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

September 6, 2024

Heath Baldner, Director,
Licensing, Engineering
NAC International, Inc.
Atlanta Corporate Headquarters
2 Sun Court, Suite 220
Peachtree Corners, GA 30092

SUBJECT: REVISION 75 OF CERTIFICATE OF COMPLIANCE NO. 9225 FOR THE MODEL NO. NAC INTERNATIONAL, INC.-LEGAL WEIGHT TRUCK PACKAGE

Dear Heath Baldner:

By letters dated September 1, 2023 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML23244A177), January 11, 2024 (ML24011A277) and August 16, 2024 (ML2421A078), NAC International, Inc., (NAC, or the applicant) requested two amendments to Certificate of Compliance (CoC) No. 9225 for the Model No. NAC-Legal Weight Truck (LWT) package. NAC requested amendments to authorize the addition of iron clad rods to damaged fuel contents and the addition of Los Alamos National Laboratory Mixed Oxide fuel rods as approved contents for the NAC-LWT.

The 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* (10 CFR) Section 71.17, “General License: NRC-Approved Package” and 49 CFR 173.471.

In accordance with 10 CFR 2.390, “Public inspections, exemptions, requests for withholding,” a copy of this letter will be available electronically for public inspection in the U.S. Nuclear Regulatory Commission’s (NRC) Public Document Room (PDR) or from the Publicly Available Records component of the NRC’s ADAMS. ADAMS is accessible from the NRC website at http://www.nrc.gov/reading-rm/adams.html. The PDR is open by appointment. To make an appointment to visit the PDR, please send an email to PDR.Resource@nrc.gov or call 1-800-397-4209 or 301-415-4737, between 8 a.m. and 4 p.m. eastern time (ET), Monday through Friday, except Federal holidays.

If you have any questions regarding this CoC, please contact Bernard White of my staff at (301) 415-6577.

Sincerely,

Signed by Diaz-Sanabria, Yoira on 09/06/24

Yoira Diaz-Sanabria, Chief
Storage and Transportation Licensing Branch
Division of Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9225
EPID Nos. L-2024-LLA-0008,
L-2023-LLA-0124,
and L-2024-LLA-0113

Enclosures:
1. CoC No. 9225, Rev. No. 75
2. Safety Evaluation Report

cc w/encls. 1& 2: R. Boyle, DOT
Julia Shenk, DOE c\o L. F. Gelder

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DOCUMENT DATE: September 6, 2024

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UNITED STATES
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WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 71-9225
Model No. NAC-LWT Package
Certificate of Compliance No. 9225
Revision No. 75

SUMMARY

By letters dated September 1, 2023 (Agencywide Documents Access and Management System Accession No. ML23244A177), January 11, 2024 (ML24011A277) and the consolidated application August 16, 2024 (ML2421A078), NAC International, Inc., (NAC, or the applicant) requested two amendments to Certificate of Compliance (CoC) No. 9225 for the Model No. NAC-Legal Weight Truck (LWT) package. NAC requested amendments to authorize the addition of iron clad (FeCrAl) rods to damaged fuel contents and the addition of Los Alamos National Laboratory (LANL) Mixed Oxide (MOX) fuel rods as approved contents for the NAC-LWT. Both of these amendment requests are included in the consolidated application submitted by NAC.

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the amendment requests using guidance in NUREG-2216, "Standard Review Plan for Transportation Packages for Spent Fuel and Radioactive Material," dated August 2020 (ML20234A651). With the applicant choosing to add iron clad rods as an already approved damaged fuel content and use the same assumptions as for zirconium clad rods, (i.e., no structural materials or thermal credit taken for the iron clad), the iron clad fuel amendment did not require a structural or thermal analysis as a part of this safety evaluation report.

Following staff review of the associated safety analysis reports (SAR), the staff finds that the requested changes do not affect the ability of the package to meet the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71, "Packaging and Transportation of Radioactive Material."

EVALUATION

1.0 GENERAL INFORMATION

1.1 Packaging Description

The NAC-LWT is a Type B(U)F-96 radioactive material transportation packaging design. It is authorized to transport several types of contents, including light-water reactor spent fuel, research reactor spent fuel, and high enriched uranyl nitrate liquid in containers specifically designed for the liquid. The NAC-LWT package may be shipped by truck, boat, or railcar and depending on the content, within an international shipping organization (ISO) container.

1.2 Contents

The applicant submitted two amendment requests for the addition of new approved contents to the NAC-LWT package for use. The first amendment request is to authorize the addition of iron clad rods to damaged fuel contents. The CoC currently allows for up to 14 of 25 rods in a pressurized-water reactor (PWR) or boiling-water reactor (BWR) shipment be classified as damaged, thus this amendment will allow for the iron clad rods to be placed in these 14 rod placements classified as damaged.

The second amendment request is to authorize the addition of LANL MOX fuel rods to the package. Parameter limits for the LANL MOX fuel are in section 5(b)(xxiv) of the certificate and are provided below:

Table 1.1 LANL MOX Fuel Rod Parameter Limits

Parameter	PNNL	EXXON	UO_2	ROD 1063	530-000	NIS5
Max. rod OD (inch)	0.565	0.451	0.229	0.55	0.63	0.5
Min. wall thick. (inch)	0.035	0.035	0.015	0.015	0.015	0.015
Rod material	Zr Alloy	Zr Alloy	SS304	Zr Alloy	Zr Alloy	SS316
Max. active length (inch)	35.6	70	36.1	47.913	18	13.5
Max. pellet OD (inch)	0.486	0.372	0.1988	0.48	0.56	0.31
Max. # of rods per transfer tube	4	2	8	3	1	3
Max. # of tubes per cask	16	16	16	6	1	4
Fuel form	Oxide	Oxide	Oxide	Oxide	Oxide or Carbide	Carbide
^{235}U wt%	0.712	0.712	94	0	0	94
^{240}Pu wt%[1]	16	16	0	10	10	4
Pu wt%	5.36	6.31	0	100	100	20
U-235 (g/rod)	6.76	7.71	159.9	0	0	159.58
U (g/rod)	949.85	1083.44	170.11	0	0	169.76
Pu (g/rod)	56.29	76.35	0	1378.77	922.01	42.38
Total U/Pu (g/rod)	1006.14	1159.79	170.11	1378.77	922.01	212.14

1. Fissile Pu-239 and Pu-241 comprise the remaining plutonium. A 9 to 1 ratio of Pu-239 to Pu-241 bounds the range of Pu-240 weight fractions analyzed herein.
2. Maximum number of tubes for ROD1063 and NIS5 is governed by the damaged fuel evaluation.

