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

SAFETY EVALUATION REPORT
Docket No. 71-9358
Model No. TN-LC Package
Certificate of Compliance No. 9358
Revision No. 6

SUMMARY

By letter dated August 9, 2021 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML211221A323), TN Americas LLC (TN) submitted an application to revise Certificate of Compliance (CoC) No. 9358 for the TN-LC packaging. The amendment request introduces a fuel assembly can (FAC) for a damaged PWR fuel assembly and adds a provision to ship damaged fuel rods. Damaged fuel assemblies are defined as having the same configuration as intact fuel assemblies, except they contain missing or partial length or dummy fuel rods with cladding defects greater than hairline cracks or pinhole leaks.

The package leak-tight criterion continues to be applicable when transporting damaged fuel in the TN-LC package. The applicant is also adding nitrogen as an authorized backfill gas for draining and following vacuum drying prior to leak-testing the cask cavity.

On February 28, 2022 (ADAMS No. ML22060A044), the applicant provided responses to staff's Request for Additional Information (RAI) letter dated December 21, 2021. The applicant also added a change to the material specification for the containment boundary O-rings that was not related to the RAIs to allow additional seal materials: VM835-75, VM125-75 or VX065-75. The addition of alternate seal materials was necessitated because the current one is being discontinued.

By letter dated March 22, 2022 (ADAMS No. ML22080A154), the applicant also requested renewal of the CoC. The certificate was renewed for a 5-year term.

By letter dated April 29, 2022 (ADAMS No. ML22119A102), the applicant provided a consolidated application Revision No. 10.

Based on the statements and representations in the application, and the conditions listed in the CoC, the U.S. Nuclear Regulatory Commission staff (the staff) concludes that the package meets the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71.

EVALUATION

1.0 GENERAL INFORMATION

The TN-LC packaging has been developed for exclusive-use transport of irradiated test, research, and commercial reactor fuel, including several types of Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), Mixed Oxide Fuel (MOX), and Evolutionary Pressurized Reactor (EPR) fuel assemblies and/or fuel pins. Additional payloads include National Research Universal Reactor (NRU), National Research Experimental Reactor (NRX), Material Test Reactor (MTR), and Training, Research and Isotope, General Atomics Reactor (TRIGA) fuel assemblies and fuel elements. The fuel is contained in specific baskets which fit into the TN-LC transport cask. The TN-LC transport package is limited to a maximum heat load of 3.0 kW depending on the fuel and basket being transported.

The TN-LC packaging consists of the following components:

- A TN-LC transport cask consisting of a containment boundary, structural shell, gamma shielding material, and solid neutron shield.

- One set of removable trunnions bolted to plates which are welded to the outer shell of the cask. There are also two pocket trunnions, in the bottom flange, that are used for rotating the cask and may be used for horizontal cask lifting.

- Impact limiters consisting of balsa and redwood blocks encased in stainless steel shells; each impact limiter is held in place by eight attachment bolts.

- Four TN-LC basket designs (TN-LC-NRUX, TN-LC-MTR, TN-LC-TRIGA, and TN-LC-1FA) with multiple fuel types and configurations. As there are different basket heights (and combinations of stacked baskets), stainless steel or aluminum spacers are provided to limit axial movement of the payload.

The TN-LC packaging may be loaded or unloaded in either a spent fuel pool or a hot cell environment. The Model No. TN-LC package is 230 inches (5,842 mm) long and 66 (1,676 mm) inches in diameter. The cask body is a right circular cylinder 197.5 inches (5,016.5 mm) long and 30 inches (762 mm) in diameter (not including the impact limiter attachments and the neutron shield). It is composed of top and bottom end flange forgings connected by inner and outer shells.

The TN-LC Unit 01 “as-fabricated” cask has a reduced minimum cavity length of 182.10 inches (4,625.5 mm) and a reduction in its shielding capability due to localized areas where the lead thickness may be as low as 3.10 inches (78.5 mm). The TN-LC Unit 01 shall only be loaded with the TN-LC-1FA basket with one PWR fuel assembly (including a FAC when transporting a damaged PWR fuel assembly) or one pin can with up to 21 PWR fuel rods.

