Safety Evaluation Report for the NAC-LWT Legal Weight Truck Cask System, Revision LWT/DOE-10B, May 2010

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OVERVIEW

This Safety Evaluation Report (SER) summarizes the results of the Department of Energy (DOE) Packaging Certification Program (PCP) Staff's review of the Safety Analysis Report for Packaging (SARP) for the NAC-LWT Legal Weight Truck Cask System, Revision LWT/DOE-10B, May 2010 [1]. The safety performance of the NAC-LWT with the intended payloads meets the requirements of 10 CFR 71 [2].

The NAC International Legal Weight Truck spent fuel shipping cask (NAC-LWT) is designed in accordance with the requirements of 10 CFR 71 and 49 CFR 173[3] to provide a safe means of transporting various fuel assemblies, fuel elements, and fuel rods. The NRC Certificate of Compliance, USA/9225/B(U)F-96, has undergone fifty-four (54) revisions. The current DOE Certificate of Compliance, USA/9225/B(U)F-96(DOE), Revision 5 was issued in September 2007 to add Sandia National Laboratory (SNL) Debris Bed Experiments (DBE) contained in welded DBE Transport Canisters as authorized contents. A SARP for the NAC-LWT, Revision 1[4] was approved in 2008 to include these contents.

The NAC-LWT SARP, Revision LWT/DOE-10B allows Argonne National Laboratory (ANL) to use the NAC-LWT cask for shipping radioactive material from the Alpha Gamma Hot Cell Facility (AGHCF) to Idaho National Laboratory (INL). The ANL irradiated sodium-bonded nuclear reactor fuel derived mixed fission products (FDMFP) will be shipped in up to three individual leak-tight, sealed 6CVS containment vessels loaded into the cavity of the NAC-LWT cask. The only change from the previously DOE approved NAC-LWT SARP, Revision 1, is the addition of the FDMFP contents shipped in the 6CVS inner containment vessel. This SER documents the review of Revision LWT/DOE-10B for these contents.

DOE PCP has concluded that changes detailed in Revision LWT/DOE-10B to the SARP have no impact on the safety performance of the LWT-NAC shipping cask and that the performance with the intended contents meets the requirements of 10 CFR 71. Reviews of each SARP Chapter are documented herein.

Chapter 1: General Information

This SER documents the DOE PCP Staff's review of, *the Safety Analysis Report for Packaging for the NACLWT Legal Weight Truck Cask System, Revision LWT/DOE-10B, May 2010.* This section of the SER covers the review of the General Information provided in Chapter 1 of the Submittal.

Section 1, General Information, of the reviewed SARP is identical to Section 1 of the NAC-LWT SARP except for the addition of the new ANL contents and the 6CVS containment vessels. The 6CVs is a leaktight containment system for shipping ANL contents. New or revised engineered drawings identify the changes to existing drawings and the new requirements for the 6CVS containment vessel and basket designs. A List of Drawings for the ANL 6CVS Transport is added to the Table of Contents and clearly identifies the revised or added drawings included in Section 1.4, License Drawings ANL Modified. The revised portions of the reviewed SARP are clearly marked by highlighting the revised or added wording.

The purpose of the Applicant's submittal is clearly stated in the accompanying transmittal letter. The application is for the approval of added FDMFP contents and the use of the 6CVS as an inner leaktight containment vessel. The 6CVS containment vessel provides separate secondary containment and pressure boundary of the FDMFP contents, and acts to transmit the loads of the FDMFP contents to the NAC-LWT containment vessel under normal conditions of transport and hypothetical accident conditions.

The SARP includes a complete list of engineered drawings for the NAC-LWT shipping cask. The following drawings revisions to the shipping cask and drawings required for the 6CVS containment vessel and basket fixture are identified in the SARP:

