

SAFETY EVALUATION REPORT
Docket No. 71-5757
Model No. Neutron Source Shipping and Installation Container
Certificate of Compliance No. 5757
Revision No. 9

SUMMARY

By application dated May 26, 2005, as supplemented August 25, 2006, the Department of Energy, Naval Reactors, requested an amendment to Certificate of Compliance No. 5757, for the Model No. Neutron Source Shipping and Installation Container. Naval Reactors requested that the authorized contents be revised to delete the term "special form" in the description of the neutron sources. Naval Reactors stated that, although the sources are double encapsulated and fully welded sources, there is no documentation that demonstrates the sources meet the testing requirements for special form, as described in 10 CFR 71.75.

The Certificate has been amended to delete the special form designation from the description of the authorized contents, and to limit the approval to existing sources. These changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

BACKGROUND

Naval Reactors originally submitted the application for approval of the neutron source shipping package on February 14, 1968. The application included a description of the neutron sources that would be shipped in the container. On July 22, 1968, the NRC issued a letter to Naval Reactors that concluded that the neutron sources, as described in the application, met the requirements for special form radioactive material. Therefore, when Revision No. 0 of Certificate of Compliance No. 5757 was issued, on May 23, 1978, the certificate included the special form designation in the description of the authorized contents.

In requesting that the special form designation be deleted, Naval Reactors stated that the DOE certificate for the package has never included the special form designation for the sources. Naval Reactors also stated that no new sources would be fabricated for shipment in this package. The only future shipments of the package will be the final shipments for disposal of the existing sources.

EVALUATION

Packaging

The Neutron Source Shipping and Installation container consists of two primary components: (1) the outer shipping container, including polyethylene shielding within a ½-inch thick carbon steel shell, which is closed by a bolted and gasketed cover; and (2) the inner container composed of an inner tube that houses the sources, surrounded by a shield structure composed of steel-encapsulated lead and polyethylene. The overall

dimensions of the package are approximately 9 feet, 5 inches in length and 5 feet, 5 inches in diameter. The maximum weight of the package is approximately 19,000 pounds.

Contents

The package is designed for the shipment of certain neutron sources, including plutonium-beryllium and radium-beryllium sources. The sources may be irradiated, and may include surface contamination as a result of previous use. Up to three sources may be shipped, and the maximum neutron emission rate is specified in the certificate. The total surface contamination on the three sources is limited to not more than an A₂ quantity of radioactivity.

In the supplement dated August 25, 2006, the applicant provided information regarding the neutron sources to be shipped in the package. The sources are double encapsulated in Type 304 stainless steel and completely welded closed. The acceptance tests for the sources included 100 percent radiographic examination and liquid penetrant testing of the welds. A pressurized helium leak test using mass spectrometry was also used to ensure leak-tightness.

For the purpose of evaluating the containment integrity of the sources, the most limiting sources were identified as plutonium-beryllium sources that were manufactured in the 1967 to 1968 time-frame.

Structural

Although the sources were not subjected to the test conditions for special form radioactive material, specified in 10 CFR 71.75, the applicant provided information that shows the sources would maintain their structural integrity under normal conditions of transport and hypothetical accident conditions. The applicant provided an evaluation of the sources for the following conditions:

- The structural integrity of the inner capsule due to the build-up of gas pressure from radioactive decay products.
- The structural integrity of the outer capsule to withstand the 30-foot drop test condition.
- The structural integrity of packaging components that could affect the sources under the 30-foot drop test condition.

The applicant identified buildup of internal pressure in the source capsules as the limiting concern regarding source containment integrity. During the decay process, helium gas is formed which causes an increase in internal pressure. The applicant evaluated the ability of the sources to maintain their structural integrity with the internal pressure that builds up over time. The applicant calculated the maximum allowable internal pressure that would still result in stresses within the inner capsule that are below the yield strength of the Type 304 stainless steel.

The maximum radial displacement of the inner capsule due to the internal pressure of 4.1 ksig at 230°F was 1.55E-4 inches from ANSYS calculations. Since this is less than the clearance of 5E-3 inches, the outer capsule will not be affected by the deformation of the inner capsule wall. The maximum axial deflection was calculated to be 8.6E-4 inches, and because of the possibility of zero clearance, the end cap's upward motion may be constrained. This case was re-analyzed using the ANSYS computer code. The results showed that the maximum stress increased to 24.8 ksi, still less than the allowable, and the radial deflection remained well below the radial clearance. Thus, the maximum internal pressure can be allowed up to 4000 psig without compromising the structural integrity of the inner capsule.

The applicant showed that the source pressures were within this allowable pressure, provided that the sources were shipped prior to February 2013. The calculations were performed for the group of most limiting plutonium-beryllium source in terms of age and quantity of radioactivity. The radium-beryllium sources are bounded by the calculations for the plutonium-beryllium sources.