The gross weight of the loaded package is 51,000 lbs (23,130 kg) including a payload of 7,100 lbs (3,220 kg). The package is designed to be transported horizontally by highway truck, ship, or by rail in exclusive use.

The packaging is constructed and assembled in accordance with the following Drawing Nos.:

65200-71-01 Revision 10	TN-LC Cask Assembly (11 sheets)
65200-71-20 Revision 5	TN-LC Impact Limiter Assembly (3 sheets)
5200-71-21 Revision 2	TN-LC Transport Packaging Transport Configuration (1 sheet)
65200-71-40 Revision 4	TN-LC-NRUX Basket - Basket Assembly (5 sheets)
65200-71-50 Revision 4	TN-LC-NRUX Basket - Basket Tube Assembly (5 sheets)
65200-71-60 Revision 4	TN-LC-MTR Basket General Assembly (4 sheets)
65200-71-70 Revision 4	TN-LC-MTR Basket Fuel Bucket (2 sheets)
65200-71-80 Revision 4	TN-LC-TRIGA Basket (5 sheets)
65200-71-90 Revision 7	TN-LC-1FA Basket (5 sheets)
65200-71-96 Revision 5	TN-LC-1FA BWR Sleeve and Hold-Down Ring (2 sheets)
65200-71-102 Revision 7	TN-LC-1FA Pin Can Basket (5 sheets)
65200-71-91 Revision 0	TN-LC-1FA PWR Basket Damaged FCA (3 Sheets)

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

2.0 STRUCTURAL AND MATERIALS EVALUATION

2.1 Structural Evaluation

The staff's evaluation addressed any changes to the structural behavior of the packaging that the addition of the FAC could have on the TN-LC cask design. Changes in the weight, thermal environment, and ability of the FAC to confine the new payload under Normal Conditions of Transport (NCT) and Hypothetical Accident Condition (HAC) are evaluated.

In Section 1.4.5.2.3 of Enclosure 2 of the application, the applicant describes the FAC as a stainless steel, square-section structure made of a sheet metal liner, a bottom closure welded to this liner, and a top closure lid, which simply sits on top of the can. There is a square structure welded to the bottom of the top lid, which slides inside the damaged fuel can liner. Because of this, the top closure lid can freely slide along the axis of the cask (within the cask cavity) but is captured by the body of the can in any direction perpendicular to the axis of the cask cavity. Finally, the top and bottom closures are sufficiently thick (in relation to the available axial gaps within the cask cavity) to ensure that they are always constrained by the basket in any direction perpendicular to the cask axis.

In Table 4.5.4-1 of the application, the applicant identifies the weight of the FAC and of the payload. The initial qualification of the package used the TN-LC-1FA basket weight to envelope all the other payloads. The review finds that the FAC weighs less than the TN-LC-1FA basket. The staff concludes that the weight of the FAC imposes no additional demand on the package and needs no further evaluation.

In Section 2.13.10.2 of the application, the applicant provides the methodology for the thermal analysis and states that, to verify that adequate clearance exists between the fuel and basket components and the cask cavity for free thermal expansion, the thermal expansions between various components were calculated and the maximum fuel lengths were determined. The average temperature of the damaged FAC is conservatively based on the maximum average 1FA basket temperature for intact fuel under NCT. The staff concludes that the thermal effects on the structural integrity of the can are bounded by the initial design.

Per Section 1.4.5.2.1, and as shown in Drawing 65200-71-91, the top lid and bottom cover are design features of the packaging that ensure that any fuel material is always confined within the fuel compartment square boundary, and that fuel material cannot be released outside the fuel compartment square boundary into the space between the 1FA basket and the TN-LC inner cavity. For side drops, both the top lid and bottom cover are self-supported and self-loaded. Also, both plates are not slender; therefore, there is no risk of buckling. For an end drop on the lid, the top cover plate is loaded with the fuel assembly through bearing on the TN-LC lid. The top lid and bottom cover perform the safety function of confining the fuel material within the 1FA basket fuel compartment, and the liner is not required for the contents to remain subcritical.

The presence of the FAC does not change the assumptions for fuel rearrangement that are used in the criticality evaluation. Any deformation of the FAC liner does not change the assumptions for fuel rod pitch, and the presence of the top lid and bottom cover confine the fuel assembly rods and any fuel debris from a damaged fuel assembly to the geometry of the 1FA basket fuel compartment. No additional evaluations for the NCT and HAC are required for the addition of the FAC.

