SAFETY EVALUATION REPORT
Docket No. 71-9225
Model No. NAC-LWT Package
Certificate of Compliance No. 9225
Revision No. 39

SUMMARY

By application dated November 2, 2004, as supplemented, NAC International, Inc. (NAC) requested an amendment to Certificate of Compliance No. 9225 for the NAC-LWT package to incorporate as approved contents up to 700 intact or damaged PULSTAR fuel elements.

PULSTAR fuel elements are low enriched (< 7 wt%) uranium oxide rods with zirconium alloy cladding. During reactor operation, 25 PULSTAR fuel elements are arranged in a rectangular 5x5 lattice, surrounded by a zirconium alloy box, and capped by top- and bottom-end fittings to form a PULSTAR fuel assembly. The PULSTAR fuel elements are transported in the NAC-LWT in the 28 MTR fuel basket configuration, which contains four modules (a top, a base and two intermediate modules) with seven cells per module. PULSTAR fuel elements may be configured as intact fuel assemblies, may be placed into a fuel rod insert, or may be placed into one of two can designs. Damaged PULSTAR fuel elements and nonfuel components of PULSTAR fuel assemblies must be loaded into cans.

NAC provided structural, thermal, containment, shielding, and criticality analyses for the package with the new contents, as well as updated package operations, maintenance program and acceptance tests.

Additionally, NAC submitted the following applications for amendment to Certificate of Compliance No. 9225:

1. By application dated February 17, 2005, NAC requested the incorporation of a screened option to enhance the operational features of the PWR/BWR transport canister.

- By application dated March 30, 2005, NAC also requested that Condition No. 5(b)(2)(xiii) of the Certificate be revised to authorize stainless steel spacers when shipping less than a full load of tritium-producing burnable absorber rods (TPBARs).

Based upon our review, the statements and representations in the applications, as supplemented, and for the reasons stated in this Safety Evaluation Report, we have concluded that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

REFERENCES

NAC International, Inc., application dated November 2, 2004, as supplemented March 3, 11, and 24, April 26, 2005.

NAC International, Inc., application dated February 17, 2005, as supplemented March 24, April 26, 2005.

NAC International, Inc., application dated March 30, 2005.

A. ADDITION OF PULSTAR FUEL AS AUTHORIZED CONTENTS

1. GENERAL INFORMATION

1.1 Packaging Description

The NAC-LWT package is a steel-encased, lead-shielded shipping cask. The cask is designed to transport commercial and test reactor assemblies or fuel rods by truck. The overall dimensions of the package, with impact limiters, are 232 inches long by 65 inches in diameter. The cask body is approximately 200 inches in length and 44 inches in diameter. The cask cavity is approximately 178 inches long and 13.4 inches in diameter.

The cask body consists of a 0.75-inch thick stainless steel inner shell, a 5.75-inch thick lead gamma shield, a 1.2-inch thick stainless steel outer shell, and a 5-inch thick neutron shield tank. The cask lid is 11.3-inch thick stainless steel stepped design, secured to a 14.25-inch thick ring forging with twelve, 1-inch diameter bolts. The cask lid containment seal is a metallic O-ring. A second teflon O-ring and a test port are provided to leak test the seal. Other penetrations in the cask cavity include the fill and drain ports, which are sealed with port covers and O-ring seals.

The neutron shield tank is 164 inches long and 5 inches thick and contains an ethylene glycol and water solution that is 1 percent boron by weight. Aluminum honeycomb impact limiters are attached to each end of the cask.

The maximum weight of the package is 52,000 pounds, and the maximum weight of the contents and basket is 4,000 pounds.

1.2 Contents

The PULSTAR fuel elements are described in Section 1.2.3.7 of the application. The low enriched (< 7 wt%) uranium oxide rods have a zirconium alloy cladding. Each rod is approximately 0.47 inches in diameter and 26.2 inches long. During reactor operation, 25 PULSTAR fuel elements (fuel rods) are arranged in a rectangular 5x5 lattice, surrounded by a zirconium alloy box, and capped by top- and bottom-end fittings to form a PULSTAR fuel assembly. The fuel assembly cross section is approximately 2.74 inches x 3.15 inches and the overall length 38 inches. The active fuel length is approximately 24 inches. The nonfuel components of a PULSTAR fuel assembly are primarily aluminum and zirconium alloy and do not contain a significant activation source. A sketch of the PULSTAR fuel assembly is provided in Figure 1.2-9 of the application.