Table 1- LIST OF SARP DRAWINGS FOR ANL 6CVS TRANSPORT

Drawing	Sheet(s)	Rev.	Title
315-40-01	1	7	Legal Weight Truck Transport Cask Assembly
315-40-02	1-2	24	NAC-LWT Cask Body Assembly
315-40-03	1-7	22	NAC-LWT Transport Cask Body
315-40-04	1	11	NAC-LWT Transport Cask Lid Assembly
315-40-05	1-2	10	NAC-LWT Transport Cask Upper Impact Limiter
315-40-06	1	10	NAC-LWT Transport Cask Lower Impact Limiter
315-40-08	1-5	18	NAC-LWT Transport Cask Parts Detail
315-40-150	1	0	Weldment, 6CVS Inner Containment Vessel Basket, Top Module, NAC-LWT
315-40-151	1	0	Weldment, 6CVS Inner Containment Vessel Basket, Intermediate Module, NAC-LWT
315-40-152	1	0	Weldment, 6CVS Inner Containment Vessel Basket, Bottom Spacer Module, NAC-LWT
315-40-153	1	0	NAC-LWT Transport Cask Assembly, 6CVS Inner Containment Vessel Contents
315-40-154	1-4	1	6CVS Inner Containment Vessel, Assembly and Details, NACLWT

Findings

Based on review of the statements and drawings given in the application, DOE PCP Staff concludes that the revisions to these drawings and related text have no impact on the safety performance of the NAC-LWT shipping cask.

Conditions of Approval

The following conditions of approval are applicable to the NAC-LWT shipping cask:

- Maximum content weight for one 6CVS containment vessel: 200 lbs.
- Maximum total decay heat load in the NAC-LWT cask cavity: 36 W (≤ 12 W per 6 CVS, three 6CVS maximum per cask)
- Minimum cooling time: >16 years

- Maximum normal operating temperature: ≤200°F
- 6CVS containment vessel design pressure: 800 psig
- No sodium is permitted external to the 6CVS containment vessel.
- Aluminum fuel element (FE) tubes of various diameters may be used to facilitate loading the ANL FDMFP into the 6CVS containment vessel. The tubes are considered dunnage.

For a 6CVS containing sodium-bonded metal FDMFP:

- Maximum ^{235}U content: ≤4 kg
- Maximum Pu content: ≤1.5 kg
- Maximum ^{239}Pu fissile gram equivalent: 3,020 g

For a 6CVS containing sodium-bonded metal FDMFP with Bakelite or carbon-based FDMFP:

- Maximum volume of Bakelite met mounts per 6CVS: 6000 cm_3
- Maximum ^{235}U content: ≤2 kg
- Maximum Pu content: ≤0.7 kg
- Maximum ^{239}Pu fissile gram equivalent: 2,100 g
- Carbide FDMFP satisfying the Fissile Gram Equivalent limits may be included in the package provided the carbon content of the carbide FDMFP is subtracted from the maximum allowed carbon content of the Bakelite met mounts. As Bakelite is modeled as 78 wt % carbon at a density of 1.25 g/cm^3, the maximum quantity of carbon in the 6CVS is limited to 5,877 grams.
- For a 6CVS containing sodium-bonded metal FDMFP with Bakelite, gas generation by radiolysis is defined by a bounding G-Value (conservatively applied as 0.3 molecules/100eV), energy production by Bakelite/epoxy contained FDMFP, and assumed duration between loading and end of transport. To bound any potential ionizing radiation from the non-Bakelite containing components, a 25% value is applied in the analysis (3W). A 30-day transport window is assigned to the calculation. This results in a 15-day transport limit for shipments containing Bakelite (See Chapter 7 of the SARP).

Chapter 2: Structural Evaluation

This section of the SER covers the assessment of the Structural Evaluation information provided in Chapter 2 of the Submittal.

Chapter 2 evaluated the structural impact of the 6CVS containment vessel and basket assembly on the NAC-LWT shipping cask during normal conditions of transport and hypothetical accident conditions. Changes to calculations concerning the impact limiter attachment points detailed in LWT/DOE-10B revision dated May 2010 were part of the scope of this review. Inputs from the NAC-LWT existing Cask SARP analysis were accepted as valid based on previous NRC review and were not part of the scope of this review.

The structural evaluation changes submitted in LWT/DOE-10B revision consist mainly of stand-alone calculations on the 6CVS containment vessels and the accompanying baskets through the normal conditions of transport (NCT) and hypothetical accident condition (HAC) drop scenarios. Thermal stresses are determined using temperature profiles that bound Section 3.8 analysis results and are combined with stresses from drops and pressures before being compared with

allowable stresses for NCT conditions. Proper load combinations are also used in comparing to HAC allowable stresses. Stresses from punctures are not considered because of protection provided by the cask body.