Drawing No. 65200-71-01 has been revised on sheet 1 to show construction details for Item 6, to show Items 1, 4, and 6 as not important to safety, to allow Item 7 to be optional under certain conditions, and to make an editorial change. Sheet 2 of the drawing has been revised to show details between Items 1 and 6. In addition, Appendix 1.4.1 has been updated to reflect the drawing changes to Revision 10. The staff's review of these changes established that these are non-code items and do not affect any ITS component design. The staff concludes that these changes are not important to safety but are addressed here for completeness of staff's evaluation of this amendment request.

The staff concludes that the inclusion of the FAC imposes no additional structural demands on the previously certified TN-LC cask design. The design remains in compliance with the requirements of 10 CFR Part 71.

2.2 Materials Evaluation

The applicant introduced additional material options for the elastomeric seals for the containment lid and port penetrations because the currently approved Parker seal compound V1289-75 has been discontinued. The applicant stated that there is no equivalence allowance available; hence, three alternative seals that exhibit similar temperature, elongation and compression properties have been added as alternate seal materials, including Parker compounds VM835-75, VM125-75, and VX065-75. Similar to the previously approved compound, the new seal materials are fluorocarbon elastomers with a Type A nominal hardness of 75. The applicant provided manufacturers' materials specifications to demonstrate that the new seals exhibit either better or similar properties to the previously approved seal.

The staff reviewed the provided information and verified that the high and low temperature performance characteristics of the new seals are compatible with the package's NCT and HAC service environments. As documented in NUREG-2215, fluorocarbon elastomers are resistant to radiation exposure up to 10^5-10^6 rads, while the applicant calculated the seal's radiation exposure in the TN-LC package to be $2x10^4$ rad/year. In addition, the manufacturer's data demonstrates that mechanical property changes in the new seal materials are minor after exposure to the maximum allowable HAC temperature (482°F). The new seal materials exhibit greater ductility (elongation) and comparable hardness and compression set at elevated temperatures with respect to the previously approved seal material

Finally, the staff notes that fluorocarbon elastomers are commonly used as containment seals in radioactive material transportation packages, as they have low gas permeability. Therefore, the staff concludes that the new seal materials are acceptable alternatives for the discontinued seal.

4.0 CONTAINMENT EVALUATION

The objective of the review is to verify that the containment performance of the Model No. TN-LC transportation package has been adequately evaluated for the tests specified under both NCT and HAC and that the package design satisfies the containment requirements of 10 CFR Part 71.

Staff reviewed the information provided by the applicant and evaluated the following change:

- Clarify that the relaxed leak rate criterion determined in 4.6.1 only applies to intact fuel.

The applicant provided the above clarification in Sections 4.4, 4.5, and 4.6 of the application, along with appropriate justifications. Staff determined that all the changes proposed in the application have no negative impact on the confinement design. As stated in Chapter 2 of this SER, the applicant introduced additional material options for the elastomeric seals for the containment lid and port penetrations. The materials evaluation concluded that the new seal materials are acceptable alternatives to replace the discontinued seal. Based on the materials evaluation provided in Chapter 2, the staff finds that the package continues to fulfill its containment function with the new materials used for the elastomeric seals.

Therefore, staff concludes that the TN-LC transportation package meets the confinement requirements in 10 CFR 71 and will continue to fulfill the confinement acceptance criteria as listed in Section 9.3, “Regulatory Requirements and Acceptance Criteria,” of NUREG 2216, “Standard Review Plan for Transportation Packages for Spent Fuel and Radioactive Material.”

Based on review of the statements and representations in the application, the NRC staff concludes that the TN-LC transportation package has been adequately described and evaluated to demonstrate that it satisfies the containment requirements of 10 CFR Part 71, and that the package meets the containment criteria of ANSI N14.5-2014.

6.0 CRITICALITY EVALUATION

The applicant requested to amend the allowable contents for the Model No. TN-LC package to allow damaged fuel assemblies within a damaged fuel assembly can (FAC), damaged fuel rods in a pin can, and intact or damaged pressurized water reactor (PWR) fuel assemblies evaluated using burnup credit in the criticality analysis. All of the proposed content changes are for contents to be loaded in the TN-LC-1FA basket. The applicant requested no changes to the packaging or basket design. The applicant modeled the packaging and basket the same as in the previously approved TN-LC package, with changes only to the contents model.