The PULSTAR fuel elements may be loaded into the module cells in one of three configurations: a) intact PULSTAR fuel assemblies; b) intact PULSTAR fuel elements loaded into a TRIGA Fuel Rod Insert (Dwg. 315-40-096); or c) intact or damaged PULSTAR fuel elements and nonfuel components of PULSTAR fuel assemblies in either the PULSTAR screened can or failed fuel can (Dwgs. 315-40-130 and 315-40-135). The contents of either can are restricted to a quantity of fissile material and a total volume of material equivalent to 25 intact PULSTAR fuel elements. The previously approved 28 MTR fuel basket design (Dwg. 315-40-052) will be used for transporting PULSTAR fuel. The 28 MTR basket assembly contains four modules (a top, a base, and two intermediate) with seven cells per module. Loading of modules with mixed PULSTAR payload configurations is allowed, but the PULSTAR cans are restricted to loading in the base and top modules. The package contents authorized for transport are as follows:

Type and form of material

Irradiated PULSTAR fuel elements in intact or damaged form. The maximum depletion is 45 %wt ^{235}U. The minimum cool time is 1.5 years.

Maximum quantity of material per package

A maximum of 700 PULSTAR fuel elements (4 modules/cask x 7 cells/module x 25 fuel elements/cell = 700 fuel elements/cask) can be loaded in the transportation cask. The maximum decay heat is 1.2 watts per fuel element, 30 watts per fuel assembly and 840 watts per package. The maximum weight of a PULSTAR assembly or loaded can is 80 lbs/cell, or 2,240 lbs total when all 28 basket cells are loaded.

1.3 Drawings

The applicant submitted the following additional packaging drawings:

LWT 315-40-129, Rev. 1	Canister Body Assembly, Failed Fuel Can, PULSTAR
LWT 315-40-130, Rev. 1	Assembly, Failed Fuel Can, PULSTAR
LWT 315-40-133, Rev. 0 (Sheets 1-2)	Transport Cask Assembly, PULSTAR Shipment, LWT Cask
LWT 315-40-134, Rev. 1	Body Weldment, Screened Fuel Can, PULSTAR Fuel
LWT 315-40-135, Rev. 1	Assembly, Screened Fuel Can, PULSTAR Fuel

These drawings show details of the two proposed can designs as well as a general arrangement for the PULSTAR shipments.

1.4 Conclusions

Based on the statements and representations in the application, as supplemented, the staff agrees that the addition of PULSTAR fuel as authorized contents does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

2. STRUCTURAL

The applicant proposes to transport up to 700 intact or damaged PULSTAR fuel elements in either assembly or element (rod) form, including fuel debris, using the 28 MTR fuel basket composed of a top module, a base module and two intermediate modules with seven fuel cells per module. PULSTAR fuel elements may be loaded into the module cells, with an opening of 3.38-inch minimum or 3.48-inch maximum square, in one of four configurations: 1) intact PULSTAR fuel assemblies; 2) intact PULSTAR fuel elements loaded into the TRIGA fuel rod insert; 3) intact or damaged PULSTAR fuel elements and nonfuel-bearing components of PULSTAR fuel assemblies in the PULSTAR screened fuel can; or 4) intact or damaged PULSTAR fuel elements and nonfuel-bearing components of PULSTAR fuel assemblies in the PULSTAR sealed fuel can.

Figure 1.2-9 of the SAR depicts a PULSTAR fuel assembly, which consists of 25 fuel elements arranged in a rectangular 5x5 lattice, and weighs 45 lbs nominally. The 28 MTR basket and its inertia effects on the LWT cask were previously evaluated for a design basis payload of 30 lbs per cell. The TRIGA fuel rod insert, which is composed of a 4x4 grid of 0.75-inch outside diameter x 0.065-inch wall stainless steel tubes, has been demonstrated structurally capable of retaining individual TRIGA rods weighing 1.44 lbs each for the free drop normal conditions of transport (NCT) and hypothetical accident conditions (HAC). The PULSTAR damaged fuel cans are modifications of the approved TRIGA damaged fuel cans in that they all have the same cross-section and identical materials of fabrication except that the former are each approximately 4 inches longer than the shorter of the two design lengths of the corresponding TRIGA damaged fuel can, screened or sealed.