2.0 STRUCTURAL EVALUATION

The objective of the structural evaluation is to verify that the applicant has adequately evaluated the structural performance of the package (packaging together with contents) and demonstrated that it meets the regulations in 10 CFR Part 71. The iron clad fuel rod amendment request does not require a structural evaluation because this fuel will be packaged in a damaged fuel can; therefore, this section only focuses on a structural evaluation for the LANL MOX fuel rods amendment.

2.1 Structural Evaluation of LANL MOX

NAC submitted the application, revision 24A of the SAR for the NAC-LWT transportation package, in which the applicant requested that the LANL MOX fuel rods be allowed as approved contents for transport in the NAC-LWT CoC No. 9225 (ML24011A277).

The applicant requested in the application to allow up to 16 transfer tubes filled with the LANL MOX fuel rods. These transfer tubes must be loaded in the PWR/BWR transport can assembly along with the divider plate assembly, and a transfer tube spacer is also required at the top and bottom end of each transfer tube.

The staff reviewed the application and issued a request for additional information (RAI) (ML24162A272). The RAI was related to the structural analysis for the divider plate assembly, which is placed in the PWR/BWR transport can assembly with the transfer tubes. In particular, the RAI focused on the applicant's two-dimensional structural analysis using the ANSYS finite element (FE) computer program to evaluate the interactions between the transfer tubes and divider plates under both normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

The applicant submitted its responses to the RAI (ML24150A206). The applicant explained that the divider plate sub-divides the rod transport canister assembly cavity into four discrete cells, thereby allowing for the segregation of four groups of four transfer tubes within the cavity under NCT and HAC. Segregation of groups of four transfer tubes within the transport canister assembly cavity was credited in the LANL MOX criticality evaluation discussed in chapter 6, "Criticality Evaluation," of the SAR. As part of the RAI responses, the applicant removed crediting the safety function of the divider plate. To support this action, NAC updated both the criticality evaluation to remove the credit given to the divider plate and the structural evaluation to remove the structural analysis of the divider plate from the application.

The staff reviewed and evaluated the proposed request in the application and updated documents (i.e., SAR, revision 24B and revised structural calculation package without the divider plate) that were submitted with the responses to the RAI to verify that the structural performance of the LANL MOX transfer tubes in the NAC-LWT transportation package meets the requirements of 10 CFR Part 71. This section of the safety evaluation report (SER) documents the staff's reviews, evaluations, and conclusions with respect to structural safety aspects of the proposed transport package.

2.1.1 Evaluation for the LANL MOX Transfer Tube Components under NCT

The applicant analyzed and evaluated the LANL MOX transfer tube structural components (i.e., transfer tube, tube weldment and tube spacer) under NCT. Each component was evaluated for end and side drop orientations which represent the two limiting cases. The applicant calculated stresses of the structural components under NCT using closed-form solutions with hand calculations.

<u>End Drop:</u> The applicant calculated stresses in the LANL MOX transfer tube components using the closed-form solutions in the proprietary NAC Calculation No. 50077-2002, Rev. 1, "Structural Evaluation of LANL MOX Transfer Tube Shipping Configuration for the NAC-LWT Transport Cask," (ML24150A207). The methodology and technical assumptions used for this structural analysis are similar to NAC Calculation No. 14629-315-2000, Rev. 2, "LWT Pin Shipment Can Assembly Structural Analysis," (ML24150A207), which were previously reviewed and accepted by the staff.

The staff reviewed the calculations and summarized the stresses with margin of safety (MS) of each transfer tube component for the end drop orientation in table 2.1 below, where MS is defined as the factor of safety (FS) minus one (MS = FS -1.0). Structural components have additional allowable design margin in strength with respect to the anticipated applied load if MS is positive (larger than zero). The results of the structural analysis show that all transfer tube components have an MS larger than zero indicating that the transfer tube components have large allowable design margins in strength under NCT.

Table 2.1 - Calculated Stress and Margin of Safety for End Drop under NCT

Component	Calculated Stress (ksi)	Allowable Stress (ksi)	Margin of Safety (MS)
Transfer Tube	0.76 (membrane)	20.0 (membrane)	25.32
Transfer Tube (weldment)	1.13 (shear)	4.2 (shear)	2.72
Tube Spacer	0.74 (membrane)	14.9 (membrane)	19.13

Note: The allowable stresses are based on American Society of Mechanical Engineer's (ASME) Boiler & Pressure Vessel Code (B&PV), section III, subsection NG.

Side Drop: The applicant did not calculate stresses in the LANL MOX transfer tube components for the side drop orientation under NCT. The applicant stated that the side drop evaluations are not required for the LANL MOX transfer tube and fuel rod, because the side drop evaluations for the 4×4 and 5×5 insert tube documented in section 5.2.5, "4×4 and 5×5 Insert - Side Drop," of Calculation No. 14629-315-2000, Rev. 2, which were previously reviewed and accepted by the staff, are applicable and bound the stresses of the LANL MOX transfer tube and fuel rod under NCT. The applicant provided the justifications for the applicability of the 4×4 and 5×5 insert tube evaluations to the LANL MOX transfer tube as following: (i) the tube geometries and material in these two tubes are equivalent, (ii) the temperature used to determine the material properties for the 4×4 and 5×5 insert tube evaluations is significantly higher than the bounding temperature used for the material properties of the LANL MOX transfer tube, and (iii) the content weight used for the 4×4 and 5×5 insert tube side drop evaluations in Calculation No. 14629-315-2000, Rev. 2 bounds that of the LANL MOX transfer tube content. Therefore, based on the factors delineated above, the applicant concluded that the tube side drop evaluations in Calculation No. 14629-315-2000, Rev. 2 are applicable and bounding for the LANL MOX transfer tube, so no additional side drop evaluations are required for the LANL MOX transfer tube.