The applicant modeled a single package with the requested contents under hypothetical accident conditions (HAC). The applicant stated that this model bounds the single package under normal conditions of transport (NCT), since the HAC model considers water in-leakage. The applicant uses the HAC single package model to demonstrate subcriticality of a single package with water in-leakage (10 CFR 71.55(b)), a single package under NCT (10 CFR 71.55(d)), and a single package under HAC (10 CFR 71.55(e)). The staff finds that the applicant’s HAC single package model bounds the conditions required to be evaluated in 10 CFR 71.55(b), 10 CFR 71.55(d), and 10 CFR 71.55(e).

For package arrays under NCT with damaged fuel assemblies in an FAC, damaged fuel rods in a pin can, or intact or damaged PWR fuel assemblies evaluated with burnup credit, the applicant modeled packages with dry interior. For damaged fuel assemblies in an FAC or damaged fuel rods in a pin can, the applicant modeled infinite arrays of packages. For intact or damaged PWR fuel assemblies evaluated with burnup credit, the applicant modeled an array of three packages. For both evaluations, the applicant conservatively modeled the fuel material with the fresh fuel composition. The resulting calculated k_{eff} was very low, since water is not present inside the package under NCT. The maximum k_{eff} calculated for package arrays with damaged fuel assemblies in an FAC, damaged fuel rods in a pin can, or intact or damaged PWR fuel assemblies evaluated with burnup credit under NCT was 0.2303.

For package arrays under HAC with damaged fuel assemblies in an FAC or damaged fuel rods in a pin can, the applicant modeled infinite arrays of packages with optimum internal and interstitial moderation by water. For package arrays under HAC with intact or damaged PWR fuel assemblies evaluated with burnup credit, the applicant modeled a single package with optimum internal moderation by water and full water reflection. The infinite array model for damaged fuel assemblies in an FAC or damaged fuel rods in a pin can supports a criticality safety index (CSI) of 0.0 for the package with these contents. The single package HAC array model for intact or damaged PWR fuel assemblies evaluated with burnup credit is the same as the for the single package under HAC with intact or damaged PWR fuel assemblies evaluated with burnup credit and corresponds to a CSI of 100 for the package with these contents. The staff finds that the applicant's requested CSI values for this package with damaged fuel assemblies in an FAC, damaged fuel rods in a pin can, or intact or damaged PWR fuel assemblies evaluated with burnup credit are calculated according to the requirements for fissile material package arrays in 10 CFR 71.59 and is acceptable.

For the damaged fuel assembly, the applicant evaluated various fuel reconfiguration scenarios, including single and double ended rod shear, missing rods, and uniform pitch expansion. The applicant also conservatively assumed that the cladding is replaced with water in the HAC model. The applicant found that the model for uniform pitch expansion was the most reactive, which is consistent with staff's expectations and experience with similar previously approved package analyses. The applicant used the expanded pitch model to determine the burnup credit loading curves for damaged fuel assemblies. This loading curve bounds intact fuel, as fuel in its as-built configuration is less reactive than fuel with missing clad and expanded pitch. Resulting loading curves are shown in Table 1.4.5-4a of the SAR for the WE 17x17 and WE 14x14 fuel classes. The loading curve for the WE 17x17 fuel class bounds the WE 15x15, WE 16x16, CE 14x14, CE 15x15, and CE 16x16 fuel classes. BW 15x15 fuel class not included in analysis or allowed for loading under BUC requirements.

For damaged fuel rods in the pin can, the applicant modeled fresh fuel material enriched to 5.0 weight percent ^{235}U (wt%), both filling the stainless-steel pin tubes and outside the tubes collected in the bottom of the pin can. The applicant conservatively modeled more material than is present in 21 rods of any design (i.e., PWR, BWR, EPR), which is the maximum number of rods allowed in the pin can. The applicant modeled an infinite array of flooded packages with damaged fuel rods, corresponding to a CSI of 0. The resulting k-eff is very low: <0.5. This is expected, since the amount of fuel material in a pin can is significantly less than a full fuel assembly.