The maximum PULSTAR fuel heat load of 840 watts is within the cask design limit of 2.5 kW. Chapter 3 of the application reports the maximum cask internal pressure of 12.5 psig and 20.7 psig for the PULSTAR fuel under the NCT and HAC, respectively. These pressures are bounded by the cask design pressure of 50 psig. Section 1.2.3.7 of the application states that the total content weight shall not exceed 80 lbs/cell or 2,240 lbs total when all 28 basket cells are loaded. Considering the MTR basket weight of 982 lbs, Table 2.2.0-1 of the application shows that the combined basket and content weight of 3,222 lbs (2,240 + 982 = 3,222) is less than the design basis of 4,000 lbs used previously in evaluating free drop and puncture conditions and tests for the cask components other than individual contents and associated fuel baskets. Table 2.2.0-2 limits the PULSTAR package weight to 50,430 lbs, which is bounded by the approved maximum package weight of 51,208 lbs. Thus, except for the MTR fuel basket, damage fuel cans, fuel rod insert, and intact fuel elements for which structural performance is governed by local inertia force and applicable pressure and temperature loading, the staff agrees that other structural components, including the cask body and closure lid assembly, need not be reevaluated for transporting the PULSTAR fuel.

The normal conditions of transportation are addressed by Sections 2.6.12.6.2 thru -4 of the application, with a revised MTR fuel basket analysis that considers an increased bounding fuel cell payload of 80 lbs, from the previously approved 30 lbs, in each of the 28 cells. For the 1-ft side-drop and end-drop cask decelerations of 24.3 g and 15.8 g, respectively, the applicant showed adequate stress performance for the basket components, including the fuel tube and the baseplate. The stress margin for the cask inner shell in resisting the side drop of the loaded basket was also found acceptable.

Section 2.6.12.6.5 compared inertia loads as applied to the PULSTAR and TRIGA damaged fuel cans, and determined that the stress results calculated for the TRIGA fuel package bound those for the PULSTAR fuel. Considering the maximum internal pressure of 3.4 atm for the PULSTAR sealed can, which is higher than the 3.0 atm for the TRIGA sealed can, the applicant reevaluated the TRIGA can and determined that the previous closure bolts stress analysis remain applicable to the PULSTAR fuel. Furthermore, stresses in the fuel can tube were found to be satisfactory when combined with the inertia load effects. Because an individual PULSTAR fuel element at 1.31 lbs weighs less than a 1.44-lb TRIGA rod, the applicant concluded that no additional evaluation is required of the TRIGA fuel rod insert for retaining the PULSTAR fuel elements.

For the hypothetical accident conditions, the applicant considered the design basis decelerations of 49.7 g and 60 g for the side-drop and end-drop conditions and tests, respectively, to reevaluate the MTR fuel basket response. Section 2.7.7.6.2 of the application demonstrates a large buckling safety margin for the basket base module. Sections 2.7.7.6.3 and -4 present the end-drop analyses for the basket baseplate and fuel tube, respectively, with adequate stress margins. On the same bases as those for the NCT, Section 2.7.7.6.6 reevaluated the PULSTAR damaged fuel cans and fuel rod insert and spacer, and determined that the structural performance of the TRIGA fuel can is bounding. As a result, the staff agrees with the applicant's conclusion that no additional structural analysis is required of those components for transporting the PULSTAR fuel under the HAC.

In the March 11, 2005, response to the staff request for additional information, Section 2.9.3 was added to the application to address structural performance of the PULSTAR intact fuel elements. The applicant stated that there are two configurations for the PULSTAR intact fuel. In the assembly form inserted in a MTR basket cell, the 5x5 array of fuel elements are spaced by a tie plate at each end and by periodic spacer tabs on each fuel element but separated at 6.37 inches apart. In the element form, individual fuel elements are loaded into the TRIGA fuel rod insert. By noting that the fuel assembly and the individual elements are provided with full-length lateral support, the applicant concluded that the fuel loading configurations will remain intact for the NCT and HAC.

On the basis of the review above, the staff concludes that the NAC-LWT package continues to meet the structural performance requirements of 10 CFR Part 71 for transporting PULSTAR fuel.

