

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



January 5, 2018

Mr. Wren Fowler  
Director, Licensing  
NAC International  
3930 East Jones Bridge Road, Suite 200  
Norcross, GA 30092

SUBJECT: REVISION 68 OF CERTIFICATE OF COMPLIANCE NO. 9225 FOR THE  
MODEL NO. NAC-LWT PACKAGE

Dear Mr. Fowler:

As requested by your application dated December 23, 2016, as supplemented May 15, 2017, May 18, 2017, August 2, 2017, and October 10, 2017, enclosed is Certificate of Compliance No. 9225, Revision No. 68, for the Model No. NAC-LWT transportation package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's safety evaluation report is also enclosed.

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 49 of the *Code of Federal Regulations* (49 CFR) 173.471. Those on the attached list have been registered as users of the package under the general license provisions of 10 CFR 71.17 or 49 CFR 173.471.

If you have any questions regarding this certificate, please contact me or John Vera of my staff at (301) 415-5790.

Sincerely,

**/RA/**

Meraj Rahimi, Acting Chief  
Spent Fuel Licensing Branch  
Division of Spent Fuel Management  
Office of Nuclear Material Safety  
and Safeguards

Docket No. 71-9225  
EPID No. L-2017-LLA-0067

Enclosures: 1. Certificate of Compliance  
No. 9225, Rev. No. 68  
2. Safety Evaluation Report  
3. Registered Users

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Enclosure 3, this  
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cc w/encls. 1& 2: R. Boyle, Department of Transportation  
J. Shuler, U.S. Department of Energy c/o L. F. Gelder  
Registered Users

W. Fowler

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SUBJECT: REVISION 68 OF CERTIFICATE OF COMPLIANCE NO. 9225 FOR THE MODEL NO. NAC-LWT PACKAGE

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**(Closes EPID L-2017-LLA-0067)**

**ADAMS Package No.: ML18010A019 LTR&SER: ML18010A020 CoC: ML18010A021**  
**Registered Users: ML18010A022**

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<b>OFC:</b>	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM
<b>NAME:</b>	JVera	SFigueroa*	VWilson*	ASotomayor*	JChang*
<b>DATE:</b>	12/ 4 /17	12/ 6 /17	12/ 4 /17	1/ 2 /18	12/ 5 /17
<b>OFC:</b>	NMSS/DSFM	NMSS/DSFM	NMSS/DSFM		
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**SAFETY EVALUATION REPORT**

**Docket No. 71-9225**  
**Model No. NAC-LWT Package**  
**Certificate of Compliance No. 9225**  
**Revision No. 68**

**SUMMARY**

By application dated December 23, 2016, as supplemented May 15, 2017, May 18, 2017, August 2, 2017, and October 10, 2017, NAC International, Inc., (NAC, or the applicant) requested an amendment to Certificate of Compliance (CoC) No. 9225 for the Model No. NAC-LWT package. NAC requested an amendment to define and add damaged NRU/NRX fuel to the authorized contents, as well as minor clarifications to the CoC. CoC No. 9225 has been amended, and staff finds that the 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.

**EVALUATION**

**1.0 GENERAL INFORMATION**

NAC requested update of drawing Drawing 315-40-172 to add a note that refers to the CoC to specify when the NRU/NRX lid assembly is to be used with or without the mesh. Condition No. 5(b)(2)(xx)(h) has been added to the CoC to specify the use of the mesh.

NAC also requested update of the CoC sections to remove references to “high burnup” PWR or BWR fuels due to potential confusion as to whether only high burnup fuel was allowed for transport. Staff confirmed that the fuel allowed for transport included, but was not limited to, high burnup fuel. The CoC has been modified by removing the words “high burnup” as appropriate.

**3.0 THERMAL EVALUATION**

**3.1 Description of Thermal Design**

As stated in the safety analysis report (SAR), the applicant requested to add up to eighteen damaged NRU or NRX fuel rods as contents in NAC-LWT package, with a heat load limit of 0.64 kW per package.

**3.2 Material Properties and Component Specifications**

The specifications and thermal properties of NAC-LWT package main components remain unchanged because there is no change in package thermal design.