For fresh fuel analyses of the damaged fuel rods, and for maximum fresh fuel assembly loading at zero burnup under the burnup credit analysis, the applicant used the CSAS5 sequence of SCALE 6.1.3, with the KENO V.a three-dimensional Monte Carlo criticality code and the 238-group ENDF/B-VII.0 cross section library. For burnup credit criticality analysis, the applicant used the STARBUCS sequence of SCALE 6.1.3, with the 238-group ENDF/B-VII.0 cross section library. STARBUCS facilitates burnup credit calculations by performing depletion analysis using ORIGEN-ARP, then incorporating the resulting isotopic composition into a criticality model evaluated using KENO V.a. The codes and cross section data used by the applicant for the criticality analysis of the TN-LC package are standards in the industry and are acceptable to staff for evaluating the package.

For burnup credit analysis of the TN-LC package, the applicant followed the review guidance for NRC staff contained in Section 6.4.7 of NUREG-2216. The applicant credited 28 isotopes – 12 actinides and 16 fission products – as shown in Table 6.10.5-3 of the SAR. This set of isotopes is consistent with that recommended in Table 6-2 of NUREG-2216 and is acceptable.

The applicant developed sets of burnup credit loading curves for WE 14x14 and WE 17x17 fuel assembly classes. Each set of loading curves contains separate curves for 5-, 10-, 15-, and 20-years cooling time, and each curve contains points up to 5.0 wt% enrichment and 30 GWd/MTU burnup. These parameters are within the recommended licensing limits in Section 6.4.7 of NUREG-2216, since the credited cooling time is less than 40 years, the maximum enrichment is 5.0 wt%, and the maximum credited burnup is less than 60 GWd/MTU, and are acceptable.

For burned fuel criticality calculations for PWR fuel in the TN-LC package, the applicant used the STARBUCS sequence of the SCALE 6.1.3 code system. This sequence uses reactor libraries with isotopic compositions as a function of burnup, enrichment, and cool time for a particular fuel type, pre-generated with the TRITON two-dimensional isotopic depletion sequence in the SCALE 6.1.3 code. The applicant generated specific reactor libraries for all fuel assemblies modeled in the burnup credit criticality analysis, assuming that either a burnable poison rod assembly (BPRA) was present during the entire irradiation, or that control rods were fully inserted during the first 15 GWd/MTU of irradiation in the reactor. Fuel assemblies with no control rod insertion in the active fuel region may be loaded using the curve generated assuming BPRA presence during the entire irradiation (as shown in Table 1.4.5-4a), and fuel assemblies with accumulated control rod insertion through the first 15 GWd/MTU of assembly burnup may be loaded using the curve generated assuming full control rod insertion for the first 15 GWd/MTU of assembly burnup (as shown in Table 1.4.5-4b). Fuel assemblies with accumulated control rod insertion greater than the first 15 GWd/MTU of assembly burnup are not authorized under package burnup credit loading requirements. The staff finds that the applicant's conclusion that the absorber exposures assumed in the generation of reactor libraries for use in the STARBUCS criticality calculations are conservative is appropriate, since these assumptions bound absorber exposures anticipated for any fuel type during irradiation in a reactor.

The applicant used the bounding burnup-dependent axial profiles built into STARBUCS to model axial variation in burnup. These profiles are consistent with those recommended in NUREG-2216, which come from NUREG/CR-6801, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses," and are acceptable to staff for modeling axial variation in burnup.

The applicant estimated the isotopic composition of burned fuel as a function of burnup, enrichment, and cooling time, which was subsequently used in the criticality calculations. The model assumptions for the isotopic depletion analysis that affect the reactivity of the package include the core specific power, moderator temperature, fuel temperature, and soluble boron concentration during irradiation. These core operating parameters are given in Table 6.10.5-27 of the SAR, and are included as loading criteria in Section 7.7.4 of the package operating procedures in the SAR.