3. THERMAL

The applicant requested the addition of PULSTAR fuel to the list of approved contents for the NAC-LWT. The PULSTAR fuel consists of intact fuel assemblies, intact fuel rods loaded in fuel rod inserts or fuel cans, or intact or damaged fuel rods and nonfuel assembly components loaded in fuel cans. The previously approved 28 MTR fuel basket design will be used for transporting the PULSTAR fuel. The 28 MTR basket assembly contains four modules (a top, a base, and two intermediate) with seven cells per module. Loading of modules with mixed PULSTAR payload configuration is allowed, but the PULSTAR cans are restricted to loading only in the base and top modules.

The following thermal characteristics are required from a PULSTAR fuel prior to loading for transportation:

Description	**Value**
Maximum Enrichment (wt % ^{235}U)	6.5
Maximum ^{235}U content per Element (grams)	33
No. of Elements (Rods) per Assembly	25
No. of Elements (Rods) per Can [1]	25
Maximum Depletion (% ^{235}U)	45
Minimum Cool Time (years)	1.5
Max. Heat Load per Element (watts)	1.2
Max. Heat Load per Assembly or Can (watts)	30

[1] The contents of a PULSTAR can are restricted to the equivalent of the fuel material in 25 PULSTAR fuel elements and of the displaced volume of 25 intact PULSTAR fuel elements.

A previously approved thermal analysis for the TRIGA fuel cluster rods basket is used to bound the thermal performance of the PULSTAR fuel contents in the 28 MTR basket. Both baskets have the same cross-sectional dimensions and material. Both baskets are exposed to the same maximum modular heat load of 210 watts. Under the most limiting normal condition of transportation (without an International Standardization Organization (ISO) container so that insolation is directly applied to the cask surface, with the cask cavity assumed to be filled with air instead of helium), a conservative two-dimensional finite element analysis (FEA) model indicates that predicted temperatures are significantly below the allowable component material limits. For example, the fuel cladding temperature is predicted at 295EF, which is well below the 1058EF limit. Beginning with this most limiting normal condition, the 30-minute hypothetical fire event is imposed upon the same computer model. All component temperatures are predicted to still remain below their allowable limit. The fuel cladding, for example, responds to the fire event by showing a temperature increase of approximately 100EF.

With a heat load of 840 watts (210 watts per module), the accessible surface temperature of an uncovered NAC-LWT is conservatively expected to be in the range of 160EF, which requires exclusive use shipment. Once inside an ISO container or a personnel barrier, as required in

Condition No. 12 of the Certificate of Compliance, the package accessible surfaces do remain below the 185EF limit.

The internal pressure is calculated by taking into account the contribution (partial pressures) from the initial cask and fuel element backfills, and the fission gas inventory due to the depletion of the PULSTAR fuel. For normal conditions of transportation, only 3% of the intact fuel rods are assumed as failed and 30% of the internal fission gases are considered as released. All can-loaded damaged fuel rods are conservatively assumed to fully contribute to the internal pressure rise. Assuming the gas at the same temperature as the fuel cladding, the resulting internal pressure for the limiting configuration of 14 intact fuel assemblies and 14 cans is approximately 13 psig, which is well below the design pressure of 50 psig. During the hypothetical fire event, the internal pressure is expected to rise to approximately 21 psig, which is still well below the allowable limit.

The staff reviewed the applicant's evaluation and agrees with the minimum overall thermal effects from the requested additions to the approved list of contents. The staff agrees with the applicant's conclusion that the package meets the requirements of 10 CFR Part 71.

4. CONTAINMENT

The staff reviewed the submittal for an amendment of Certificate of Compliance (CoC) No. 9225 for the NAC-LWT cask to incorporate as approved contents up to 700 intact or damaged PULSTAR fuel elements .

The NAC-LWT cask includes a containment system, preventing the release of radioactive material. The containment boundary, which remains unchanged in this amendment request, has been described in previous submittals and has been reviewed by the staff. This amendment requests a change to the approved content to include PULSTAR fuel elements. The PULSTAR fuel characteristics are given in Table 1.2-8 of the application.

The applicant performed the containment evaluation in accordance with ANSI N14.5 and NUREG/CR-6487 guidance, which is acceptable to the staff. This amendment request satisfied the 10 CFR Part 71 requirements for a B(U)F-96 designation. System pressure and average temperature during normal and accident conditions are documented in Sections 3.4.4.5 and 3.5.4.4 and summarized in Table 4.5-22 of the application. Maximum depletion is 45% of U-235, which corresponds to a burnup of 27,600 MWD/MTU.