The staff reviewed the input parameters used for the LANL MOX transfer tube analysis in section 4.1, "Design Input," of Calculation No. 50077-2002, Rev. 1 and compared them with the input parameters used for the insert tube analysis in Calculation No. 14629-315-2000, Rev. 2 and found that the applicant's statements are accurate. The staff agrees that the results of the insert tube side drop analysis in ML24150A207can be used as the results of the LANL MOX transfer tube side drop analysis. Since the calculated MS are all positive (larger than zero), the staff determined that the structural components of the LANL MOX transfer tube have adequate design margin in strength for the side drop orientation and are safe under NCT.

Based on the reviews of the statements, analyses and evaluations provided in the application, the staff concluded that the LANL MOX transfer tube were adequately evaluated for the test in 10 CFR 71.71(c)(7).

2.1.2 Evaluation for the LANL MOX Transfer Tube Components under HAC

The applicant also analyzed and evaluated the LANL MOX transfer tube structural components under HAC. Each component was evaluated for end and side drop orientations. The applicant calculated stresses of the structural components under HAC using closed-form solutions with hand calculations.

End Drop: The applicant calculated stresses in the LANL MOX transfer tube components using the closed-form solutions in Calculation No. 50077-2002, Rev. 1. The methodology and technical assumptions used for the structural analysis are similar to the ones in Calculation No. 14629-315-2000, Rev. 2.

The staff reviewed the calculations and summarized the stresses with MS of each transfer tube component for the end drop orientation under HAC in table 2.2 below. The results of the analysis show that all transfer tube components have a MS larger than zero indicating that the components have adequate allowable design margins in strength and are safe under HAC.

Table 2.2 - Calculated Stress and Margin of Safety for End Drop under HAC

Component	Calculated Stress (ksi)	Allowable Stress (ksi)	Margin of Safety (MS)
Transfer Tube	2.88 (membrane)	46.3 (membrane)	15.10
Transfer Tube (weldment)	4.28 (shear)	5.33 (shear)	0.25
Tube Spacer	2.82 (membrane)	37.1 (membrane)	12.16

Note: The allowable stresses are based on ASME B&PV, section III, appendix F.

Side Drop: The applicant did not calculate stresses in the LANL MOX transfer tube components for the side drop orientation under HAC for the same reasons discussed in section 2.1 of the SER above. Since the stresses of the 4×4 and 5×5 insert tube documented in Calculation No. 14629-315-2000, Rev. 2 bound the stresses of the LANL MOX transfer tube and fuel rod for the side drop orientation under HAC, the applicant used the results of the structural analysis for the 4×4 and 5×5 insert tube. The staff reviewed the results of the analysis and found that the calculated MS are all positive (larger than zero). The staff determined that the structural components of the LANL MOX transfer tube have adequate design margins in strength and are safe under HAC.

2.2 Structural Conclusion for LANL MOX

Based on the reviews of the statements, analyses and evaluations provided in the application, the staff concluded that the LANL MOX transfer tube and fuel rods inside the NAC-LWT packaging were adequately evaluated for the test in 10 CFR 71.73(c)(1).

3.0 THERMAL EVALUATION

The objective of thermal evaluation is to verify that the thermal performance of the package design has been adequately evaluated for the thermal tests specified under NCT and HAC, and that the package design meets the thermal performance requirements of 10 CFR Part 71. The iron clad fuel rod amendment does not require thermal evaluation since the iron clad rods are loaded in the package as damaged fuel; therefore, this section only focuses on a thermal evaluation for the LANL MOX fuel rods amendment.

3.1 Description of Thermal Design for LANL MOX Fuel

NAC requested to add up to 16 transfer tubes filled with LANL MOX fuel rods as contents in NAC NAC-LWT package, with a heat load limit of 25 W per package. NAC-LWT package is shipped by truck, ISO container and/or rail car, as a Type B(U)F-96 package.

3.2 Material Properties and Component Specifications for the LANL MOX

The staff reviewed SAR chapter 3, "Thermal Evaluation" of the application (SAR, Rev. 24A) and confirmed that the thermal specifications and properties of NAC-LWT package main components remain unchanged because there is no change in package thermal design.

3.3 Thermal Evaluations for NCT and HAC for the LANL MOX Fuel Rods

The applicant stated, in chapter 3 of the SAR, Rev. 24A, that LANL MOX fuel does not contain a significant heat source or fission gas quantity, when compared to the high burnup light-water reactor (LWR) MOX fuel (e.g., PWR/BWR MOX fuel rods), which has both a significant fission gas quantity to release and a significant heat load, as shown in the consolidated SAR, Rev. 47 (ML24107A104). It also states that given the similarity in the package thermal configuration of the LANL MOX payload to that of the high burnup LWR MOX payload, both thermal evaluation and package cavity pressurization of the LANL MOX payload (25 W) will be bounded by those of the LWR MOX payload (2.3 kW for PWR MOX and 2.1 kW for BWR MOX).

In review of both SAR Rev. 24A and consolidated SAR Rev. 47, staff confirmed that the NAC-LWT package loaded with LWR MOX payload (2.3 kW for PWR MOX and 2.1 kW for BWR MOX) was already reviewed and approved by the NRC. The staff also confirmed that the thermal evaluation and internal pressure of the package loaded with the proposed LANL MOX fuel will be bounded by that of the package loaded with LWR MOX fuel, due to lower decay heat for LANL MOX fuel.

3.4 Temperatures used for Side Drop Evaluation for the LANL MOX Divider Plates

The staff reviewed appendix A, "Transfer Tube Temperature Determination" of the NAC's Calculation Package No. 50077-2002 Rev. 1, "Structural Evaluation of LANL MOX Transfer Tube Shipping Configuration for the NAC-LWT Transport Cask," and confirmed that the use of the thermal analysis, based on a 1.26 kW heat load, significantly bounds the 25 W condition of the LANL MOX fuel rods to determine the peak temperature in the package cavity. Therefore, the staff accepts that the use of 300 degrees Fahrenheit (°F) for the allowable stress calculations is bounding.