Drop analyses use quasi-static methods in which the inertial load of the 6CVS is simulated by manipulation of the containment vessel material density and the inertial load of contents is represented by a pressure simulating the applied inertial load (25 g for NCT, 61 g for HAC). Dynamic amplification is not considered in these quasi-static analyses. Another nonconservatism noted is that the analyses credit full integration of the vessel rings as part of the containment structure even though they are only attached with seal and intermittent fillet welds. However, given the large margins determined for both NCT and HAC and previous analysis and testing of vessels of similar design in the 9975, 9977 and the T-3[6] shipping packages, no further analysis is deemed necessary.

Findings

Based on review of the statements and representations given in Chapter 2 of the NAC-LWT SARP, the DOE PCP Staff concludes that the addition of the 6CVS and contents has no impact on the safety performance of NAC-LWT shipping cask and that the requirements of 10 CFR 71 for normal conditions of transport and hypothetical accident conditions are satisfied..

Conditions of Approval

Approval of this application does not require special structural conditions.

Chapter 3: Thermal Evaluation

This section of the SER covers the review of the Thermal Evaluation information provided in Chapter 3 of the Submittal and Appendices of the Submittal.

The thermal analysis of Chapter 3 included the new transport configuration consisting of three 6CVS containment vessel loaded in the 6CVS basket in the NAC-LWT cask. The transport condition for the NAC-LWT cask is defined to be the NAC-LWT cask in a closed ISO container in which the NAC-LWT cask is backfilled with helium at atmospheric pressure. The contents of a single 6CVS containment vessel generate a 12 W total heat load, which corresponds to a maximum package heat load of 36 W for the NAC-LWT cask.

Findings

Based on review of the statements and thermal models and results presented in Chapter 3 of the NAC-LWT SARP, the DOE PCP Staff concludes that the addition of the 6CVS, contents, and transport configuration has no impact on the safety performance of NAC-LWT shipping cask and that the requirements of 10 CFR 71 for normal conditions of transport and hypothetical accident conditions are satisfied.

Conditions of Approval

The maximum total heat load for the contents of a single 6CVS containment vessel is 12 W which corresponds to a maximum package heat load of 36 W for the NAC-LWT cask.

The 6CVS and NAC-LWT cask are backfilled to 1 atmosphere with inert gas.

For shipments containing Bakelite, a 15-day transport limit should be imposed starting at the moment the 6CVS is backfilled with inert gas and sealed and ends when the consignment is accepted by the Receiver (see Chapter 7 of the SARP for implementation).

Chapter 4: Containment

This section of the SER covers the review of the Containment information provided in Chapter 4 of the Submittal.

The review of Chapter 4 included the addition of the ANL 6CVS inner containment vessel to the NAC-LWT packaging. Each of the 6CVS vessels provides an independently leaktight vessel to provide a second containment boundary to the NAC-LWT cask. The addition of the 6CVS containment vessel does not change the containment boundary of the NAC-LWT packaging from the previously approved SARP.

Findings

Based on review of the statements and representations given in Chapter 4 of the NAC-LWT SARP, the DOE PCP Staff concludes that the addition of the 6CVS inner containment vessel has no impact on the safety performance of NAC-LWT shipping cask and that the requirements of 10 CFR 71 for normal conditions of transport and hypothetical accident conditions are satisfied. The Alternate B vent and drain port covers of the NAC-LWT are required for the use of the 6CVS containment vessel in the NAC-LWT cask and have been previously evaluated and accepted as part of the containment boundary of the NAC-LWT cask.

Conditions of Approval

The Alternate B Vent and Drain Port Covers are required as part of the NAC-LWT cask when shipping the ANL contents in the 6CVS containment vessels. Prior to each transport of the 6CVS contents, new metallic seals will be installed on the cask lid and the Alternate B Vent and Drain Port Covers, before final installation and torquing. Both the 6CVS containments vessel and the cask containment boundary shall be leak tested as required in Chapters 7 and 8 of the SARP.

Chapter 5: Shielding Evaluation

This section of the SER covers the review of the Shielding Evaluation information provided in Chapter 5 of the Submittal.

The shielding analysis focused on the addition of up to three ANL 6CVS vessels in the NACLWT cask. The total computed source was assigned to one 6CVS rather than distributing the source across multiple 6CVS vessels.

Findings

Based on review of the statements and evaluations presented in Chapter 5 of the NAC-LWT SARP, the DOE PCP Staff concludes that the evaluation of the ANL source materials in the 6CVS inner containment vessels has been described adequately and conservatively and has no impact on the safety performance of NAC-LWT shipping cask. The dose rate requirements of 10 CFR 71 for normal conditions of transport and hypothetical accident conditions are satisfied.