Applicant used depletion bias and bias uncertainty from NUREG-2216 for isotopic depletion code validation. This is acceptable as they used ORIGEN-ARP libraries based on TRITON depletion analyses using ENDF/B-VII cross section data, and because the TN-LC package is neutronically similar to the GBC-32 cask used to develop the bias and bias uncertainty values in NUREG-2216. The applicant demonstrated neutronic similarity in Section 6.10.5.7 of the SAR by comparing global neutronic parameters (EALF, AEG, and H/X), and also by performing a sensitivity/uncertainty analysis comparing the sensitivity data file from the TN-LC model to that from the GBC-32. The global neutronic parameters were very similar for both systems, as shown in Tables 6.10.5-12 through 6.10.5-14, and the c_k values for the TN-LC package compared to the GBC-32 cask were around 0.9 for the burnups credited. System comparisons resulting in c_k values 0.9 or higher are considered similar, with c_k values above 0.8 considered moderately similar. Staff finds the global neutronic parameter and sensitivity/uncertainty comparisons performed by the applicant acceptable for demonstrating similarity to the GBC-32 cask used to develop the recommended depletion code bias and bias uncertainty values in NUREG-2216.

For the criticality analysis, the applicant used the STARBUCS sequence of the SCALE 6.1.3 code for burnup credit calculations, and the CSAS5 sequence of SCALE 6.1.3 for fresh fuel maximum enrichment calculations. For both sets of calculations, the applicant used the 238-group ENDF/B-VII.0 cross section library. The applicant had previously validated fresh fuel calculations for use with the previously approved contents. That validation, which resulted in an upper subcritical limit (USL) of 0.9420, remains applicable to the fresh fuel maximum enrichment calculations for the burnup credit loading curve. For major actinide validation of the TN-LC burnup credit criticality calculations using STARBUCS, the applicant benchmarked the code against 157 critical configurations from the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook, including 80 Haut Taux de Combustion (HTC) configurations shown to be highly applicable to spent fuel applications in NUREG/CR-6979. The applicant performed trending analyses on energy of the average lethargy causing fission (EALF), average neutron energy group causing fission (AEG), fuel rod pitch, assembly separation, ^{235}U enrichment, moderator-to-fuel volume ratio, hydrogen to fissile ratio, and plutonium content (Pu/U+Pu). The applicant demonstrated that resulting k_{eff} values are normally distributed, such that the single-sided lower tolerance limit method of NUREG/CR-6361 can be used. The resulting USL for criticality calculations evaluated using burnup credit is 0.9424. The staff finds that the applicant appropriately validated the fresh fuel criticality calculations and the major actinide component of the burnup credit criticality calculations for the package, consistent with the recommendations for computational method validation in NUREG-2216.

For minor actinides and fission products, the applicant followed the recommendations of NUREG-2216, and used 1.5% of the minor actinide and fission product worth as the criticality code bias due to these nuclides. The staff finds this acceptable since: 1) the applicant used the SCALE code system with ENDF/B-VII.0 cross section data; 2) the applicant demonstrated similarity of the TN-LC package to the GBC-32 cask used to develop the minor actinide and fission product criticality code bias recommendation in NUREG-2216 (as discussed above); and 3) the applicant demonstrated that the maximum minor actinide and fission product worth is less than 0.1.

The applicant evaluated potential misloaded fuel assemblies in the TN-LC-1FA basket according to the recommendations for misload analyses contained in Section 6.4.7.5 of NUREG-2216. The results demonstrate that the misloaded configurations meet a misload USL with a reduced administrative margin of 0.02 Δk_{eff}. The staff reviewed the applicant's misload analysis, and finds that it is consistent with the recommendations in Section 6.4.7.5 of NUREG-2216, and that the criticality design of the package adequately protects against the consequences of fuel assembly misloads.

The applicant included additional administrative procedures for loading PWR fuel evaluated for criticality safety using burnup credit in the TN-LC-1FA basket, shown in Section 7.7.4 of the operating procedures in the SAR. These procedures include:

- Verification of the location of highly underburned and high reactivity fuel in the spent fuel pool prior to and after loading to ensure appropriate fuel assemblies have been loaded,
- No fresh fuel in pool at time of loading, or verification that fuel being loaded into the cask is not fresh, either visually or by qualitative measurement,
- A pool audit prior to loading, including visual verification of assembly identification numbers, and
- Fuel assemblies without visible identification are only to be loaded after quantitative burnup measurement of the fuel assembly.

The staff finds these additional procedures are comparable to those recommended in Section 6.4.7.5 of NUREG-2216, and are acceptable for reducing the likelihood and severity of misload events.