3.5 Thermal Evaluation Findings for the LANL MOX

Based on review of the statements and representations in the application, the staff concludes that the loading of LANL MOX fuel rods into the NAC-LWT package has been adequately described and evaluated that the thermal performance of the package meets the thermal requirements of 10 CFR Part 71.

4.0 CONTAINMENT EVALUATION

There were no changes made to the package's containment evaluation in both amendment requests for the iron clad fuel rods or the LANL MOX fuel rods, therefore a containment evaluation is not needed.

5.0 SHIELDING EVALUATION

The objective of the shielding evaluation is to ensure that there is adequate protection to the public and occupational workers against direct radiation from the proposed contents of the NAC-LWT transportation package, and to verify that the package design meets the external radiation requirements of 10 CFR 71.47 and 10 CFR 71.51 for NCT and HAC.

For the shielding evaluation for the LANL MOX fuel, the staff reviewed this application and determined that shielding evaluations for the LANL MOX fuel rods materials are not required. The reason for this determination is that the source associated with these rods is limited to decay radiation (primarily alpha) of the as-built fuel materials and the package surface dose rates associated with LANL MOX fuel rods, which are estimated to be less than 1 mrem/hr. Lastly, most of the LANL MOX heat being associated with alpha decay will not contribute significantly to package dose rates. Therefore, the shielding evaluation for the iron clad fuel is provided below.

5.1 Shielding Evaluation for Iron Clad Fuel

For the iron clad fuel rods, NAC submitted an amendment to request the revision of the content description for the 25 high burnup PWR and BWR spent fuel rods, which will include up to 14 damaged fuel rods, and iron cladding as an alternate cladding material for the 14 damaged fuel rods. NAC requested approval of no more than 14 iron clad fuel rods or unfueled rod segments as damaged fuel rods. This revision is similar to Revision No. 23 of the CoC that authorized the shipment of 25 PWR or BWR fuel rods in NAC-LWT Package.

The staff reviewed the addition of the new contents using the guidance in section 5 of NUREG-2216. This evaluation is based on the NAC SAR, Revision 47, dated June 2024 (ML24107A098) and the changes described in NAC-LWT SAR, Revision 23C, dated August 2023 (ML23244A178) as supplemented by NAC-LWT SAR, Revision 24C, dated June 2024 (ML24180A196).

5.2 Description of the Shielding Design for Iron Clad Fuel

5.2.1 Packaging Design Features for the Iron Clad Fuel

The NRC staff reviewed chapter 1, "General Information," in the SAR as well as the additional information on the shielding design in chapter 5 of the SAR, "Shielding." The staff determined that all figures, drawings, and tables describing the shielding features are sufficiently detailed to support an in-depth evaluation. The NAC-LWT is a cylindrical packaging system. The shielding design features of the NAC-LWT include multi-walled centrically shielding layers with various materials that surround the fuel.

5.2.2 Codes and Standards for the Iron Clad Fuel

The staff finds that the NAC-LWT SAR identified the appropriate regulations in 10 CFR Part 71 throughout chapter 5. The staff also verified that the NAC-LWT SAR appropriately states that the American National Standards Institute (ANSI)/American Nuclear Society (ANS) ANSI/ANS 6.1.1-1977, “Neutron and Gamma-Ray Flux to Dose Rate Factors,” version for the flux to dose rate conversion factors was used. The staff finds this acceptable because this is consistent with the acceptance criterion in NUREG-2216.

5.2.3 Summary Table of Maximum Radiation Levels for the Iron Clad Fuel

The staff examined the summary tables for the NAC-LWT with 14 failed iron clad fuel rods in tables 5.3.25-9 and 5.3.25-10 of the SAR for PWR, BWR 7X7, and BWR 8X8 of the NAC-LWT SAR. The staff reviewed these tables to ensure that the NAC-LWT meets the dose rate requirements in 10 CFR 71.47 and 10 CFR 71.51. Since the NAC-LWT SAR states that under NCT the radial dose rates for all three types of fuels exceed 200 mrem/hr, and therefore the NAC-LWT package will be operated under “exclusive use,” the staff verified that the evaluated radiation levels do not exceed those specified in 10 CFR 71.47(b).

The staff verified that the summary table states that the limit of 10 mrem/hr will not be exceeded, at any point, 2 meters from the outer lateral surface of the vehicle. The highest calculated dose 2 meters from the vehicle is 9.6 mrem/hr. The staff finds that this meets the requirement in 10 CFR 71.47(b)(3).

The staff verified that the summary table states that the external radiation dose during HAC does not exceed 1 rem/hr at 1 meter from the external surface of the package. The axial surface dose rates for all three fuel types are below the limits 1 rem/hr at 1 meter as shown in table 5.3.25-10. The highest calculated dose after subjecting the package to the tests and conditions for HAC is 295.9 mrem/hr at 1 meter from the package surface. The staff finds that this meets the requirement of 10 CFR 71.51(a)(2).

5.3 Source Specification for Iron Clad Fuel

5.3.1 Source Term Determination

For the iron clad fuel rods, the applicant performed source term calculations using the SAS2H module of the SCALE code system and dose rate calculations using the SAS4 module of the SCALE code system. The staff notes the applicant used an older version of the SCALE code system, SCALE 4.3, and source terms evaluated using SAS2H. NAC calculated three-dimensional (3-D) dose rates using the Monte Carlo N-Particle (MCNP) transport code for up to 14 high burnup, iron clad damaged fuel rods which may be loaded in a shipment of up to 25 PWR or BWR fuel rods, in section 5.3.12 of the SAR. The source terms for 25 intact, high burnup, zirconium clad fuel rods are shown in table 5.3.11-1 and table 5.3.11-2 in SAR Rev. 47. The source terms for the iron clad fuel rods are presented in the tables 5.3.25-1 through 5.3.25-3. PWR and BWR 8×8 fuel assemblies were evaluated for a burnup of 80,000 MWd/MTU with 240 days cool time and BWR fuel assemblies were evaluated for a 300 day cool time.

