SAFETY EVALUATION REPORT

Docket 72-1025
NAC Multi-Purpose Canister (NAC-MPC) System
Certificate of Compliance No. 1025
Amendment No. 1

SUMMARY

By application dated September 29, 2000, as supplemented October 5, 2000, March 16, April 6, and July 27, 2001, NAC International, Inc. (NAC) requested an amendment to the Certificate of Compliance (certificate) for the NAC Multi-Purpose Canister System (NAC-MPC).

The application requested changes to the certificate, including its attachment, and Revision 0 of the Final Safety Analysis Report (FSAR). The requested changes were: a) an alternate fuel basket design with enlarged fuel tubes in the corner locations of the basket; b) an increase in the operational time limits for canister loading, closure and transfer provided in the Technical Specifications to allow for canister heat loads that are lower than the design basis heat load; c) revisions to the Technical Specifications for canister surface contamination to maintain doses to workers As Low As Reasonably Achievable (ALARA); and, d) minor revisions to some of the drawings to reflect changes identified during cask and component fabrication.

Based on the statements and representations in the application, as supplemented, the staff agrees that the NAC-MPC system, as amended, meets the requirements of 10 CFR Part 72.

1.0 General

NAC submitted revisions to some of the engineering drawings for the NAC-MPC. The changes include the optional basket configuration with oversized fuel tubes in the four corner locations. Other changes include: a) minor variations in a few dimensions and tolerances to allow for proper fit-up during fabrication; b) revision of the epoxy enamel coating from the specific designation of Ameron PSX 738 engineered siloxane to the equivalent Ameron engineered siloxane or the Keeler and Long E-series epoxy enamel; and, c) addition and clarification of some weld symbols. The applicant concluded, and the staff agrees, that the modifications of the drawings do not impact the ability of the cask to meet the requirements of 10 CFR Part 72.

3.0 Structural Evaluation

This section evaluates an alternate fuel basket design to accommodate oversized fuel tubes in the four corner locations of the basket which allow loading of fuel assemblies with slight physical effects (e.g., twisted or bowed). The oversized fuel tube is configured by removing the BORAL sheet and stainless steel cover from each side of a standard canister-loaded fuel tube and expanding the fuel tube cavity from 7.8 inches to 8.0 inches square. The slots in the top and bottom weldments are also enlarged accordingly, but there are no changes made to the other basket components, such as support disks, heat transfer disks, tie rods, and spacers.

Safety Analysis Report (SAR) Section 11.3.2.3 notes that the fuel tube in a directly loaded uncanistered configuration has previously been demonstrated to be structurally acceptable for cask drop events. By comparing the design parameters such as the clear span length and equivalent static load of the oversized fuel tube to those of the directly loaded fuel tube, the applicant concludes, and the staff agrees, that the stress in the oversized fuel tube is bounded by the directly loaded fuel tube for the design basis side drop of 55g and end drop of 56.1g.

The staff reviewed the SAR Section 11.3.2.4 evaluation of the enlarged slots in the top and bottom weldments. The staff agrees with the applicant's conclusion that the effects of enlarged slots are not significant and the stress performance of the top and bottom weldments continues to be acceptable.

The SAR reports a fuel rod buckling capability of 94 g and 78 g for the Zircaloy and stainless steel clads, respectively. The buckling capabilities are identical to those that were previously found acceptable by the staff in the review of the NAC International, Storage Transport Cask, (NAC-STC), docket 71-9235 (the NAC-STC incorporates the NAC-MPC for transport). Additionally, the applicant evaluated the effects of bowing and twisting of the spent fuel rods on buckling capabilities under the design basis end-drop deceleration of 56.1g and stated that the maximum bow (or twist) that a Yankee-Class fuel assembly can sustain and still fit into an oversized fuel tube is 0.441 inches. Considering the entire fuel assembly length of about 112 inches and for a bounding rod section of 17.8 inches between spacer grids, NAC calculates an axial load eccentricity of 0.0112 inches. Since this eccentricity is negligibly small, the staff agrees with the applicant's conclusion that loading bowed or twisted fuel rods in the oversized fuel tube has an insignificant effect on the fuel rod buckling capabilities.

The applicant concludes, and the staff agrees, that the alternate fuel basket design with the enlarged fuel tubes is structurally acceptable for loading the Yankee-Class fuel assemblies with slight physical effects.

4.0 Thermal Evaluation

The thermal review ensures that the cask and fuel material temperatures of the NAC-MPC system for Yankee Rowe fuel assemblies will remain within the allowable values or criteria for normal, off-normal, and accident conditions. This objective includes confirmation that the temperatures of the fuel cladding (fission product barrier) will be maintained throughout the storage period to protect the cladding against degradation which could lead to gross rupture. The review also confirms that the thermal design of the cask has been evaluated using acceptable analytical and/or testing methods.