The staff reviewed List of SAR Changes and Section 1.2, "Package Description," of the application (SAR, Rev. 16B) and verified that there is no change in specifications and thermal properties of the package main components which will affect thermal performance.

### **3.3 Thermal Evaluation under Normal Conditions of Transport (NCT)**

#### **3.3.1 Heat and Cold**

The applicant stated in Section 3.1, "Discussion," of the application that the maximum heat load for up to 18 damaged NRU/NRX fuels is 0.64 kW per cask, but a heat load of 0.8 kW (0.64 kW x 1.25) per package is used in thermal evaluation considering the concentration of the NRU/NRX rods. Based on the NRU/NRX rod diameters and the diameter of the tube containing them. The maximum compaction to concentrate the heat load in the basket is 25%.

The staff reviewed Section 3.1 of the application and verified that a heat load of 0.8 kW was used in thermal evaluation.

#### **3.3.2 Maximum Temperatures**

The applicant stated in Section 3.4.1.19, "Thermal Evaluation of Intact or Damaged NRU or NRX Fuels," of the application that thermal analysis of the NAC-LWT containing damaged NRU/NRX fuels was performed using the same model of ANSYS computer code and the same thermal conditions as described the previous SAR that NRC approved.

The applicant stated in Section 3.4.1.19 of the application that a maximum temperature in the model for damaged NRU/NRX fuels is 271°F, which is below than the allowable temperature limit of 400°F for aluminum fuel cladding as defined in SAR Section 3.4.1.3.3. The applicant also stated that the maximum temperature for stainless tubes and support disks is bounded by the maximum damaged fuel temperature of 271°F and therefore is lower than the allowable temperature of 800°F for stainless steel.

The staff reviewed Section 3.4.1.19 of the application and determined that the applicant's calculated component temperatures are below the corresponding limits because the heat load of the damaged NRU/NRX fuels (a heat load of 0.64 kW or a higher heat of 0.80 kW used for thermal evaluation) is bounded by the heat load of the MTR fuels (1.26 kW) which was approved by the NRC. The staff finds that the NAC-LWT package, loaded with damaged NRU/NRX fuels, performs its thermal design function and meets the requirements of 10 CFR 71.71.

#### **3.3.3 Minimum Temperatures and Maximum Internal Pressure**

The staff reviewed SAR Section 3.4.3, "Minimum Temperatures," and Section 3.4.4, "Maximum Internal Pressure," of the application and finds there is no significant issue for the NAC-LWT package loaded with damaged NRU/NRX fuel because (a) the same package is used for loading intact NRU/NRX fuels in which the package was reviewed and approved by NRC, and (b) the maximum normal operating pressure (MNOP) of NAC-LWT is less than 65 psia (or 79.7 psig) and is bounded by the MNOP of the 300 production TPBARs in the consolidation canister of 289 psig.

### **3.4 Thermal Evaluation under Hypothetical Accident Conditions (HAC)**

The applicant stated in Section 3.4, "Thermal Evaluation for Normal Conditions of Transport," of the application that the heat load limit for the NRU/NRX material (0.64 kW) is lower than the heat load of 1.26 kW for the MTR fuels (mentioned in SAR Section 3.1). The same NAC-LWT package is used for loading the NRU/NRX fuels and for loading the MTR fuels. Therefore, it is conservative to use the temperature increase of the package inner shell of the MTR configuration for the fire accident condition of the NRU/NRX fuels. The maximum inner shell temperature is 337°F for fire accident (Table 3.5-2, Condition 2 located in the SAR) and the minimum inner shell temperature for the normal condition is 180°F (Table 2.4-6, Condition 2 located in the SAR). For the MTR configuration, the bounding temperature increase of inner shell due to fire accident is 157°F (337°F - 180°F) during the fire and cool down stages, which corresponds to the Condition 2 (package transported via truck trailer and cavity gas is air).