These cool times for iron clad fuel are 90 days longer than the zirconium alloy-based fuel in tables 5.3.11-1 and 5.3.11-2.

5.3.2 Axial Source profile

The axial source profile for the iron clad fuel rods is the same as those used in the section 5.3.12.2 of the SAR. The staff approved this profile in a previous SAR revision as show in consolidated NAC-LWT SAR, Revision 47, proprietary SAR (ML24011A158).

5.3.3 Shielding Model

The applicant used the previous source term for 25 intact PWR or BWR zirconium fuel rods by replacing up to 14 zirconium fuel rods with iron clad fuel rods and assuming them as damaged fuel. NAC notes that due to the extra 90-day cool time, the source terms for the iron clad rods are identical to the source term for the zirconium clad rods. This evaluation for the iron clad rods used a cobalt impurity of maximum 1.2 g/kg for cobalt inventory, which is included as a condition in the CoC. In its Revision 23C submittal, NAC modified the proprietary Calculation No. 14662-500, “LWT Damaged PWR and BWR Rods Shielding Analysis,” to analyze damaged iron clad rods. Calculation No. 14662-500 was evaluated for 39 rods, but the total source for this evaluation was 25 rods including 14 damaged iron clad fuel rods. The design of the packaging remains unchanged from the approved designed in previous revisions of the CoC. The applicant used the MCNP transport code in SAR, Revision 24, to model for dose rates evaluation.

5.3.4 Material Properties

The NAC-LWT is made of stainless steel, lead, and a neutron shield jacket containing a borated water/ethylene glycol mixture for neutron shielding. The staff verified that the applicant identified the materials and mass densities of the canister, basket, package, and impact limiter. These are specified in table 5.3.23-5 of the SAR. The staff found that the values used are typical values for the commonly used materials and are reasonable for use in the shielding analysis.

5.4 Shielding Evaluation Methods for Iron Clad Fuel

For the shielding analysis the applicant uses the MCNP 6.2 code. From the output files provided in Calculation 50082-5001, the applicant used the default cross sections provided with this version of the MCNP code, a 3-D code that employs the Monte Carlo method. It is widely used and recognized for shielding analyses and mentioned in NUREG-2216 as an acceptable code for use in shielding evaluations involving spent fuel. The staff found the use is of this code acceptable for this application.

5.4.1 Key Input and Output Data

The staff verified that key input data for the shielding calculations are identified and that information about the source and shielding were properly input into the codes by examining the input file provided by the applicant. The staff verified that proper convergence was achieved from the calculation by reviewing a representative output file and that the calculated radiation levels in the output file agree with the radiation levels reported in the SAR.

5.4.2 Radiation Levels

The staff reviewed the calculated radiation levels in figures 5.3.25-1 through 5.3.23-3 of the SAR. The maximum radial and axial dose rates for both NCT and HAC for damaged fuel are presented in tables 5.3.25-9 and 5.3.25-10 of the applications, and these dose rates satisfy the limits in 10 CFR 71.47(b) and 10 CFR 71.51(a)(2). The staff verified that the analysis presented at the selected locations are those of maximum radiation levels and include radiation streaming paths. The staff also verified that the applicant's evaluation addresses damage to the shielding under NCT and HAC.

5.5 Conclusion for Iron Clad Fuel

Based on the evaluation of the NAC-LWT, the staff has the following evaluation findings for the addition of iron clad fuels:

- As documented in section 5.2 of this SER, the staff found that the package description and evaluation satisfied the shielding requirements of 10 CFR Part 71.

- As documented in section 5.3 of this SER, the staff found that the source specification used in the shielding evaluation was sufficient to provide a basis for evaluation of the package against the shielding requirements of 10 CFR Part 71.

- As documented in section 5.4 of this SER, the staff found that the models used in the shielding evaluation were described in sufficient detail and permitted an independent review of the package shielding design.

- As documented in section 5.4.2 of this SER, the staff found that the external radiation levels satisfy the requirements of 10 CFR 71.47 for packages transported by an exclusive use vehicle.

- As documented in section 5.4.2 of this SER, the staff found that the maximum external radiation level at 1 meter from the external surface of the package will not exceed 1 rem/hr after HAC, consistent with the tests specified in 10 CFR 71.73, and therefore meets the requirements in 10 CFR 71.51(a)(2).

The staff also performed some confirmatory analyses as part of its review. The staff used the SCALE code system, Version 6.3, a later version than that used by the applicant, to calculate source terms for various burnup and cooling time combinations of the proposed contents. The source term calculations for different burnup and cooling time combinations generally supported the applicant's basis for using the source terms for the maximum burnup for the shielding analysis. The staff evaluation resulted in a significant increase in the source terms, both neutron and gamma. The staff evaluated the impacts of this source term on the package's ability to demonstrate compliance with the dose rate limits for both axial and radial directions using MCNP code. The dose rate results meet the regulatory limits in 10 CFR Part 71 for exclusive use.

Based on its review of the statements and representations in the SAR, including the proprietary calculation package, and applicant responses to staff questions and independent confirmatory calculations, the staff has reasonable assurance that the shielding design has been adequately described and evaluated and that the SAR meets the external radiation requirements of 10 CFR Part 71.

6.0 CRITICALITY EVALUATION

6.1 Review objective

The objective of the criticality evaluation is to determine if the Model No. NAC-LWT loaded with the proposed new contents continues to meet the regulatory requirements of criticality safety as prescribed in Sections 10 CFR 71.55 and 71.59 under NCT and HAC as prescribed in 10 CFR 71.71 and 71.73. The staff followed the guidance provided in NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," in its review. The following sections of this SER documents the staff's review and conclusions for both the iron clad fuel and LANL MOX fuel.

6.2 Criticality safety evaluation for Iron Clad Fuel

This proposed change consists of adding PWR and BWR fuel clad with an iron, chromium, and aluminum alloy (FeCrAl) as authorized contents in the NAC-LWT package.