Radionuclide activities listed in Tables 4.5-23 through 4.5-25 were taken from the source term and shielding evaluation documented in Chapter 5 of the application. Radionuclides are separated into gas, volatile, and fine sections. Also included in the tables are B(U)F-96 compliant isotope A_2 values and group average A_2 values. Reference information on PULSTAR fuel surface contamination is not available. The applicant stated that as PULSTAR fuel rods are similar to light water reactor (LWR) fuel rods, the maximum surface contamination available for LWR rods is applied. Combining the radionuclide inventories with release fractions from NUREG-1617, the applicant obtained the allowable leakage rates documented in Table 4.5-27 of the application. The maximum allowable leakage rate was calculated as 5.49×10^{-6} ref-cm^3/sec, or 7.84×10^{-6} std-cm^3/sec (helium). This allowable leakage rate is greater than the allowable test leakage rate for shipment of PULSTAR fuel, which is $5.5x10^{-7}$ std-cm^3/sec (helium). Staff's independent confirmatory analysis verified the applicant's results.

Based on the review of the statements and representations in the application and on independent confirmatory analysis, the staff concludes that the NAC-LWT containment design to incorporate as approved contents up to 700 intact or damaged PULSTAR fuel elements, has been adequately described and evaluated and that the package design meets the containment requirements of 10 CFR Part 71.

5. SHIELDING

The shielding analysis for the Model No. NAC-LWT has been revised to consider a payload of up to 700 PULSTAR fuel elements. Intact fuel elements may be loaded in the cask as assemblies in a 5x5 array, as shown in Figure 1.2-9 of the SAR, in a 4x4 TRIGA fuel rod insert, in a PULSTAR failed fuel can, or in a PULSTAR screened fuel can. Damaged fuel elements may be loaded in a PULSTAR failed or screened fuel can. Twenty eight assemblies, rod inserts, or fuel cans may be placed in four 7-element MTR basket modules stacked in the cask cavity, with a maximum of 25 elements per basket position.

PULSTAR fuel characteristics are listed in Table 1.2-8 of the SAR. The elements consist of zirconium alloy-clad UO_2 pellets, with a maximum enrichment of 6.5 weight-percent ^{235}U, and up to 33 grams of ^{235}U per element. The elements are depleted to a maximum of 45% of the initial ^{235}U, corresponding to a burn-up of roughly 28 GWd/MTU, and cooled a minimum of 1.5 years.

The applicant determined the neutron and gamma source term of the fuel material using the SAS2H sequence of the SCALE code package, which uses the ORIGEN-S isotope depletion and decay code. The source term was calculated assuming a conservative cooling time of 1 year. The resulting neutron and gamma source terms for a single assembly of 25 PULSTAR fuel elements are shown in Tables 5.3-112 and 5.3-113, respectively. The overall source term for a full load of 700 PULSTAR fuel elements is shown in Table 5.1-3 in comparison to the previously approved allowable payloads for the Model No. NAC-LWT. The neutron and gamma source term for this payload is bounded by the source terms for the previously approved payloads of 42 MTR elements, 25 PWR rods, 1 PWR assembly, and 2 BWR assemblies.

The applicant's shielding model for intact fuel considered a homogenized fuel region of 25 fuel elements surrounded by the assembly zirconium alloy box. For damaged fuel, two models were used: one which homogenized the fuel over the full 30-inch height of the fuel can and another which homogenized the fuel over a 9.23-inch height at the top of the fuel can. In both of the damaged fuel models, no credit was taken for the fuel can structure and the fuel material was moved to the highest point in each basket to get the source closer to the minimum radial shielding point of the cask. Under normal conditions of transport, the cask was modeled with its radial shields and impact limiters intact, while under hypothetical accident conditions, the impact limiters and radial neutron shield are assumed to have been removed.

