demonstrated that the OP-100 structure meets DOT/UN standards No. 1A2/X150/S.

The applicant identified the primary shielding for the OP-100 as the DU shield, encased in 12-gauge, type 304 stainless steel shell, of either the IR-100 radiography device or the IR-50 source changer. The applicant stated that a pigtail assembly, along with a lock box and lockball, secures the source in the center of the DU shield for either the IR-100 radiography device or the IR-50 source changer. Licensing drawings IR 100-1B and IR 50-1B provided by the applicant indicated that the minimum DU thickness is 1.78 inches. The applicant also asserted that the OP-100 package is designed for non-exclusive use and that the transport index, which is determined by pre-ship measurement, shall not exceed 10.

Based upon a review of the shielding design information provided by the applicant, staff determined that the OP-100 shielding design is adequately described

3.2 Radiation Source Specification

The amendment requested to add a single source of 120 curies of Se-75 in special form contained in either the IR-100 radiography device or IR-50 source changer as allowable content. The radioactivity of this new content is the same as the previously approved Ir-192 source.

3.3 Shielding Model

For original issuance of the certificate of compliance with an Ir-192 source, the applicant demonstrated compliance with the regulations by performing the tests described in 10 CFR 71.71 and 10 CFR 71.73 and measured the subsequent package dose rate. The applicant reported the measured dose rates in Table 5-1. However, staff noted that dose rates reported in Table 5-1 were confusing and asked the applicant to clarify the information provided. The applicant responded by e-mail on August 17, 2015 (ADAMS accession number ML15237A279). In preparing the SER, staff noted that the dose rates for NCT in Table 5-1 did not appear in Sections 2.12.1.7.1.5, 2.12.1.7.3.4 and 2.12.1.7.4.3 of the SAR and requested the applicant to explain and to justify this discrepancy. The applicant provided additional information via e-mail on September 22, 23, and 30, 2015 (ADAMS accession numbers ML15279A224, ML15266A141, and ML15266A354).

From their responses, staff determined the applicant demonstrated compliance with 10 CFR 71.71 as follows:

1. measured dose rates of 151 mrem/hr at the surface of an IR-50 source changer and 1.5 mrem/hr at one meter from the surface of an IR-50 source changer with a 110 Ci Ir-192 source, and;
2. used the ratio 120/110, i.e.; 1.091, to calculate a dose rate of 165 mrem/hr on the surface of an IR-50 source changer and 1.6 mrem/hr one meter from the surface of an IR-50 source changer for a 120 Ci Ir-192 source.

The applicant reported the 165 mrem/hr and 1.6 mrem/hr dose rates in Table 5-1 for a 120 Ci Ir-192 source. Staff noted that the dose rates for the OP-100 should be much lower than those reported by the applicant because of the additional shielding and distance from the source provided by the structure of the OP-100 overpack. Based on measurement, the applicant determined that the Transport Index for the OP-100 containing 120 Ci of Ir-192 in an IR-50 source changer will not exceed 1.6. The staff also noted that the actual TI should be much smaller for the OP-100 because of the additional shielding and distance from the source provided by the structure of the OP-100 overpack.

For HAC, staff determined the applicant demonstrated compliance with 10 CFR 71.73 as follows:

1. performed the tests as prescribed in 10 CFR 71.73,
2. after performing the tests described in 10 CFR 71.73, measured a dose rate of 1.3 mrem/hr at one meter from the surface of the IR-50 source changer using an 83 Ci Ir-192 source, and
3. used the ratio of 120/83, i.e., 1.4458, to calculate a dose rate of 1.9 mrem/hr for a 120 Ci Ir-192 source.

The applicant reported the 1.9 mrem/hr dose rate one meter from the surface of the package under hypothetical accident conditions in Table 5-1. Staff noted that the dose rates for the OP-100 should be much lower than those reported by the applicant because of the additional shielding and distance from the source provided by the structure of the OP-100 overpack.

The applicant compared the gamma constants of Ir-192 and Se-75 and demonstrated that the gamma constants are 0.460 and 0.203 rem per hour per curie of radioactivity respectively. Staff reviewed the gamma constants used by the applicant to the data in the latest publications [Refs. 1, 2], and determined that the applicant used conservative values. This comparison demonstrated that, for the same radioactivity and shielding design, the Ir-192 source bounds the Se-75 source.

3.4 Conclusions

The staff reviewed the description of the package shielding design and the source terms. The staff also reviewed the design method and the maximum dose rates of the package under NCT and HAC. Based on its review, the staff determined that the applicant's design approach, i.e., demonstration of compliance with the regulation by testing, is acceptable. The staff also found that the radiation intensity of Se-75 is much lower than that of Ir-192 with the same radioactivity, based on the comparison of their respective gamma constants, which account for the decay scheme, energy spectrum, and the number of photons emitted per curie of activity. Therefore, the special form source strength of 120 Ci of Ir-192 bounds that of a single special form source of 120 Ci of Se-75.

3.5 Evaluation Findings

Based on the staff's review of the statements and representations provided in the application, the staff has reasonable assurance that the shielding design of the OP-100 package with the proposed contents meets the regulatory requirements of 10 CFR 71.47 and 71.51.

References:
1. M. M. Ninkovic, et. al., "Air Kerma Rate Constants for Gamma Emitters," Radiation Protection Dosimetry (2005), Vol. 115, No. 1–4, pp. 247–250.
2. P. Hayward, et., al., "Radiography of Welds Using Selenium 75, Ir 192, and X-ray," 12th A-PCNDT 2006 – Asia-Pacific Conference on NDT, 5th – 10th Nov 2006, Auckland, New Zealand.

CONDITIONS

The CoC includes the following condition(s) of approval:

Condition 5(a)(2) was revised to incorporate Se-75 into the package description.

Condition 5(b)(1) was revised to incorporate Se-75 as allowable contents.

The references section has been updated to include this request.

Minor editorial corrections were made.

CONCLUSIONS

Based on the statements and representations contained in the application, as supplemented, and the conditions listed above, the staff concludes that the design has been adequately described and evaluated, and the Model No. OP-100 package meets the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9185, Revision No. 10
on October 20, 2015.