The applicant previously evaluated an array of 25 bare fuel rods without cladding (i.e., "damaged" configuration). This is conservative as only 14 such FeCrAl rods are allowed per package. The applicant also ignored the geometric limitations of the rod holder and varied the pitch to determine optimum moderation. Prior NRC staff review found this conservatively demonstrated the maximum reactivity of a system limited to individual fuel rods in a rod holder. Since the applicant's design basis case credited neither the neutron absorption nor the moderator displacement caused by the presence of cladding, staff finds that the applicant's bounding analysis remains applicable to non-zircaloy clad fuel.

6.3 Criticality Safety Evaluation for LANL MOX Fuel

The applicant requested for the Model No. NAC-LWT package to permit shipment of variable quantities of MOX and uranium oxide (UO_2) rods in the transfer tube array. The NAC-LWT package may transport up to 16 transfer tubes with undamaged fuel rods. There are six unique rod types that bound the rods intended for shipment. The fuel rods may be composed of UO_2 fuel pellets, plutonium oxide fuel pellets, mixed oxide fuel pellets, plutonium carbide fuel pellets, or mixed carbide fuel pellets. Reactivity as a function of rod type is shown in table 6.7.7-3 of the SAR.

The applicant has determined that the divider assembly does not perform a safety function. Because of this determination, the applicant has made the use of the divider assembly optional. Due to the optional nature of the divider assembly, the applicant has removed the divider assembly from SAR criticality analyses. This has led to a slight increase in maximum k_{eff} compared to analyses done with the divider assembly in place.

The applicant assigned a Criticality Safety Index (CSI) of 25 to the LANL MOX fuel rods per 10 CFR 71.59. Given a CSI of 25, the value of "N" must be 2, therefore the analysis must consider an array of at least 10 packages under NCT and 4 packages under HAC. An infinite array of packages is analyzed by the applicant for NCT, and a four-package array was analyzed for HAC. The staff agrees that the analysis met these conditions, and that the CSI has been accurately assigned.

The applicant performed analyses on the NAC-LWT with up to 16 transfer tubes with LANL MOX fuel rods. The payload was assumed to have undamaged fuel rods, consistent with the structural analysis for the fuel rods. The fuel was assumed to be fresh, so no burnup credit was given. Preferential flooding evaluations of the canister containing the rod array were also included in the applicant's analysis.

The applicant used the MCNP 6.2 code package with the ENDF/B-VI cross-section library for all models. MCNP uses the Monte Carlo technique to calculate k_{eff} of a system. In the applicant's analyses, approximately 1000 cycles with 10,000 neutron histories per cycle are tracked through the system. Staff agrees that is the applicant used an appropriate method for calculating k_{eff} of the NAC-LWT package.

The applicant used MCNP to model the NAC-LWT package with 16 transfer tubes made of Type 304 stainless steel consisting of four 2×2 arrays of transfer tubes in the PWR insert and can weldment. The 2×2 arrays are separated by a divider plate made of Type 304 stainless steel. The applicant analyzed two divider options – thick and thin, as described in table 6.7.7-4 of the SAR. The accident condition modeled by the applicant completely removes the neutron shielding, the neutron shield tank and the package impact limiters. In the NCT model, the impact limiter diameter is modeled as identical to the neutron shield tank diameter. This allows for closer packing for the package array than physically possible. Under normal conditions, the package outer surface is surrounded by a rectangular body with reflecting boundary conditions. The boundary conditions are imposed on the sides, top and bottom, which simulates an infinite array of packages. Under accident conditions, a four-package array is modeled and surrounded by a full density water reflector. Staff agrees these are appropriate modeling assumptions for NCT and HAC.

Each of the six rod types were evaluated by the applicant to determine the bounding fuel type using the thinner divider and the maximum pitch. The 530-000 and ROD1603 rods have a high plutonium content and are significantly more reactive than other rods. Due to this, the applicant limited the content to one 530-000 rod per tube (with one tube per package) and three ROD1063 rods per tube (with 12 tubes per package). The NIS5 carbide rods are modeled with three rods axially per tube. These rods are demonstrated by the applicant to be subcritical ($k_{eff} + 2\sigma < 0.49$). The UO_2 rods have a smaller radial cross-sectional area that allows for more than one rod in the x/y plane. Therefore, the applicant considered up to four rods per elevation, or eight per tube, which is demonstrated to be subcritical by the applicant ($k_{eff} + 2\sigma < 0.64$). The Pacific Northwest National Laboratory (PNNL) and Exxon rods are natural uranium with a small amount of plutonium. The PNNL rods are modeled by the applicant with four axially per tube and the Exxon rods are modeled with two axially per tube. These rods are also demonstrated by the applicant to be subcritical ($k_{eff} + 2\sigma < 0.37$). Based on the above results, the applicant determined that a mixed loading consideration was not required. The applicant determined that with a payload limitation of one 530-000 rod/tube per package and three ROD1063 rods per tube (12 tubes per package), and 16 tubes of ROD1063 (48 rods per package) represented a bounding reactivity configuration. ROD1063 was used by the applicant for the following studies, which staff agrees is an appropriate bounding reactivity configuration.

The applicant modeled various divider thicknesses and pitches for a single package of ROD1063 under HAC. The most reactive configuration was a thin divider tube at maximum pitch. The applicant noted that this configuration maximized the H/U-235 ratio. As noted in the structural evaluation, there is no permanent deformation to the basket because of HAC and only minimal elastic deformation (max ~0.1 inches) during the drop. Per table 6.7.7-4 of the SAR, the maximum $k_{eff} + 2\sigma$ calculated by the applicant was 0.82274.

The applicant modeled a single package of ROD1063 under HAC at various internal and external moderator densities, including preferential flooding of the fuel region. The applicant's preferential flooding scenarios evaluated the square container containing the rod array at a moderator density independent of the remainder of the package cavity. Maximum reactivity was achieved by a preferentially flooded fuel region and void cavity and package exterior. Per table 6.7.7-5 the SAR, the maximum k_{eff} + 2σ calculated by the applicant was 0.82274.

For the single package evaluation, the applicant modeled the package using the inner shell as the containment for the NAC-LWT. To obtain the most reactive preferential flooded and fully flooded cases, the applicant removed the lead and outer shells (including the neutron shield) and reflected the system by 20 centimeters of water at full density on the X, Y, and Z faces. Per table 6.7.7-6 of the SAR, the maximum k_{eff} + 2σ calculated by the applicant was 0.61912.