The staff finds the applicant has demonstrated that the TN-LC package, when loaded with fuel assemblies meeting the characteristics of the contents described in Table 1.4.5-1 of the SAR, will be adequately subcritical under all conditions. Therefore, the applicant has shown, and the staff finds that, the TN-LC package meets the fissile material requirements of §71.55 for single packages, and §71.59 for arrays of packages with a CSI of 0.0 for damaged fuel rods in a pin can, and a CSI of 100 for intact fuel assemblies, or damaged fuel assemblies in a FAC, which meet the burnup credit loading curve requirements shown in Table 1.4.5-4a of the SAR.

7.0 OPERATING PROCEDURES

Procedures are provided for transport of the package either directly from a spent fuel pool or directly from a hot cell. Appendix 7.7 of Chapter 7 contains a sub-appendix for each basket design detailing its loading procedures.

A TN-LC cask with a TN-LC-1FA basket may be configured in one of four configurations:

- A TN-LC-1FA basket for transporting a PWR assembly,

- A TN-LC-1FA basket and damaged fuel assembly can placed inside the TN-LC-1FA basket when transporting a damaged PWR fuel assembly, or

- A BWR sleeve and hold-down ring placed inside the TN-LC-1FA basket when transporting a BWR assembly, or

- A TN-LC-1FA pin can placed inside the BWR sleeve when transporting individual LWR fuel rods. Spacers may be required for shorter fuel assemblies or rods. The TN-LC-1FA pin can may be loaded prior to placement in the cask or loaded while in the cask.

The TN-LC Unit 01 shall only be loaded with the TN-LC-1FA basket (equipped with the damaged FAC if loading a damaged PWR fuel assembly) with one PWR fuel assembly or one fuel rod pin can with up to 21 PWR or BWR intact or damaged fuel rods.

The operating procedures were updated to (i) include the use of a Damaged Fuel Assembly Can when a damaged PWR fuel assembly is transported, and mention the operation of inserting it into the 1FA basket in this case (and later installing or removing its lid during operations), (ii) add nitrogen as an authorized backfill gas for draining (step 14 of Section 7.1.2) and following vacuum drying prior to leak-testing (step 6 of Section 7.1.2.1) the cask cavity.

Also, nitrogen can now be used in the cask cavity as a replacement for helium to perform the leak-testing of the O-rings, as long as the cask cavity is filled with helium prior to shipment. This addition makes leak-testing operations easier because it prevents the O-ring elastomer seals to become saturated with helium, which could be a factor in complicating the leak tests.

The candidate fuel assemblies/elements or fuel rods to be transported in a specific basket must be evaluated to verify that they meet the fuel qualification requirements of the applicable fuel specification as listed in Table 7-1.

For the transportation of fuel within the TN-LC-1FA where burnup credit is employed for criticality safety, additional administrative controls to prevent misloading are also outlined in Appendix 7.7.4. Fuel loading plans developed above shall also include these additional requirements:

− A requirement to compare the reactor operating parameters for the irradiation period of the fuel assembly against those shown in Table 6.10.5-27 to ensure compliance with the isotopic depletion analysis,

− A requirement for having no fresh fuel in pool at the time of loading, or a verification that the fuel being loaded into the cask is not fresh, either visually or by a qualitative measurement,

− A pool audit prior to loading, including a visual verification of assembly identification numbers,

− Identification of highly underburned and high reactivity fuel assemblies in the pool both prior to and after loading. Alternatively, the licensee can perform a misload evaluation using the methodology and criteria described in Section 6.10.5.8 to identify these highly underburned and high reactivity fuel assemblies.

− A requirement that assemblies without visible identification number must have a quantitative confirmatory burn up measurement prior to loading.

The staff finds these additional procedures are comparable to those recommended in Section 6.4.7.5 of NUREG-2216 and are acceptable for precluding potential misload events or reducing the likelihood and severity of misload events.

8.0 ACCEPTANCE TESTS AND MAINTENANCE

The acceptance tests and maintenance chapter was updated to clarify that the relaxed leak rate criterion determined in Section 4.6.1 of the application only applies to intact fuel only. Therefore, the leak-tight criterion will apply when transporting damaged fuel in the TN-LC package, not the relaxed criterion from Section 4.6.1.