Conditions of Approval

The Certificate of Compliance shall limit the quantities the ANL source material as identified and limited in Chapter 1 of the SARP.

For a 6CVS containing sodium-bonded metal FDMFP:

- Maximum ^{235}U content: ≤4 kg
- Maximum Pu content: ≤1.5 kg
- Maximum ^{239}Pu fissile gram equivalent: 3,020 g

For a 6CVS containing sodium-bonded metal FDMFP with Bakelite or carbon-based FDMFP:

- Maximum volume of Bakelite met mounts per 6CVS: 6000 cm3
- Maximum ^{235}U content: ≤2 kg
- Maximum Pu content: ≤0.7 kg
- Maximum ^{239}Pu fissile gram equivalent: 2,100 g
- Carbide FDMFP satisfying the Fissile Gram Equivalent limits may be included in the package provided the carbon content of the carbide FDMFP is subtracted from the maximum allowed carbon content of the Bakelite met mounts. As Bakelite is modeled as 78 wt % carbon at a density of 1.25 g/cm3, the maximum quantity of carbon in the 6CVS is limited to 5,877 grams.

The NAC-LWT with authorized ANL contents may be shipped under non-exclusive use conditions

Chapter 6: Criticality Evaluation

This section of the SER covers the review of the Criticality Evaluation information provided in Chapter 6 of the Submittal.

The review of Chapter 6 focused on the criticality evaluations for the NAC-LWT with ANL contents loaded in the 6CVS vessels. The contents were limited to those identified in Section 5 of this SER. An infinite array of NAC-LWT packages was evaluated for NCT and HAC in criticality calculations..

Findings

Based on the review of the statements and representations in the Submittal, the DOE PCP Staff has concluded that the packaging design and bounding analyses have been adequately described to meet the requirements of 10 CFR 71.

Conditions of Approval

The Certificate of Compliance shall limit the quantities the ANL source material as identified and limited in Chapter 1 of the SARP.

For a 6CVS containing sodium-bonded metal FDMFP:

- Maximum ^{235}U content: **≤4 kg**
- Maximum Pu content: **≤1.5 kg**
- Maximum ^{239}Pu fissile gram equivalent: **3,020 g**

For a 6CVS containing sodium-bonded metal FDMFP with Bakelite or carbon-based FDMFP:

- Maximum volume of Bakelite met mounts per 6CVS: 6000 cm3
- Maximum ^{235}U content: ≤2 kg
- Maximum Pu content: ≤0.7 kg
- Maximum ^{239}Pu fissile gram equivalent: 2,100 g
- Carbide FDMFP satisfying the Fissile Gram Equivalent limits may be included in the package provided the carbon content of the carbide FDMFP is subtracted from the maximum allowed carbon content of the Bakelite met mounts. As Bakelite is modeled as 78 wt % carbon at a density of 1.25 g/cm3, the maximum quantity of carbon in the 6CVS is limited to 5,877 grams.

The Criticality Safety Index (CSI) for the NAC-LWT with authorized ANL contents is zero (CSI=0).

Chapter 7: Package Operations

This section of the SER covers the review of the Package Operations information provided in Chapter 7 of the Submittal.

The review of Chapter 7 focused on the operating procedures for loading and unloading ANL contents into the 6CVS containment vessel and the loading and unloading the 6CVS containment vessels and basket modules into the NAC-LWT shipping cask.

Findings

Based on the review of the statements and representations presented in the application, the Staff concludes that NAC-LWT operating procedures meet the requirements of 10 CFR 71 and that the procedures are adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

Conditions of Approval

The procedural steps for operating the NAC-LWT shipping cask specified in Chapter 7 of the SARP shall be incorporated in their entirety into the Certificate of Compliance as a condition of package approval. The steps will provide the basis that the users/shippers will use to develop formal, site-specific operating procedures for shipping ANL contents in the NAC-LWT shipping cask.

In addition, SARP Section 3.8.4, identifies a 15 day transport limit for shipments containing Bakelite due to gas generation by radiolysis. Therefore, for a 6CVS containing sodium-bonded metal FDMFP with Bakelite (Ref SARP 1.2.3.10), the Certificate of Compliance shall include the 15 day transport limit as a condition of package approval. The 15-day clock begins when the 6CVS is closed (SARP 7.1.14, Step 20) and ends when the consignment is accepted by the Receiver. When shipping a 6CVS containing sodium-bonded metal FDMFP with Bakelite, the shipper shall provide the receiver with the date and time the 6CVS was sealed. The shipper must verify that the shipment can be completed within the 15 day transport limit.