Therefore, the applicant stated in Section 3.5.3.17, "Evaluation of Intact or Damaged NRU or NRX Fuels," of the application that it is conservative to use the temperature increase (157°F) of the package inner shell of the MTR configuration for the fire accident condition of the damaged NRU/NRX fuels. The applicant calculated a maximum fuel temperature of 428°F for the NRU/NRX material by adding the temperature increase of 157°F to the maximum fuel temperature of 271°F under the NCT. The applicant stated in SAR Section 3.5.3.17 that (a) the maximum NRU/NRX fuel temperature of 428°F is below the limit of 500°F defined in SAR Section 3.5.3.2 and (b) the maximum temperature of the tube and support disk is bounded by the fuel temperature of 428°F, which is lower than the normal allowable temperature of 800°F for the stainless steel.

The staff reviewed Section 3.5.3.17 of the application and determined that the applicant's approach is acceptable. This is because (a) the applicant's approach neglects the thermal inertia of the contents inside the NRU/NRX package, (b) the package thermal design remains unchanged, (c) the heat load of damaged NRU/NRX fuels (0.64 kW) is bounded by the heat load of MTR fuels (1.26 kW) that was already approved by NRC, and (d) the maximum temperatures of NRU/NRX fuels and package components are below the corresponding limits. The applicant's approach was approved in the previous application.

### **3.5 Evaluation Findings**

Based on review of the statements and representations in the application, the staff concludes that the addition of damaged NRU/NRX fuels to 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.

## **5.0 SHIELDING EVALUATION**

The objective of the shielding review is to verify that the NAC-LWT radioactive material transportation package design with the requested changes to the NRU/NRX fuel contents continues to satisfy the external radiation regulatory requirements of 10 CFR Part 71.47 and 71.51 for dose rate limits of the package under NCT and HAC. The package is approved as exclusive use only. Shipment of the NAC-LWT cask may be made by truck, ISO container, and/or by railcar, as a Type B(U)F-96 package.

## 5.1 Description of the Shielding Design

There are no changes proposed to the packaging design features previously approved.

### 5.1.1 Summary Table of Maximum Radiation Levels

In support of the initial request to add NRU/NRX fuel as approved contents for the NAC-LWT package, the applicant calculated the dose rates of the package under NCT as well as HAC to demonstrate that the package design with the new proposed contents met the regulatory requirements of 10 CFR 71.47 and 71.51. The results of the supporting analyses were incorporated into the NAC-LWT SAR. The supporting analyses considered bounding damaged fuel cases, even though at the time only undamaged fuels were requested to be included as approved contents. These were first approved in CoC No. 9225, Rev. 58. Staff reviewed the SAR and supporting analysis results in the context of the current request to add damaged NRX/NRU fuel as approved contents for the NAC-LWT package.

The applicant provided a summary of the maximum dose rates in Table 5.3.2-24 of the SAR, which show that the maximum dose rate is 313.3 mrem/hr at the surface of the package. The dose rates at 2 meter from the surface of package under NCT is 0.45 mrem/hr, and the maximum dose rate is 41.6 mrem/hr at 1 meter from the surface of the package under HAC. The maximum dose rates occur with a package containing the damaged NRU LEU spent fuel.

The staff reviewed the applicant's summary of maximum dose rates and finds that the dose rates for the package with the undamaged NRU/NRX fuels are below the regulatory limits with sufficient safety margins. For exclusive-use shipment, the maximum limit for the external surface dose rates is 1000 mrem/hr. The staff confirmed the dose rates through confirmatory calculations using MAVRIC/MONACO shielding codes as part of SCALE code. The staff conservatively modeled the content as a point source at the top of the fuel. This position of the source gives the maximum dose rates at the surface. On this basis, the staff determined that the package meets the regulatory requirements of 10 CFR 71.47 and 71.51.

## 5.2 Source Specification

As demonstrated in the Model No. NAC-LWT Package SAR, the applicant calculated source terms of the NRU and NRX undamaged assemblies for the package under both NCT and HAC using TRITON in SCALE 6.1. The TRITON models use the 238 group ENDF/B-VII library. The TRITON inputs for all source term calculations are provided in Figure 5.3.20-3 through Figure 5.3.20-6 of the SAR.