To determine the package external dose rates due to gammas and neutrons, the applicant used the MCNP three-dimensional Monte Carlo code with the ANSI/ANS 6.1.1-1977 flux-to-dose rate conversion factors. Radial dose rates were calculated on contact with the packaging surface, at 1 meter, and at 2 meters under normal conditions of transport, and at the package surface and at 1 meter under hypothetical accident conditions, for all three shielding models. Axial dose rates were calculated on the top and bottom cask surfaces under normal conditions of transport and hypothetical accident conditions, for all three shielding models. The resulting dose rates are presented in Tables 5.3-119 and 5.3-120 of the SAR. The 9.23-inch damaged fuel model resulted in the maximum dose rate for all dose locations except the axial cask bottom, in which case the maximum resulted from the intact assembly model. In all cases there is substantial margin between the calculated and allowable external dose rates for the package. Because the maximum dose rate at the package surface exceeds 200 mrem/hr, the cask must be shipped as an exclusive use transport. The maximum dose rates for all dose locations are summarized in the following table:

Table 1: Maximum External Dose Rates for NAC-LWT Package (mrem/hr)

	Normal Conditions of Transport			Hypothetical Accident Conditions	
	Surface	1 m	2 m	Surface	1 m
Radial:	269	24.6	5.2	511	33.4
Axial:	11.6	N/A	N/A	81.1	N/A

The staff performed confirmatory calculations of the applicant's source term using the SAS2H sequence of the SCALE 5 code with the ORIGEN-S isotope depletion and decay code and the 44-group cross-section set. Using assumptions regarding fuel composition, cycle length, and fuel geometry similar to the applicant's, the staff calculated neutron and gamma sources that closely agreed with those cited in the application.

Based on the statements and representations made in the shielding analysis in the applicant's SAR, and on the staff's own analysis, the staff has reasonable assurance that the Model No. NAC-LWT meets the external dose rate requirements of 10 CFR Part 71 when limited to the contents described in Table 1.8 of the SAR.

6. CRITICALITY

The NRC staff performed a criticality safety review of the proposed amendment for the NAC-LWT package to incorporate as approved contents up to 700 intact or damaged PULSTAR fuel elements.

Intact PULSTAR fuel elements may be loaded as intact fuel assemblies, as individual intact elements (rods) placed into a TRIGA fuel rod insert (a 4x4 rod holder), or into a PULSTAR fuel can. Damaged PULSTAR fuel elements, including fuel debris, pellets, pieces and associated non fuel components must be loaded into a PULSTAR fuel can. The contents of a PULSTAR can are restricted to the equivalent of the fuel material in 25 PULSTAR intact fuel elements and of the displaced volume of 25 intact PULSTAR fuel elements. Two different can designs are available: the PULSTAR screened fuel can and the PULSTAR failed fuel can. The intact PULSTAR fuel can be placed in the base, intermediate, and top modules of the 28 MTR basket assembly. The PULSTAR fuel cans will only be loaded into the top and base modules of the same basket assembly.

Analyses were performed by the licensee to encompass credible fuel configurations, including normal and hypothetical accident conditions to ensure that effective multiplication factor (k_{eff}) was below 0.95 for all analyzed configurations, including corrections for bias and uncertainty. The fuel may contain enrichments of ^{235}U up to a maximum of 6.5 wt% and is considered fresh (i.e., no burnup credit is taken) for all criticality calculations to maximize the potential reactivity of the fuel. The licensee used the SCALE 4.3 criticality sequence computer code package using the 27GROUPNDF4 cross-section library for fissile and shielding media in their calculations.

The applicant performed analyses for the NAC-LWT cask with all 28 MTR 7-element modules containing intact zircaloy clad UO_2 PULSTAR fuel elements at an enrichment of 6.5 wt% ^{235}U in a 5x5 rectangular configuration within a zircaloy box with aluminum upper and lower fittings. Analyses were also performed with PULSTAR elements in the 4x4 TRIGA rod holder and the two can designs for damaged fuel, including fuel debris. Analyses for damaged PULSTAR fuel in the two can configurations evaluate both discrete and homogenized fuel as possible contents. NRC staff noted that the analyses performed were similar in methodology to analyses for other previously approved fuel contents in the NAC-LWT cask.

The PULSTAR evaluations rely on the base models developed for MTR fuel because the fuel elements are placed in the 28 MTR basket configuration with spacers. The MTR computer models were modified to include the PULSTAR fuel assemblies, fuel rod holder and cans and are evaluated for mechanical perturbations and payload radial and axial shifting. In all cases the calculated multiplication factor (k_{eff}) was less than the 0.95 acceptance criterion.

