



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

SAFETY EVALUATION REPORT

**Docket No. 71-9355
Model No. 435-B
Certificate of Compliance No. 9355
Revision No. 1**

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SUMMARY

The U.S. Department of Energy, National Nuclear Security Administration (NNSA or the applicant), requested a revision to the Certificate of Compliance (CoC) for the Model No. 435-B packaging by application dated June 9, 2016 (Agencywide Document Access and Management System (ADAMS) Accession No. ML16250A245), as supplemented on the following dates:

- 1) August 25, 2016 (ADAMS Accession No. ML16246A189),
- 2) October 26, 2016 (ADAMS Accession No. ML16347A463), and
- 3) December 13, 2016 (ADAMS Accession No. ML16349A231).

In summary, the applicant proposes the following revisions to the design of the Model No. 435-B package:

- 1) Change the called for tempers for aluminum alloy 6061 to align the 6061 aluminum alloy description according to the American Society of Mechanical Engineers (ASME) specifications and temper designations,
- 2) Change the licensing drawings with respect to welds and weld symbols to conform with American Welding Society's (AWS's) A2.4,
- 3) Apply corrections to facilitate manufacturing and operations of the package,
- 4) Expand the description of the material of construction to align with the American Society for Testing and Materials (ASTM) specifications, and
- 5) Delete Radium-226 (^{226}Ra) from the list of authorized contents.

The packaging consists of a base; a bell cover; an internal lodgment, which supports the Long Term Storage Shield (LTSS); an inner container, which supports shielded devices; and two internal impact limiters. Unless noted, all elements are made of Type 304 stainless steel in conformance with ASTM A240. The package is designed to be transported singly, with its longitudinal axis vertical, by ground, air, or by water in non-exclusive use. The 435-B package provides a leaktight containment of the radioactive contents under all normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

The NRC staff (the staff) reviewed the application, including relevant supplemental information, 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, and the conditions listed below, the staff concludes that the package meets the requirements of Title 10 of the *Code of Federal Regulation* (CFR) Part 71.

1.0 GENERAL INFORMATION

1.1 Packaging

Section 1.2.1 of the safety analysis report (also referred as “the application” in this document) provides a detailed description of the packaging. Section 1.1, “Packaging,” of the safety evaluation report (SER) for revision 0 of the CoC of the Model No. 435-B (ADAMS Accession No. ML14199A693) includes a brief description of the structural protection features for the 435-B package. The principal structural components of the Model No. 435-B package are as follows:

- a. Lower Body Assembly (Base)
- b. Upper Body Assembly (Bell)
- c. Lodgment/LTSS
- d. Inner Container/Shielded Device
- e. Internal Impact Limiters

The “Summary” section of this SER includes a discussion of the changes requested by the applicant. Among the changes, the applicant requested changes to the called for tempers for aluminum alloy 6061 used to fabricate the lodgment and the internal impact limiters and adding an option of center hole to the lower torispherical head for manufacturing purposes. The applicant also asked to expand the description of the material of construction to align with the ASTM specifications as well as changes related to the fabrication of the Model No. 435-B.

1.2 Drawings

The packaging is constructed in accordance with the following AREVA Federal Services LLC drawings:

- a. 1916-01-01-SAR, “435-B Package Assembly SAR Drawing,” sheets 1-7, Revision 5
- b. 1916-01-02-SAR, “435-B LTSS Lodgment SAR Drawing,” sheets 1-2, Revision 2
- c. 1916-01-03-SAR, “435-B Inner Container SAR Drawing,” sheets 1-2, Revision 3

The applicant revised all the drawings to reflect the changes related to this licensing action request. The staff reviewed the drawings and found them to be an adequate representation of the package. The drawings included dimensions, package markings, materials of construction, and the codes and standards used to design the package.

1.3 Contents

The applicant requested to remove ²²⁶Ra as authorized content for the Model No. 435-B and to delete Note 3 of Table 1 (in Condition No. 5.(b)(2)(i)) of the CoC for the Model No. 435-B). Note 3 of Table 1 of the CoC, Revision 0, read “Impurities may include oxygen, carbon, sulfur, bromine, and chlorine (hydrous and anhydrous).” The staff removed Note 3 because it is related to ²²⁶Ra, which is no longer an authorized content for the Model No. 435-B.