Chapter 8: Acceptance Tests and Maintenance Program

This section of the SER covers the review of the Acceptance Tests and Maintenance Program information provided in Chapter 8 of the Submittal.

The review focused on the acceptance tests for the 6CVS containment vessels and basket assemblies prior to first use and the 6CVS containment vessel maintenance program requirements.

Findings

Based on the DOE PCP Staff's review of the statements and representations given in the application, the DOE PCP Staff concludes that the Acceptance Tests for the NAC-LWT with the ANL contents meet the requirements of 10 CFR 71, and that the Maintenance Program is adequate to assure regulatory-compliant packaging performance during its service life. The Staff also concludes that the information provided for the Acceptance Tests and Maintenance Program is adequate.

Conditions of Approval

The Acceptance Tests and Maintenance Program requirements of Sections 8.1 and 8.2 of Chapter 8 of the SARP shall be incorporated into the CoC as a condition of package approval.

Chapter 9: References

Section 9.0 of the SARP lists the documents, papers, and reports that are referenced in the SARP for the NAC-LWT cask. There were minor revisions on Section 9.0 to include ASME B&PV Code and AWS references for the ANL 6CVS. In addition, Section 9.2 was added to the SARP and lists references that are applicable to the design, fabrication, inspection, acceptance, and testing of the 6CVS Vessel.

Chapter 10: Quality Assurance

This section of the SER covers the review of the Quality Assurance (QA) program description and packaging-specific QA requirements provided in Chapter 10 of the Submittal.

Chapter 10 of the SARP describes the quality assurance requirements for ensuring the safety of the NAC-LWT packaging, as applied by SNL for the transport of DBE; and by ANL for the transport of Argonne sodium bonded nuclear reactor fuel derived mixed fission products in sealed 6CVS vessels. The applicant made minor editorial revisions to this chapter address the addition of the ANL 6CVS to the SARP.

Appendix 10A was revised to include a description of the NAC QA requirements for hardware and associated services as applicable to the design, fabrication, procurement, handling, use, and storage of the ANL 6CVS and their transportation in the NAC-LWT cask(s).

Appendix 10B was added to provide a description of the ANL QA requirements for ensuring the safety of the NAC-LWT packaging as applied by ANL for the transportation of mixed fission products derived from irradiated sodium bonded nuclear reactor fuel examination.

The focus areas of the Staff review were the revisions to Chapter 10 and Appendix 10A, and the addition of Appendix 10B. The 6CVS was not being fabricated at the time of this review, so a fabrication audit has not been conducted by the DOE PCP Staff to date.

Findings

Based on review of the statements and representations in the Submittal, the DOE PCP Staff concludes that the QA program has been adequately described and meets the QA requirements of 10 CFR 71, Subpart H. Packaging-specific requirements are adequate to assure that the packaging is designed, fabricated, assembled, tested, used, maintained, modified, and repaired in a manner consistent with its evaluation.

Conditions of Approval

DOE PCP has concluded that no additional QA-related conditions of approval need to be added to the existing CoC for the approval of this request.

References

[1] NAC International, Safety Analysis Report for Packaging for the NAC-LWT Legal Weight Truck Cask System, Revision LWT/DOE-10B, May 2010.

[2] Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), Packaging and Transportation of Radioactive Materials.

[3] Title 49, Code of Federal Regulations, Part 173 (49 CFR 173), Shippers General Requirements for Shipments and Packagings.

[4] NAC International, Safety Analysis Report for Packaging for the NAC-LWT Legal Weight Truck Cask System, Revision 1, January, 2008

[5] Addendum to the Consolidated Safety Analysis Report for the T-3 Spent Fuel Shipping Cask Demonstrating Compliance to the Requirements of 10CFR71 Sodium-Bonded Fuel, FFTF-30866, Revision 2.

[6] Addendum to the Consolidated Safety Analysis Report for the T-3 Spent Fuel Shipping Cask Demonstrating Compliance to the Requirements of 10 CFR 71 Sodium-Bonded Fuel, FFTF-30866, Revision 2.