The applicant also evaluated the structural integrity of the outer source capsule due to impact under the 30-foot drop test in 10 CFR 71.73. The applicant estimated the maximum g-loads that the sources would experience under top end, bottom end, and side drops. The structural integrity of the outer capsule was evaluated, considering the loading of its own weight. The structural analysis indicated that the sources could withstand these impact forces with a large margin of safety. The staff noted that the combined loads of pressure and impact were not considered for either the inner or the outer capsule. The staff concluded that the outer capsule would not be subjected to the combined loads. If the inner capsule failed due to the combined loads under drop test conditions, the outer capsule could withstand the resulting internal pressure loading, since its wall thickness is greater and since the resulting internal pressure would be less than that calculated for the inner capsule.

In addition, the failure of other packaging components, such as the bottom end block, was evaluated. Failure of these other packaging components could subject the sources to additional crushing loads. The g-loads required to cause other packaging components to fail were significantly greater than the calculated g-loads for the 30-foot drop. The applicant therefore concluded that the source capsule would retain its structural integrity under drop test conditions. The staff agrees with the applicant's conclusion that the sources would retain their structural integrity under normal conditions of transport and hypothetical accident conditions.

Thermal

The package was previously evaluated under the normal conditions (heat and cold) and the fire test conditions. Deleting the special form designation of the sources does not affect the performance of the package under these conditions and tests.

Containment

The radioactive material is contained within sealed sources. Each source is suspended within a source tube by a source installation shaft. The source tube is closed by the container cap assembly.

The sources are subject to helium buildup inside the source capsule as a result of the alpha radiation emitted by the plutonium or radium in the source. Staff reviewed the applicant's calculations of the rate of production of helium in the sources. These calculations are conservative in that they assumed all alpha decays resulted in the production of a helium atom. This ignored all the alpha decays that result in activation of the beryllium and the emission of a neutron. Also, the activity was only calculated at the beginning of each five year period. Thus, the activity used for the calculations was higher than that actually present in the source. Additionally, a 5 percent margin was built into the calculation of the time to reach the maximum pressure to account for other gas production. The applicant's calculations show that for the limiting source, the pressure build-up due to helium production will not effect the structural integrity of the source until at least 2013. Similarly, the analysis for the other sources shows that their structural integrity is not affected by the internal pressure until at least 2032. If disposition of the limiting source has not occurred by 2013, and for the other sources by 2032, the applicant would need to re-evaluate the helium buildup with more realistic assumptions. Since the package is grandfathered under the provisions of 10 CFR 71.19(a), any sources must be shipped in the package prior to October 1, 2008.

The previous evaluation of the package showed that the sources would be retained within the package (inner shielding container and outer shipping container) under normal and accident conditions. The radioactive material is doubly encapsulated within fully welded stainless steel enclosures. The applicant provided analyses that showed that the sources would maintain their structural integrity under normal and accident conditions, as described above. Since the sources would maintain their structural integrity and the package would retain the sources within the inner cavity under normal conditions of transport and hypothetical accident conditions, the staff agrees that deleting the special form designation does not affect the ability of the package to meet the requirements of 10 CFR 71.51 for Type B packages.

Shielding

The previous evaluation of the package showed that the package meets the dose rate limits in Part 71 under normal and accident conditions. Since the sources maintain their structural integrity under normal and accident conditions, deleting the special form designation does not affect the ability of the package to meet the requirements of 10 CFR 71.47 and 10 CFR 71.51 regarding external dose rates.

Package Operations

There were no changes to the package operating procedures. The applicant has shown that the radioactive material is not dispersible and that the sources will maintain their structural integrity under normal and accident conditions. The package is not leak tested prior to shipment. However, since the sources are doubly encapsulated and fully

welded, the applicant concluded and the staff agrees that the package meets the containment requirements without leakage testing.

Acceptance Tests and Maintenance Program

There were no changes to the package acceptance tests or maintenance program. The applicant stated that the stainless steel sources are corrosion resistant due to their construction (doubly encapsulated with Type 304 stainless steel). The acceptance tests for the sources included 100 percent radiographic examination and liquid penetrant testing of the welds. A pressurized helium leak test using mass spectrometry was also used to ensure leak-tightness.

CONCLUSION

The applicant provided evaluations that showed that the neutron sources would maintain their structural integrity under normal conditions of transport and hypothetical accident conditions. Therefore, the description of the contents was revised to delete the special form designation for the neutron sources. In addition, the certificate was revised to clarify that only currently existing sources are authorized for transport (new Condition No. 7).

Editorial changes were made to the packaging description in Condition No. 5(a)(2), and the contents description in Condition Nos. 5(b)(1)(i) and (ii). Condition No. 5(c) was revised to delete reference to Transport Index for Criticality Control, consistent with 10 CFR 71.4 that defines the Criticality Safety Index. Condition No. 9 was added to authorize use of the previous revision of the certificate for a period of approximately one year.

The staff has concluded that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 5757,
Revision No. 9, on 2/2/2007.