The staff has reviewed the description of the contents and concludes that it meets the requirements of 10 CFR Part 71.

2.0 STRUCTURAL EVALUATION

The purpose of this evaluation is to verify that the proposed changes to the design of the 435-B transport package provide adequate protection against loss or dispersal of radioactive contents and to verify that the package design meets the requirements of 10 CFR Part 71 under NCT and HAC. The applicant requested several changes that included clarifying text in the application and expanding flexibility in manufacturing.

2.1 *Description of Structural Design*

The principal structural components of the Model No. 435-B package are as follows:

- a. Lower Body Assembly (Base)
- b. Upper Body Assembly (Bell)
- c. Lodgment/LTSS
- d. Inner Container/Shielded Device
- e. Internal Impact Limiters

Section 1.2.1 of the application and Section 1.1, "Packaging," of the SER for Revision 0 of the CoC of the Model No. 435-B include a description of the structural protection features for the 435-B package.

2.1.2 Design Criteria

The design criteria for the Model 435-B package remained unchanged.

2.2 *Mechanical Properties of Materials*

The applicant requested correcting the temper specifications for aluminum alloy 6061 because, for some sizes and shapes of aluminum stock, the T651 temper for aluminum alloy 6061 is not available. The applicant revised the text in the application to consistently refer to the aluminum alloy used to fabricate the lodgment and the components of the internal impact limiters as 6061-T6. In the drawings included in Section 1.3.3 of the application, the applicant changed the tempers to T6 with the option to use T651, T6510, or T6511. The mechanical properties of aluminum listed in Table 2.2-4 are unchanged and remain applicable. The proposed changes to the tempers utilized will not affect thermal properties and shielding performance of the package.

The staff notes that the tempers mentioned in the paragraph above are variants of aluminum alloy 6061 and share alloy composition and many physical properties, but develop different mechanical property values as a result of different processing. Tempers T651, T6510, and T6511 processing include solution heat treatments, stress relieved by stretching, and, then, artificial aging. Temper T6 is processed the same as these tempers with the exception of no stress relief. Both T6 and T651 tempers are recognized by the ASME, Boiler and Pressure Vessel (B&PV) Code, Section II, Part D. The staff reviewed various literature references of temperature dependent mechanical properties including:

- a. yield strength,
- b. ultimate tensile strength,
- c. allowable strength,
- d. elongation, and
- e. resilience.

The staff found that there were minor differences for these material properties between all tempers.

Based on the information reviewed by the staff, the staff finds that the Model 435-B transportation package meets the regulatory requirements for mitigating galvanic or chemical reactions, is unaffected metallurgically by cold temperatures, and is constructed with materials and by using processes in accordance with acceptable industry codes and standards. The staff also finds the proposed changes to the aluminum alloy 6061 tempers to be acceptable based on the above discussion. The staff has reasonable assurance that these materials will perform as intended for the Model No. 435-B design.

2.3 Fabrication

The applicant requested to add an optional center hole to the lower torispherical head in order to facilitate fabrication. The optional hole is no larger than that currently in the upper torispherical head. If such a hole is used for fabrication, it must be patched, welded, and subjected to liquid penetrant (LP) and radiographic inspection (RT). (Section 8.0, "Acceptance Tests and Maintenance Program Review," of this SER includes the staff's evaluation related to changes proposed by the applicant to the methods for examining welds.) The staff finds the repair methods specified in the application acceptable, since the applicant provided reasonable assurance by selecting a full volumetric RT inspection that will reveal any rejectable indications and subsequently allow a sound repair.

2.4 Normal Conditions of Transport and Hypothetical Accident Conditions

As discussed in the sections above, and in the "Summary" section of this SER, the applicant proposed changes to the design of the Model No. 435-B. Sections 2.2 and 2.3 of this SER, include the staff's evaluation as it relates to the performance of these materials as intended for the Model No. 435-B design. In terms of the request to add an optional center hole to the lower torispherical head (for manufacturing purposes), the applicant states that the hole will be no bigger than the hole in the upper torispherical head currently approved in the CoC, Revision 0, for the Model No. 435-B. This optional hole will be filled (repaired), ground smooth, and inspected using radiography (see Section 8.0 of this SER). In Section 2.6.5, "Vibration," of the application, the applicant estimated the maximum stresses due to vibration to be 979.2 pounds per square inch (psi) for the upper torispherical head material, which is less than the endurance limit of 13,216 psi according to Table I-9.2 of ASME B&PV, Section III. The staff assumed a maximum stress concentration factor of 4 (from Regulatory Guide 7.6, "Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels") for such a repair and finds that the fatigue limit due to vibration is less than the endurance limit for the material. Therefore, the staff finds that the changes requested by the applicant, including adding an optional center hole in the upper torispherical head will not affect the structural performance of the package under NCT or HAC.