The applicant requested that the times associated with certain loading operations (i.e., vacuum drying and transfer to storage pad) be increased to permit more time for these operations to occur before entering the technical specification limiting condition of operations (LCO) action statement. The applicant did not request a change to the maximum heat loading for the NAC-MPC (12.5 kW) and as a consequence the maximum temperatures of the various components do not increase except for vacuum drying during loading operations and transfer to storage pad. The applicant has analyzed the NAC-MPC to increase the operational time limits for heat loads of 12.5 kW, 10.5 kW, 8.5 kW, 6.5 kW and 4.5 kW. Increasing these operational time limits results in the increase of the component temperatures close to their maximum limits for the fuel cladding and the heat transfer disk. A summary of the associated temperature changes are provided in table 4.1 for the fuel cladding and the aluminum heat transfer disk.

The applicant performed a sensitivity analysis of the thermal design due to the relative closeness of the calculated temperatures to their limits. The applicant demonstrated that the calculated temperatures may have a variance of 10°F which is well below any calculated margin, as shown in table 4.1. Additionally, the staff reviewed the applicant's proprietary calculation for the transfer cask's thermal transient analysis and found it to adequately support the conclusions presented in the SAR.

Since the original NAC-MPC application was submitted to the NRC, some fuel misloading events have occurred in spent fuel storage casks at commercial reactor sites other than Yankee Rowe. The NRC has determined that the overall risk associated with fuel misloading events does not warrant special consideration within the thermal analysis because there is no adverse safety impact. A fuel misloading, in a worst case scenario, would cause some fuel rods to overheat and possibly result in fuel cladding rupture. However, the fuel would remain in its analyzed configuration since the rupture openings would be small due to the ductile cladding and the containment boundary of the storage canister would remain intact. Since risk is defined as frequency multiplied by the consequence, the overall risk associated with a misloading event would be acceptable since there are no adverse consequences even though some misloading events have occurred at other reactor sites and could possibly occur again.

Based on the information presented in the SAR, the applicant's analysis and conclusions, the staff's independent calculations, and NRC judgements regarding misloading risk, the staff agrees with the applicant's conclusion that the changes to allowable times for certain loading operations do not impact the ability of the cask to meet the requirements of 10 CFR Part 72.

TABLE 4.1

NAC-MPC (YR) Component		Fuel Cladding	Heat Transfer Disk
Allowable Temperature (short term)		806°F	700°F
Maximum Temperature During Vacuum Drying or Transfer Operations within the time limits established by the technical specifications (refer to Table 4.4.3-7 of the SAR)	12.5 kW	725°F	658°F
	10.5 kW	729°F	651°F
	8.5 kW	726°F	638°F
	6.5 kW	724°F (from NAC calculations)	601°F
	4.5 kW	717°F (steady state)	523°F (steady state)
Maximum Temperature During Vacuum Drying or Transfer Operations, post in-pool or post forced air cooling when tech spec time limits are exceeded (from NAC Calc EC455-3405 Rev 5, Page 39)	12.5 kW	703°F	625°F
	10.5 kW	660°F	582°F
	8.5 kW	639°F	559°F
	6.5 kW	699°F	577°F
	4.5 kW	NA-no time limit	NA-no time limit

5.0 Shielding Evaluation

The shielding evaluation of the NAC-MPC was not revised due to this amendment. This amendment change included an alternate fuel basket design to accommodate oversized fuel tubes in the four corner locations of the basket for allowing loading fuel assemblies with slight physical effects. The oversized fuel tube is configured by removing the BORAL sheets and stainless steel cover from each side of a standard canister loaded fuel tube and expanding the inside dimensions to fill the resulting space in the fuel tube opening. The alternate basket design removes 16 of 144 BORAL plates.

Removing the 16 BORAL plates results in a loss of 41 kg of material from the fuel/basket region. The applicant's shielding evaluation in the SAR models the fuel/basket region as a homogenized mass. Therefore, removing this material, which accounts for less than 1% of the fuel/basket mass, results in no significant change to the gamma and neutron surface dose rates. In addition, the applicant demonstrated, as discussed in Chapter 3 of this SER, that bowed or twisted fuel rods in the oversized fuel tube will stay intact following design basis accidents.

The applicant concludes, and the staff agrees, that the alternate fuel basket design with the enlarged fuel tubes for loading the Yankee-Class fuel assemblies with slight physical effects meets the shielding requirements of 10 CFR Part 72.

6.0 Criticality Evaluation

The criticality analysis of the NAC-MPC has been revised to include an alternate fuel basket design with enlarged fuel tubes in the four corner locations of the basket to accommodate fuel assemblies with slight physical effects. The enlarged fuel tubes are made by removing the BORAL sheet and stainless steel cover from each side of a standard fuel tube and expanding the inside dimensions to fill the resulting space in the fuel tube opening. Using KENO V.a with the 27 group cross section library, as in the previous analysis, the applicant calculated k_{eff} for the MPC canister with enlarged fuel tubes. The calculations used assumptions similar to those used in determining k_{eff} for the MPC without enlarged fuel tubes.