The applicant also evaluated a normal condition infinite package array. Per table 6.7.7-7 of the SAR, the maximum k_{eff} + 2σ calculated by the applicant was 0.76307.

The applicant had previously established individual upper subcritical limits (USLs) for UO_2 and MOX systems based on benchmarking against laboratory critical experiments with similar neutronic parameters. The USL for an array of UO_2 rods was established by the applicant as 0.9376. The USL the applicant determined for an array of MOX rods was 0.9331. There is a difference of 0.0045 between the two fuel types with the MOX rods providing the more limiting condition. Staff agrees that all maximum k_{eff} values are below the limiting USL and that conservative estimates were used.

6.4 Conclusion

For the iron clad fuel, the applicant did not propose any change in this amendment that would affect any other aspect of its previous criticality analyses (e.g., moderator density, arrays of packages). Since design basis evaluations remains applicable with the proposed changes, staff finds the applicant's prior criticality analysis provide reasonable assurance that the NAC-LWT transportation package will remain subcritical.

For requested changes to the CoC for the LANL MOX fuel, initial assumptions, model configurations, analyses, and results were reviewed by staff. The staff finds that the applicant has identified the most reactive configuration of the Model No. NAC-LWT package with the requested contents, and that the criticality results are conservative. Therefore, the staff finds with reasonable assurance that the package, with the requested contents, will meet the criticality safety requirements of 10 CFR Part 71.

7.0 MATERIALS EVALUATION

The objective of the materials evaluation is to verify that the applicant has adequately evaluated the performance of the package (packaging together with contents) and demonstrated that the performance of the materials used to fabricate the package meets the regulatory requirements of 10 CFR Part 71.

For the iron clad fuel, staff reviewed the application and determined that since it is being added to the package as damaged fuel content, this does not change the performance of the package, and does not affect any aspect of the previous materials evaluation. Therefore, staff agrees the prior evaluation meets the regulatory requirements of 10 CFR Part 71.

The material evaluation for the LANL MOX fuel is presented below.

7.1 Material Evaluation for the LANL MOX Fuel

For the LANL MOX fuel, the staff reviewed revision 74 to the NAC-LWT SAR, to verify that the material performance of the LANL MOX transfer tube shipping configuration meets the requirements of 10 CFR Part 71. The LANL MOX transfer tube shipping configuration is designed to position and support up to 16 transfer tubes filled with LANL MOX fuel rods.

7.1.1 Materials of Construction

As described in Calculation Package 50077-2002, SAR section 1.1, and the licensing drawings, the LANL MOX Transfer Tube Shipping Configuration is comprised of an existing NAC-LWT packaging body assembly, basket assembly, PWR insert, and rod transport can assembly with new transfer tube assemblies and a new divider plate. The 16 transfer tubes are fabricated of ASTM International (ASTM) A269 type 304 stainless steel. The transfer tube spacers and end spacers are fabricated from ASME SA276 type 430 stainless steel. The transfer tube end caps are fabricated from ASME SA276/SA240 type 304 stainless steel. The divider plate is fabricated from ASME SA240 type 304 stainless steel.

Per the above discussion, the staff finds that the applicant's description of the materials of construction to be acceptable.

7.1.2 Drawings

The applicant provided new drawings in Volume 1 of the SAR to incorporate the new transfer tube assemblies and divider plate. The drawings include a parts list that provides the material specification of each component, and they also provide the welding and examination requirements. The staff notes that the level of detail in the new drawings are consistent with those of the previously approved drawings. The staff reviewed the drawing content with respect to the guidance in NUREG-2216, section 7.4.1, "Drawings" and NUREG/CR-5502, "Engineering Drawings for 10 CFR Part 71 Package Approvals." The staff confirmed that the drawings provide an adequate description of the materials, fabrication, and examination requirements. Therefore, the staff finds the drawings to be acceptable.

7.1.3 Codes and Standards

The staff verified that the new transfer tube assemblies and divider plate use ASME and ASTM steel materials. That staff notes that the cited material standards are consistent with NRC guidance in NUREG-2216, which states that important to safety components that do not comprise the containment boundary may be constructed of materials certified by ASME, ASTM, or the American Iron and Steel Institute.

The staff verified that the new transfer tube assemblies and divider plate follow the same structural and allowable stress criteria as the previously approved fuel baskets, ASME B&PV Code section III, subsection NG. The staff notes that the cited standards are consistent with NRC guidance in NUREG-2216, which states that fuel basket structures may be fabricated in accordance with ASME B&PV Code section III, subsection NG, "Core Supports".

Therefore, the staff finds the materials codes and standards to be acceptable.

7.1.4 Welding

The new transfer tube assemblies and divider plate use the same welding codes and standards as the previously approved designs. The weld design and nondestructive examination (NDE) will be in accordance with ASME B&PV Code subsection NG, and the welding procedures, processes, and welder qualifications will be in accordance with ASME B&PV Code section IX. The visual examinations of the welds will be performed in accordance with ASME B&PV, Section V, Articles 1 and 9, with acceptance standards per section III, subsection NG, Article NG-5360. The staff reviewed ASME B&PV code for the design, fabrication, and examination of the welds in the application. The staff determined that the ASME B&PV code identified are consistent with the guidance in NUREG-2216. Therefore, the staff finds the welding and NDE codes and standards to be acceptable.

7.1.5 Mechanical Properties

As described in the Design Input Section of Calculation Package 50077-2002, the applicant provided the mechanical properties used in the structural analyses for the LANL MOX transfer tube shipping configuration. The staff verified that the mechanical and physical property data for the major structural materials, namely type 304 and 430 stainless steels, were obtained from ASME B&PV Code, consistent with the guidance in NUREG-2216, section 7.4.4.