2.5 Evaluation Findings

The staff reviewed documentation provided by the applicant to verify that statements presented by the applicant are accurate and within acceptable engineering practices. Based on the review of the statements, representations, and supplemental information to the application, the staff concludes that the structural design has been adequately described and evaluated and that the package has adequate structural integrity to meet the requirements of 10 CFR Part 71.

7.0 PACKAGE OPERATIONS

The purpose of this evaluation is to verify that changes to the operating controls and procedures of the 435-B transport package meet the requirements of 10 CFR Part 71. The applicant removed ^{226}Ra as contents in Tables Nos. 7.1-1, "Basic 435-B Limits," 7.1-2, "Watts Per Source Unit," and 7.1-5, "A_i Activity Limit." The applicant did not propose changes to the operating procedures depicted in Chapter 7, "Package Operations," of the application. The changes to Chapter 7 of the application do not impact the findings made by the staff in the SER for Revision 0 of the CoC for the Model No. 435-B. Therefore, the 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 be operated in a manner consistent with its evaluation for approval.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM REVIEW

8.1 Weld Examination

Examination and inspection of welds will be performed in accordance with the applicable requirements shown on the drawings. The applicant noted that several application drawings included a note that stated that all welds, excluding seal welds, will be subjected to LP inspection. The applicant added tack welds and intermittent welds to these notes. Liquid penetrant inspection of tack welds and intermittent welds is problematic because the LP inspection results in indications at the weld "starts" and "stops." These indications are not relevant in determining the acceptability of a tack or an intermittent weld. However, these LP inspections may result in large areas of pigmentation that may mask defects and, therefore, these areas of pigmentation are unacceptable. The applicant revised the statement(s) in the applicable drawings (in the application) to specify that seal, tack, and intermittent welds are excluded from the requirement for LP inspection. These welds will be subjected to visual inspection (VT).

The staff notes the following:

- 1) *Tack welds* - Tack welds are used as a temporary means of holding components in the proper location, alignment, and distance apart, until final welding can be completed. Subsequent to final welding, tack welds are ground to a feathered condition to ensure a smooth transition when consumed as part of the final welding. In addition, when tack welds used to install temporary attachments are to be removed, these are mapped, removed, ground flush, and subject to LP inspection and UT inspection to ensure minimum thickness.
- 2) *Intermittent welds* - Intermittent welds may be used when the loads do not justify continuous fillets.
- 3) *Visual inspection (VT)* - Visual inspections can only locate defects on the weld surface. However, LP inspection is often referred to as an extension of the VT method. In addition, the AWS D.1.1 Code states the following:

"welds subject to LP testing, in addition to VT, shall be evaluated on the basis of the requirements for VT."

The staff finds that excluding the tack and intermittent welds from the requirements for LP is acceptable based on the above discussion and that reasonable assurance exists that rejectable indications will be revealed by VT.

8.2 Evaluation Findings

Based on review of the statements and representations in the application, the staff concludes that the acceptance tests for the packaging meet the requirements of 10 CFR Part 71, and that the maintenance program is adequate to assure packaging performance during its service life.

CONDITIONS

The certificate of compliance includes the following condition(s) of approval:

Condition No. 3.(b), "Title and Identification of Report or Application," includes the date of the consolidated application for the Model No. 435-B.

Condition No. 5.(a)(3), "Drawings," contains the latest revision of the licensing drawings.

Condition No. 5.(b)(2)(i), "Maximum quantity of material," "Table 1. Maximum Activity of LTSS Payload Source Nuclides," was revised to remove ²²⁶Ra, as well as Note 3 of Table 1, as authorized content of the Model No. 435-B. Note 4 was renumbered as Note 3.

The "References" section contains the consolidated application submitted on August 25, 2016, and the relevant supplements provided as part of the review process of this licensing action.

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 that the Model No. 435-B package meets the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9355, Revision No. 1,
on 2/2/17.