For the single package model, the analyses were performed for an optimally moderated cask, including preferential flooding of the PULSTAR canisters, and close reflection of the containment system by water. For optimally moderated package arrays, two cases were considered. First, an analysis was performed for an infinite array of packages loaded with fuel assemblies or fuel elements in the fuel rod inserts. Second, an analysis was performed for an array of three casks loaded with fuel elements within the PULSTAR cans in the top and bottom modules. Based on 10 CFR 71.59, the criticality safety index (CSI) for the fuel assemblies or fuel elements in fuel rod inserts is 0.0, because N is infinite for normal and accident conditions. For the mixed (canned and uncanned fuel) model, the CSI is 33.4, because 2N = 3, and CSI = 50/N. These CSI values are specified in Condition No. 5(c) of the Certificate of Compliance.

Based on NAC's parametric study of PULSTAR intact and damaged fuel configurations, and based on the confirmatory calculations performed by NRC staff, the staff agrees that there is sufficient conservatism in the calculations to allow the loading of intact fuel elements, either as 5x5 assemblies or as 4x4 rod inserts, into any module cell of the 28 MTR basket. The calculations also support loading up to 14 damaged fuel cans containing up to 25 PULSTAR fuel elements (in either intact or damaged form, including fuel debris) each in the top and base modules, with the balance of module cells containing intact assemblies or rod inserts.

Given that the proposed changes to the Certificate of Compliance apply solely to adding the new PULSTAR intact and damaged fuel types; that the new fuel types are adequately and conservatively modeled; and that staff confirmatory calculations agree with NAC's calculations; the staff concludes that the proposed changes to the Certificate of Compliance meet the requirements of 10 CFR Part 71.

7. PACKAGE OPERATIONS

The applicant included a supplemental section 7.1.9 to describe the dry loading operations for the PULSTAR fuel. Sections 7.2.3 and 7.2.4 were revised to include wet and dry unloading of the PULSTAR fuel.

8. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Due to an Oct 1, 2004 revision of 10 CFR 71.63 regarding plutonium double containment, the TRIGA sealed failed fuel can hydrostatic test (formerly Section 8.1.9.3) was deleted. No hydrostatic pressure testing of the PULSTAR sealed can is required in order to meet regulatory requirements.

B. INCORPORATION OF A SCREENED FUEL CAN OPTION FOR THE PWR/BWR TRANSPORT CANISTER

By application dated February 17, 2005, NAC requested an amendment to Certificate of Compliance No. 9225, for the Model No. NAC-LWT package. The amendment requested the incorporation of a screened canister as an alternate to the currently approved sealed and free-flow configurations for the PWR/BWR transport canister.

The applicant submitted the following revised packaging drawings:

LWT 315-40-098, Rev. 3 (Sheets 1-2)	Can Assembly, LWT Pin Shipment
LWT 315-40-100, Rev. 3 (Sheets 1-3)	Lids, PWR/BWR Transport Canister
LWT 315-40-104, Rev. 1 (Sheets 1-2)	LWT Cask Assembly, PWR Transport Canister

These updated drawings define the previously approved sealed and free-flow operational configurations of the PWR/BWR fuel canister, as well as the amendment request for the screened configuration. The changes are considered minor and do not affect the evaluation for the package with the transport canister.

This change does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

C. USE OF STAINLESS STEEL SPACERS WHEN SHIPPING LESS THAN A FULL LOAD OF TPBARS

By application dated March 30, 2005, NAC requested revision of Condition No. 5(b)(2)(xiii) of Certificate of Compliance No. 9225. This condition describes the maximum quantity of material per package when shipping tritium-producing burnable absorber rods (TPBARs), as described in Condition No. 5(b)(1)(xii). The revision would authorize use of stainless steel spacers when shipping less than a full load of TPBARs. The stainless steel spacers would serve as dunnage to protect individual TPBARs during transport. The stainless steel spacers would be limited in weight and volume, such that the total weight and volume of the reduced number of TPBARs plus the stainless steel spacers would be not more than the weight and volume of the maximum load of 300 TPBARs.