The staff reviewed the applicant's thermal analysis to ensure that the material properties are valid under the service conditions associated with the LANL MOX fuel loaded into the NAC-LWT package. In SAR appendix A, section A.4, the applicant evaluated the maximum inner shell temperatures based on the previously analyzed materials test reactor Fuel Analytical Model. The staff reviewed the applicant's thermal analysis in SAR sections 3.4 and 3.5 and verified that the component temperatures remain below each of the material's allowable service temperatures during NCT and HAC conditions. Therefore, the staff finds the mechanical properties used in the applicant's structural analysis to be acceptable.

7.1.6 Corrosion Resistance and Content Reactions

The staff reviewed the revision changes and verified that they do not introduce any adverse corrosive or other reactions that were not previously considered in the staff's prior review of the NAC-LWT CoC. The materials of construction and the service environments are bounded by those that were previously evaluated in the CoC. Therefore, the staff finds the applicant's evaluation of corrosion resistance and potential adverse reactions to be acceptable.

7.1.7 Package Contents

As described in SAR sections 1.1 and 1.2.3.28, table 1.1-1, the new transfer tube shipping configuration may hold up to 16 transfer tubes containing various LANL MOX fuel types in accordance with table 1.2-20 of the SAR. Each transfer tube is limited to a single LANL MOX fuel type.

The LANL MOX fuel rods, as shown in figure 1.2.3-25 of the SAR, consist of mixed oxide fuel pellets and have either zirconium alloy or stainless steel cladding. Fuel rod characteristics for each of the LANL MOX variants (PNNL, Exxon, UO_2, ROD 1063, 530-000, & NIS5), and the maximum number of rods per tube and rods per package is contained in table 1.2-20 of the SAR.

Therefore, the staff finds the description of the package contents to be acceptable.

7.1.7 Conclusion

Based on the evaluation of the NAC-LWT, the staff has the following evaluation findings for the LANL MOX Fuel:

- The applicant has met the requirements in 10 CFR 71.33. The applicant described the materials used in the transportation package in sufficient detail to support the staff's evaluation.
- The applicant has met the requirements of 10 CFR 71.31(c). The applicant identified the applicable codes and standards for the design, fabrication, testing, and maintenance of the package and, in the absence of codes and standards, has adequately described controls for material qualification and fabrication.
- The applicant has met the requirements in 10 CFR 71.43(f) and 10 CFR 71.51(a). The applicant demonstrated effective materials performance of packaging components under NCT and HAC. The applicant has met the requirements of 10 CFR 71.43(f) and 71.55(d)(2). The applicant has demonstrated that the package will be designed and constructed such that the analyzed geometric form of its contents will not be substantially altered and there will be no loss or dispersal of the contents under the tests for NCT.
- The staff concludes that revision 74 to the NAC- LWT CoC adequately considers material properties and material quality controls such that the design is in compliance with 10 CFR Part 71. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

8.0 PACKAGE OPERATIONS

The purpose of the package operations evaluation is to verify that the proposed changes to the operating controls and procedures of the transport package continue to meet the requirements of 10 CFR Part 71.

For the iron clad fuel amendment, staff reviewed the application and determined that since it is being added to the package as damaged fuel content, this does not change the performance of the package, and does not affect any aspect of the packaging operations. Therefore, no additional analysis is required.

The SAR chapter 7 provides procedures for package loading, unloading, and preparation of the empty package for transport. SAR sections 7.1.22, "Procedure for the Dry Loading of LANL MOX Fuel Rods," and 7.2.9, "Procedure for the Dry Unloading of LANL MOX Fuel Rods," provide revised operating procedures for the dry loading and unloading of LANL MOX fuel rods, respectively, into the NAC-LWT package.

The staff reviewed the Operating Procedures in SAR chapter 7 to verify that the package will be operated in a manner that is consistent with its design evaluation. Based on its evaluation, the staff concludes that the combination of the engineered safety features and the operating procedures provide adequate measures and reasonable assurance for safe operation of the proposed dry loading and unloading of LANL MOX fuel rods in accordance with 10 CFR Part 71. Further, the CoC is conditioned such that the package must be prepared for shipment and operated in accordance with the Operating Procedures specified in the SAR chapter 7.

CONDITIONS

The following changes have been made to the certificate:

Condition No. 5(a)(3)(ii), “Drawings,” was updated to reflect the latest revision (revision 1P) of two drawings: No. LWT 315-40-188, Rev. 2P LWT, Transport Cask Shipping Configuration, LANL MOX and No. LWT 315-40-189, Rev 3P, Transfer Tube Details, LANL MOX

Condition No. 5(b)(1)(viii), has been updated to include that iron clad (FeCrAl) fuel rods, and non-fueled non-zirconium rod sections, require an additional 90-day cool time beyond the indicated zircaloy based value to specify parameter limits.

Condition No. 5(b)(1)(ix), has been updated to include a note that iron clad (FeCrAl) fuel rods, and non-fueled non-zirconium rod sections, require an additional 90-day cool time beyond the indicated zircaloy based value.

Condition No. 5(b)(1)(xxiv), has been added the type and form of materials section to include specifications for the LANL MOX Fuel Rods

Condition No. 5(b)(2)(ix), has been edited to specify that damaged fuel also includes unfueled rods/rod segments or that the fuel rods may be composed of segments. Limited the number of iron clad (FeCrAl) fuel rods to no more than 14 fueled or unfueled rods, and Co 60 impurity for iron clad rods is limited to 1.2 g/kg.

Condition No. 5(b)(2)(x), has been edited to specify that damaged fuel also includes unfueled rods/rod segments or that the fuel rods may be composed of segments. Limited the number of iron clad (FeCrAl) fuel rods to no more than 14 fueled or unfueled, and Co 60 impurity for iron clad rods is limited to 1.2 g/kg.

Condition No. 5(b)(2)(xxv), was added describing loading and spacing requirements for LANL MOX Fuel Rods.

Condition No. 5(c), has been edited to include the CSI for the LANL MOX Fuel Rods.

Condition No. 20, updated to include authorizing use of revision 74 of the certificate.

The references section has been updated to include the consolidated application dated August 16, 2024.

CONCLUSION

Based on the statements and representations in the applications, as supplemented, and the conditions listed above, the staff concludes that the Model No. NAC-LWT package design has been adequately described and evaluated, and that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with CoC No. 9225, Revision No. 75.