The geometry used by the applicant in the analysis for damaged fuel is based on a configuration where the fuel collapsed at the top of the basket tubes in order to bound any hypothetical fuel reconfiguration. The damaged LEU NRU fuel was analyzed for a loading at a minimum enrichment, maximum burnup and minimum cooling time. Minimum dimensions were used where applicable. The staff finds that this assumption is conservative and acceptable because assuming the combination of maximum burnup, minimum cooling time, and minimum enrichment produces the maximum source terms. This is consistent with the guidance provided in NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel." NRU source terms are calculated using detailed operating histories for HEU and LEU fuel provided by Atomic Energy of Canada Limited (AECL). NRX damaged fuel source terms are calculated using the maximum reactor power and U-235 Core Loading. The evaluated fuel material properties are provided in Table 5.3.20-3 of the SAR. The fuel material composition for

the damaged fuel properties is shown in Table 5.3.20-4 of the SAR. All sources are calculated for a U-235 depletion of greater than 80%. NRU LEU is composed of U<sub>3</sub>-Si-Al. All Si is modeled as aluminum. The staff finds this assumption acceptable because this assumption produces bounding neutron source terms due to (alpha, n) neutron production in aluminum.

The applicant stated that for thermal evaluations an alternative heat load for damaged NRU LEU fuel is calculated using a burnup of 347 MWd as oppose to the 363 MWd burnup for shielding evaluations. The thermal calculations show that the burnup of 347 MWd still bounds the actual NRU LEU burnup of 327 MWd in terms of decay heat. All shielding evaluations use the more conservative higher burnup source terms.

### **5.3 Model Specification**

The applicant performed shielding evaluation using MCNP5 v1.60. The MCNP shielding model used the source terms calculated using the TRITON code to estimate the dose rate profiles at various distances from the side, top and bottom of the cask for both normal and accident conditions. The damaged fuel configuration collapses the fuel in the basket tubes fully. This configuration means that the fuel has lost the structural or clad integrity requirements of the undamaged NRU or Rod Segments NRX fuel assembly and is fully dispersed in the caddy. For package under HAC, The axial lead gamma shield extends from the bottom of the NAC-LWT cavity to approximately 3 inches (7.62 cm) below the top of the cavity. The fissile material is conservatively modeled closest to the point of minimum gamma shielding. The staff finds that these assumptions will result in larger dose rates and, therefore, are conservative. As such, these assumptions are acceptable.

The flux-to-dose rate conversion factors employed in the MCNP analysis are from ANSI/ANS 6.1.1-1977. The ANSI/ANS neutron and gamma dose conversion factors are shown in Table 5.3.20-15 and Table 5.3.20-16 of the SAR, respectively.

The assumptions used in shielding analyses of the package under HAC include the loss of neutron shielding material, loss of the neutron shielding shell and the impact limiters. For package under HAC, the analysis assumptions includes a gap between the lead and outer shell. The dose rates for the lead slump accident are shown in Table 5.1.1-5. These dose rates show that even with the lead slumped, the hypothetical accident dose rate limits are not exceeded.

### **5.4 Evaluation Findings**

The staff reviewed the TRITON input files provided by the applicant to make sure they have the correct information like burnup, enrichment, power operation and cooling times, and also modeled the package using MAVRIC sequence from SCALE system, version 6.1. MAVRIC calculates dose rates by performing a three-dimensional Monte-Carlo analysis (MONACO) using automated biasing procedure. The staff found that the dose rates were in agreement with the applicant's results by 3% difference. The method used by the applicant to calculate radiation source terms and dose rates is consistent with accepted industry practices and standards. The staff reviewed the maximum dose rates for package under normal conditions of transport and hypothetical accident conditions and finds that the values are below the regulatory limits as prescribed in 10 CFR 71.47 and 71.51.

Based on its review of the statements and representations provided in the application, the staff finds that the applicant's shielding safety analyses are consistent with the appropriate codes and standards and NRC guidance, and that the package with the new contents satisfy the dose

rate limits set forth in 10 CFR Part 71. On this basis, the staff find with a reasonable assurance that the NAC-LWT package with the proposed new contents meets the regulatory requirements of 10 CFR 71.47 and 71.51. In its review, the staff followed the guidance provided in NUREG-NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel."