The calculation model consisted of a fully flooded, two spacer-plate horizontal slice of the cask, containing 36 Yankee Class United Nuclear Type A fresh fuel assemblies. The horizontal slice consisted of a stainless steel spacer plate region, an aluminum heat transfer spacer plate region, and two water regions, stacked axially with the minimum distance between the plate regions. A periodic boundary was applied to the top and bottom of the model to make the cask infinite in length, and the four sides of the cuboid containing the cask slice were reflected to make an infinite array in the x-y plane. The most reactive mechanical configuration was previously determined to consist of the fuel tubes and assemblies moved toward the center of the basket, maximum fuel tube opening, minimum spacer disk opening, maximum spacer disk thickness, and closely packed spacer disk openings. The resulting maximum k_{eff} for the basket configuration with four enlarged fuel tubes was 0.9182, including bias and uncertainty, for the storage cask under hypothetical accident conditions. This is 0.0161 higher than the maximum k_{eff} for the previously approved basket configuration without enlarged fuel tubes.

The staff performed confirmatory calculations using assumptions similar to the applicant's. Using KENO V.a in the SCALE 4.4 CSAS25 sequence with the 44 group cross section library, the staff calculated a maximum k_{eff} of 0.9027 ± 0.0008 for the storage cask under hypothetical accident conditions. This value is in good agreement with the applicant's results before correcting for bias and uncertainty.

The applicant concludes, and the staff agrees, that the NAC-MPC meets the criticality requirements of 10 CFR Part 72 for the basket configuration with four enlarged fuel tubes.

11.0 Accident Analysis

The applicant has requested a revision to the removable surface contamination limits to 10,000 dpm/100 cm^2 β-γ and 100 dpm/100 cm^2 α. The staff accepts maintaining removable surface contamination limits below 1000 dpm/100 cm^2 β-γ and 20 dpm/100 cm^2 α, which are consistent with Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors." The values of Regulatory Guide 1.86 represent levels that can be achieved with reasonable decontamination methods and are consistent with current radiological control practices for preventing the spread of contamination to clean or uncontrolled areas. However, the applicant demonstrated in its analysis that higher removable surface contamination limits result in a dose savings to workers and result in minimal impact to off site doses to the public.

The applicant is not proposing any changes to canister loading operations, rather the applicant is proposing to avoid unnecessary dose to workers in an attempt to decontaminate the canister following loading operations. Canisters are not expected to have removable surface contamination levels above 10,000 dpm/100 cm^2 β-γ and 100 dpm/100 cm^2 α. By minimizing the decontamination steps, the applicant estimates a 140 mrem/canister dose savings to workers. The staff reviewed the assumptions and calculations and agrees with the applicant's results.

The applicant analyzed the off-site dose impact from permitting the higher surface dose contamination limits. NAC assumed under accident conditions, 100% of the removable surface contamination from 16 canisters is instantaneously released through the concrete cask inlets and outlets to the environment. The off-site impact from this event is 1 mrem/year at 100 meters. The staff reviewed the assumptions and calculation and agrees that this analysis is conservative.

The staff reviewed the analyses provided by the applicant and has reasonable assurance that increasing the removal surface contamination limits to 10,000 dpm/100 cm^2 β-γ and 100 dpm/100 cm^2 α has minimal impact on off-site doses and results in a dose savings to workers. The staff also notes that analysis provided in the SAR is generic and these removable surface contamination limits should be evaluated in accordance with the requirements of 10 CFR 72.212.

Materials Evaluation

The NAC-MPC Yankee Rowe amendment to incorporate a new basket alternative provides no significant change or impact to the materials of the NAC-MPC system, as previously evaluated. The removal of boral on each side of the four corner, peripheral fuel tubes causes no significant change in the ability of the materials to perform their intended function. No materials of construction or fabrication processes, including welding processes for the system are changed. The engineering drawings were revised to change the epoxy enamel coating from the specific designation of Ameron PSX 738 engineered siloxane to the equivalent Ameron engineered siloxane or the Keeler and Long E-series epoxy enamel. No additional coatings are introduced and no additional sources of chemical, galvanic, or other corrosive actions are introduced.

The increased cask loading time specifications for the varying heat loads described in Section 4 of this SER continue to result in cladding temperatures that are below the short term temperature limits for zirconium alloy and stainless steel clad fuel. Additionally, all other

structures, systems, and components (SSC's) of the system continue to remain below allowable temperature limits.

The increased surface contamination limits cause no additional significant chemical, galvanic, or corrosive reactions with the materials that comprise the fuel canister, the transfer cask, and the coating on the transfer cask.

The staff finds that the Yankee Rowe spent fuel amendment causes no significant change or impact to the NAC-MPC, as previously evaluated.

Conclusion

The certificate was revised to allow an alternate fuel basket design with enlarged fuel tubes in the four corner locations. Appendix A of the certificate (the technical specifications) was revised to incorporate increases in the operational time limits for canister loading, closure and transfer and to modify the removable surface contamination limits of the canister. The engineering drawings were modified to include the alternate fuel basket design and other minor changes. The changes do not affect the ability of the NAC-MPC to meet the requirements of 10 CFR Part 72.

Issued with Certificate of Compliance No. 1025, Amendment No. 1,
on January 23, 2002.