The applicant evaluated the use of stainless steel spacers for the shipment of partial loads of TPBARs. Because the total weight and volume of the load would be less than or equal to the full load of TPBARs, the applicant concluded that the structural and pressure evaluations would remain valid for the reduced payload with dunnage added. The containment evaluation would be bounded, because the source term would be reduced and the package is leak tight for TPBAR shipments. The shielding evaluation would not be affected, because the source term is reduced for partial loads. The thermal evaluation would not be affected since the maximum decay heat per TPBAR and per package remain unchanged, and the decay heat of the partial load would be less than the full load of 300 TPBARs. The Package Operations, described in Section 7.1.9 of the application, were revised to include use of dunnage, with the appropriate weight and volume restriction for shipments with dunnage. The applicant concluded and the staff agrees that the shipment of partial loads of TPBARs with stainless steel spacers, which are limited in weight and volume, is bounded by the previous evaluations performed for the TPBAR contents.

As requested by the applicant, Condition No. 5(b)(2)(xiii) is revised as follows:

> For TPBARs as described in Item 5.(b)(1)(xii):
>
> 300 TPBARs, including a maximum of 2 damaged rods, positioned within a consolidation canister, as shown in Figure 1.2-10 of the application. The maximum decay heat is 2.31 watts per rod and 693 watts per package. The maximum weight of the TPBARs and the consolidation canister is 1,000 pounds. Consolidation canisters with fewer than 300 TPBARs may also contain stainless steel spacers of various geometries. The total weight and volume of the reduced TPBAR contents plus the spacers must be less than or equal to the weight and volume of 300 TPBARs.

This change does not affect the ability of the package to meet the requirements of 10 CFR Part 71.

D. CONDITIONS

In summary, the following changes were made to the Certificate of Compliance:

- The packaging description in Condition No. 5(a) was revised for clarity.

- The list of drawings in Condition No. 5(a)(3) was updated, and new drawings were included to support the shipment of PULSTAR fuel.

- Conditions No. 5(b)(1)(xiii) and 5(b)(2)(xiv) were added. These conditions describe the PULSTAR contents, as requested by the applicant.

- Condition No. 5(b)(2)(ii) was revised to correct a typographical discrepancy.

- Conditions No. 5(b)(2)(vii)(c) and 5(b)(2)(viii) were revised to indicate the Revision1 for drawing 315-40-086.

- Condition No. 5(b)(2)(xiii) was revised to allow the use of stainless steel spacers in consolidation canisters with fewer than 300 TPBARs, provided that the total weight and volume of the reduced TPBAR contents plus the spacers remain less than or equal to the weight and volume of 300 TPBARs.

- Condition No. 5(c) was revised to include the Criticality Safety Index of 0.0 (zero) for intact uncanned PULSTAR fuel and 33.4 for shipments of PULSTAR fuel in cans.

- Condition No. 11, which specifies the water/ethylene glycol solution used in the neutron shield tank, was revised to include PULSTAR shipments.

- Condition No. 12 was revised to include the PULSTAR fuel to the list of contents that must use either an ISO container or the personnel barrier when shipping.

In addition, the following additional condition was included in the revised certificate:

- Condition No. 16, which includes specific provisions for PULSTAR shipments, was added:

16. For shipment of PULSTAR fuel:

    (a) Intact fuel elements may be configured as PULSTAR fuel assemblies, may be placed into a TRIGA fuel rod insert (a 4 x 4 rod holder), or may be loaded into PULSTAR fuel cans. Intact PULSTAR fuel assemblies and PULSTAR fuel elements in a TRIGA fuel rod insert may be loaded in any module of the 28 MTR basket assembly. PULSTAR fuel cans may only be loaded into the top or base module of the 28 MTR basket assembly.

    (b) Damaged PULSTAR fuel elements and nonfuel components of PULSTAR fuel assemblies must be loaded into PULSTAR cans. Damaged PULSTAR fuel, including fuel debris, pellets or pieces, may be placed in an encapsulating rod prior to loading into a PULSTAR fuel can. PULSTAR fuel cans may only be loaded into the top or base module of the 28 MTR basket assembly.

    (c) Loading of modules with mixed PULSTAR payload configuration is allowed.

As a consequence of the inclusion of the new Condition No. 16, the previous Condition Nos. 16-18 were renumbered 17-19, respectively.

CONCLUSION

Based upon our review, the statements and representations in the applications, as supplemented, and for the reasons stated in this Safety Evaluation Report, and with the conditions listed above, we have concluded that the changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9225,
Revision No. 39, on 05 May 2005.