The containment boundary components, i.e., lid and seals, bottom plug and seals, vent port plug seal and drain port plug seal shall be subject to periodic maintenance, and pre-shipment leakage testing in accordance with ANSI N14.5. The personnel performing the leakage test is qualified in accordance with SNT-TC-1A or alternatively, ISO 9712.

CONDITIONS

The following changes were made to the Conditions of the certificate:

Item No. 3.b reflects the latest revision (Revision No. 10) of the application

Condition No. 5(a)(3) was modified to include Revision 10 of licensing drawing 65200-71-01 for the TN-LC cask assembly, Revision 7 of licensing drawing 65200-71-90 for the TN-LC 1FA basket, and Revision 0 of the new licensing drawing 65200-71-91 for the TN-LC-1FA PWR Basket Damaged Fuel Assembly Can. Drawing 65200-71-02 for the regulatory plate was removed from the list of drawings, as not required by the regulations.

Condition No. 5(b)(1)(iv) was modified to define a damaged fuel assembly, specify they can also contain top and bottom end fittings or nozzles or tie plates depending on the fuel type and that they are authorized for transport only when confined in a Fuel Assembly Can (FAC). Condition No. 5(b)(1)(iv) also defines damaged fuel rods as complete or partial-length fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks, and states that, in the absence of PRAs, burnup credit restrictions as shown in Table 11a and Table 11b are required for transportation of PWR fuel assemblies. Burnup credit is not applicable to BW 15x15 fuel class. Revisions were made to Table 8 regarding the maximum assembly + PRA + damaged FAC weight, as well as the maximum assembly length, both now converted in SI units. A new row was added to Table 8 regarding burnup credit restrictions in the absence of PRAs which now refer to two new tables in the CoC, Table 11a and 11b, for the maximum planar average initial enrichment/minimum burnup combination – PWR fuel assembly classes with or without control rod insertions.

Condition No. 5(b)(2) was modified to include only the bounding maximum weights of 1,850 lbs per PWR assembly with PRAs and Fuel Assembly Can (as applicable) and 790 lbs per BWR assembly with channels, and include damaged PWR fuel assemblies confined in a FAC as authorized contents.

Condition No. 5(c) was modified to remove the word intact regarding the PWR fuel assemblies described in Condition No. 5(b)(1)(iv) because they could also be damaged

Condition No. 9 was modified to state that poison rod assemblies are required for shipment of PWR assemblies only if burnup credit is not considered.

Condition No. 11 authorizes the previous revision of the certificate until the expiration date of the present certificate, i.e., December 31, 2022.

Condition No. 12 (previously numbered 11) extends the validity of the certificate for 5 more years per the applicant renewal request dated March 22, 2022.

The reference section of the certificate was modified to indicate Revision No. 10 of the consolidated application, dated April 2022.

CONCLUSION

Based on the statements and representations in the application, the staff finds that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with CoC No. 9358, Revision No. 6.

Certificate of Compliance No. 9358, Revision No. 6, for the Model No. TN-LC package DATE May 20, 2022

DISTRIBUTION:
SHelton, NMSS/DFM
ADimitriadis, R-I/DNMS/DIRHB
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ADAMS Accession No.: ML22131A320; ML22131A322

OFFICE	NMSS/DFM/STLB	NMSS/DFM/CTCFB	NMSS/DFM/MSB	NMSS/DFM /NARAB
NAME	PSaverot *PS*	JSolis *JS*	OKhan *OK*	ABarto *AB*
DATE	May 11, 2022	May 12, 2022	May 12, 2022	May 12, 2022
OFFICE	NRR/DEX/ESEB	NMSS/DFM	NMSS/DFM/MSB	NMSS/DFM/FFLB
NAME	SSamaddar *SS*	DMarcano *DM*	TBoyce SSamaddar for *SS*	MDiaz *MD*
DATE	May 12, 2022	May 13, 2022	May 13, 2022	May 13, 2022
OFFICE	NMSS/DFM/STLB	NMSS/DFM/STLB	NMSS/DFM/STLB	
NAME	SFigueroa *SF*	PSaverot *PS*	YDiaz-Sanabria *YD*	
DATE	May 16, 2022	May 16, 2022	May 20, 2022	

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