## **6.0 CRITICALITY EVALUATION**

The applicant requested an amendment to define and add damaged NRU/NRX fuel to the authorized contents for CoC No. 9225. The staff had previously reviewed and approved the inclusion of undamaged NRU and NRX fuel assemblies within the NAC-LWT transportation package in CoC No. 9225, Revision 58 in 2013. This prior approval included undamaged NRU/NRX fuel in the form of loose rods or intact fuel assemblies.

The applicant performed a criticality safety evaluation which the staff found acceptable as documented in its safety evaluation report (SER) dated February 28, 2013 (ADAMS Accession No. ML13059A562) for that previous request of undamaged NRU/NRX fuel. The applicant determined a maximum reactivity configuration which the staff found met the requirements of 10 CFR 71.55(b) as discussed in Section 6.3.4 of the staff's SER. The model used for the criticality analyses included the following assumptions: NRU fuel not constrained by the caddy, broken rods that fill the diameter of the tube and shortened to preserve the fuel amount, moderation by full density water in the fuel tubes and package cavity, most reactive pitch, reflected by a flooded package exterior and loss of the neutron shield. This is consistent with hypothetical accident conditions for this package. The criticality safety index for this package is 100, therefore, this is the same model used for both single package and package arrays.

For this amendment request, the applicant used the previous model, including the same computer code and cross section libraries, to perform sensitivity studies on the acceptability of damaged NRU/NRX fuel within the NAC-LWT for the proposed amendment. The staff found using this model acceptable as it has been previously reviewed and approved by the staff. The maximum k-eff of the maximum reactivity model discussed above with undamaged fuel is 0.9256 which is below the USL of 0.9270.

As stated in Section 1.3.2.12 of the NAC-LWT SAR, NRU and NRX HEU fuel rods are made of uranium and aluminum with aluminum cladding. NRU LEU fuel rods are made of uranium, aluminum and silicone with aluminum cladding. The fuel rods are arranged in a circular geometry for both fuel types. NRU assemblies have 12 rods per assembly; NRX assemblies have 7 rods per assembly. NRU/NRX fuel is shipped within the NRU/NRX fuel basket which consists of 18 tubes where a single assembly is loaded per tube. NRX fuel is required to be shipped within a caddy which goes inside the tube which further restricts the allowable diameter the assembly can occupy.

### **6.1 Revised Definitions**

To support the inclusion of damaged fuel, the applicant also provided revised definitions of undamaged and damaged NRU/NRX fuel assemblies and rod and rod segments within Table 1.1-1 of Revision 44 to the NAC-LWT SAR. These definitions have been revised to clarify that when assemblies are cropped, only non-fuel bearing components are removed and integrity of the rod array is maintained.

The amendment also requires loose rods to be placed in a caddy. The staff finds this acceptable as the presence of the caddy puts the system in a less reactive geometry by



increasing leakage. This is discussed in Section 6.7.3.5 of the NAC-LWT SAR and confirmed by staff calculations using the SCALE 6.1 code package.

## 6.2 Removal of Cladding

The NAC-LWT with NRU and NRX maximum reactivity model as discussed above is undermoderated such that removal of cladding, as may be the case with damaged fuel, would cause reactivity to increase due to the increase in water moderation. The definition of damaged NRU/NRX fuel within Table 1.1-1 of Revision 44 to the NAC-LWT SAR includes allowance for clad through-wall damage (such as clad splitting) to be limited to 5% of the fueled surface area and for clad removed to be limited to 2% of the fueled surface area.

The applicant performed a criticality evaluation assuming loss of 2% of the cladding. This results in a k-eff increase less than  $0.003 \Delta k$ . Although this increase is very small, it results in exceeding the k-eff over the USL. However, due to the following considerations, the staff still found this acceptable. The maximum reactivity criticality model assumes loose rods without the caddy. As discussed above, loose rods will now be required to be shipped within the caddy and fuel that has been cropped must maintain rod array integrity. Therefore the model using the broken rods is more conservative than the full length rod array that will be shipped. The applicant performed a sensitivity study assuming the loose rods with 2% cladding loss were confined to the caddy, the results in Table 6.3.7-10 of the application show that restricting the loose rods to the caddy with 2% cladding loss will produce a k-eff of  $< 0.9$ . Although the applicant did not demonstrate fuel rod structural integrity during HAC, the staff finds that it would be extremely unlikely for the rod array to break in such a way to form the maximum reactivity geometry analyzed by the applicant. Therefore, the staff finds with the 2% missing clad contents, there is reasonable assurance of the package remaining subcritical.

The revised definitions of undamaged fuel states that during cropping that some fuel material may be exposed. The staff found this acceptable because this is not considered a loss of cladding since this cladding was not included in the undamaged (maximum reactivity) criticality model and the cladding would be removed from the ends of the assembly which has an insignificant impact on reactivity.

## 6.3 Partial loading

Since the NAC-LWT system is undermoderated, the applicant provided justification that less than a full assembly may be loaded. The applicant used the maximum reactivity model and performed sensitivity studies removing rods. The applicant's study determined that removing one rod from the interior of the tube causes reactivity to increase insignificantly, and that k-eff remains below the USL. Removing more rods or removing rods from other locations resulted in a decrease in k-eff. Therefore, the staff found it acceptable to allow loading of less than a fuel assembly within a basket tube because there is reasonable assurance the package will remain subcritical.

## 6.4 Evaluation Findings

The staff finds the inclusion of damaged fuel acceptable. This is based on the revised definitions of undamaged and damaged fuel, which limits cladding loss to 2% or less, and the requirement of cropped assemblies maintain the rod array and not be loaded with loose rods, and that loose rods be loaded in the caddy. The staff also finds acceptable loading of less than a full assembly. Based on the applicant's submitted information and the discussions above, the

staff finds that these changes do not adversely affect the package's ability to maintain a subcritical condition per the requirements of 10 CFR 71.55 and 71.59.

CoC No. 9225 has been amended based on the statements and representations in the application, and staff finds that the 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.

## **CONDITIONS**

The following changes have been made to the certificate:

Condition No. 5(a)(3)(ii), "Drawings," was updated to reflect the latest revision of drawing no. LWT 315-40-172, (Sheets 1 - 2), "Lid Assembly, NRU/NRX."

Condition No. 5(b)(1)(viii), has been edited to remove the words "high burnup," because the PWR fuel the condition refers to includes, but is not exclusively, high burnup fuel.

Condition No. 5(b)(1)(ix), has been edited to remove the words "high burnup," because the BWR fuel the condition refers to includes, but is not exclusively, high burnup fuel.

Condition No. 5(b)(1)(xix), was updated to include "damaged" NRU or NRX fuel.

Condition No. 5(b)(2)(ix), has been edited to remove the words "high burnup," because the PWR fuel the condition refers to includes, but is not exclusively, high burnup fuel.

Condition No. 5(b)(2)(x), has been edited to remove the words "high burnup," because the BWR fuel the condition refers to includes, but is not exclusively, high burnup fuel.

Condition No. 5(b)(2)(xx), has been edited to add damaged NRU or NRX fuel, and subsections (a) through (l) have been added to specify conditions related to comingling of fuel, use of the caddy, consideration of damage, use of dunnage, and 2% surface clad loss for damaged NRU or NRX fuels.

Condition No. 5(c), has been edited to remove the words "high burnup," from the PWR and BWR fuels specified in Condition No. 5(b)(1)(viii) and Condition No. 5(b)(1)(ix), because the fuels the condition refers to include, but are not exclusively, high burnup fuel.

The former Condition No. 20, allowing use of Revision 64 of the certificate has been deleted. Condition No. 20 now allows Revision 67 of this certificate to be used until December 31, 2018. Former Conditions 22 through 23 have been renumbered accordingly, to 21 through 22.

The references section has been updated to include this application supplement.

## **CONCLUSION**

Based on the statements and representations in the application, 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. 68.