NAC INTERNATIONAL, INC.

NAC MUTLI-PURPOSED CANISTER (NAC-MPC) SYSTEM

SAFETY EVALUATION REPORT

AMENDMENT NO. 3

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Docket No. 72-1025
NAC-MPC STORAGE SYSTEM
Certificate of Compliance No. 1025
Amendment No. 3

SUMMARY

By applications dated April 18, 2002, May 15, 2002, and January 17, 2003, as supplemented on July 17, 2002, and October 3, 2002, NAC International, Inc. (NAC) requested approval of an amendment, under the provisions of 10 CFR Part 72, Subpart K, to Certificate of Compliance No. 1025 for the Multi-Purpose Canister (MPC) Storage System.

NAC requested changes to the Certificate of Compliance (CoC), including its attachments, and revision of the Final Safety Analysis Report (FSAR). The requested changes were: (1) to incorporate fuel enrichment fabrication tolerances into the Yankee Class fuel parameters; (2) to incorporate fuel assemblies with up to 20 damaged fuel rods, recaged fuel assemblies, Yankee Rowe damaged fuel can, and fuel assembly weights up to 950 pounds; (3) to revise the average surface dose rate limits for the concrete cask; (4) to incorporate administrative changes in the ASME Code Alternatives for the NAC-MPC canister; (5) to correct the Connecticut Yankee (CY) maximum fuel enrichment, maximum initial uranium mass, and maximum burnup parameters, and (6) to incorporate editorial and administrative changes.

The NRC staff has reviewed the application using the guidance provided in NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems." Based on the statements and representations in the application, as supplemented, the staff concludes that the NAC-MPC system, as amended, meets the requirements of 10 CFR Part 72. The changes to the CoC are indicated by change bars in the margins.

BACKGROUND

The NAC-MPC system consists of the following components: (1) transportable storage canister (TSC), which contains the spent fuel; (2) vertical concrete cask (VCC), which contains the TSC during storage; and (3) a transfer cask, which contains the TSC during loading, unloading and transfer operations. Each TSC stores up to 36 fuel assemblies from the Yankee Nuclear Power Plant (Yankee Rowe), a pressurized water reactor (PWR) and up to 26 fuel assemblies from Connecticut Yankee (Haddam Neck), a decommissioned PWR.

The NAC-MPC was originally approved for storage of spent fuel from the Yankee Rowe plant. Amendment No. 2 to the NAC-MPC CoC added CY spent fuel to the authorized contents of the NAC-MPC system. The amendment also revised the CoC format for consistency and revised CoC Appendix A, Technical Specifications (TS) and Appendix B, Approved Contents and Design Features in its entirety to address the addition of CY fuel.

STRUCTURAL EVALUATION

Fuel Assembly Weights up to 950 Pounds

The amendment proposes to revise CoC Appendix B Table B2-1, Yankee Class Fuel Assembly Limits, by increasing the approved fuel assembly weight from 900 lbs up to 950 lbs. It continues to limit the maximum content weight that can be loaded into the canister to 30,600 lbs, recognizing that not all fuel assemblies would weigh up to the maximum allowable. NAC performed a structural re-evaluation of the canister and fuel basket during a VCC tip-over accident to evaluate the effects of the weight change on the NAC-MPC system. The Safety Analysis Report (SAR) Section 11.2.12.3 indicates that, because the maximum content weight is limited to 30,600 lbs, the previously calculated stress results for the canister shell continues to be applicable. However, to accommodate the actual weight of certain fuel assemblies and damaged fuel cans, which could weigh up to the maximum allowable, a fuel assembly weight of 950 lbs was assumed for all 36 fuel assemblies. The resulting maximum fuel weight of 34,200 lbs was conservatively used for the fuel basket support disk analysis, including the inertial load effect of four damaged fuel cans located in the basket corner positions.

The structural re-analysis of the basket support disks followed the same approach as that used for the previously approved contents. The weights of the fuel assembly, aluminum heat transfer disks, rods and spacers, and fuel tube were properly factored by appropriate g-load and conservatively applied as concentrated forces at the mid-span of the ligaments of the support disks. The SAR Tables 11.2.12.3-4 through -13 list stress results for the top five support disks. The minimum margins are 1.42 and 0.17 for the primary membrane and primary membrane-plus-bending stresses, respectively, which are positive and acceptable. The SAR Tables 11.2.12.3-14 through -18 list buckling evaluation results for the support disk ligaments. The interaction equations criteria for the ligament axial force and bending moment are satisfied, which ensures that the support disk will not buckle. On this basis, the NRC concluded that the canister and fuel basket would continue to have acceptable structural performance for fuel assembly weights up to 950 pounds.

Use of Damaged Fuel Cans

The amendment proposes the use of a damaged fuel can to confine a Yankee Class intact fuel assembly, damaged fuel assembly, re-caged fuel assembly, or a reconfigured fuel assembly. NAC Drawing 455-902, Can Details, Damaged Fuel, MPC-Yankee, shows design details of the 8.1 inch-square by 114.4 inch-long Yankee damaged fuel can, which consists of an 18-gage stainless steel shell body, a bottom plate and a top closure assembly with screened openings to allow gaseous and liquid media to escape. NAC Drawing 455-871, Details, Canister, MPC-Yankee, shows that four Yankee damaged fuel cans are required to be placed in the canister in conjunction with the use of a special shield lid, which is machined with four 9.3 inch-square by 1.4 inch-deep recesses, to provide needed space to accept the cans.

The SAR Section 3.4.1.1.11 presents a structural analysis of the Yankee damaged fuel can for normal operations, including can lifting. The welds and key components, including the tube body, closure lid, lifting lug, and side plates, are shown to have large stress margins. The corresponding analyses for a 60-g inertial load, which bound the impact g-loads associated with the VCC tip-over and 6-inch vertical drop accidents, are presented in SAR Sections 11.2.12.3.7 and 11.3.2.5, respectively. These analyses also demonstrate acceptable stress performance and buckling capability of the Yankee damaged fuel can.

ASME Code Alternatives
The amendment proposes the use of ASME Code *Alternatives* in place of ASME Code *Exceptions*. The wording change is made to be consistent with current interim staff guidance, ISG-10, Revision 1, "Alternatives to the ASME Code." The change in terminology is administrative in nature and has no particular regulatory or safety impact.

Based on the applicant's structural evaluation for this amendment, the staff concludes that the proposed changes will not affect the ability of the package to meet the regulatory requirements of 10 CFR Part 72.

SHIELDING EVALUATION

Summary
The amendment proposes to revise the CoC by increasing fuel weights from 900 to 950 pounds, allowing nominal minor variations in certain fuel parameter values, changing the design basis average surface dose rate for the air inlet/outlets to $\leq$ 200 mrem/hr, and allowing the use of a new damaged fuel can. Additionally, the applicant provided a MCBEND shielding analysis as a supplemental portion of the SAR to provide more in-depth information about streaming through the air inlet and outlet vents of the concrete cask.

Discussion
The NAC-MPC system consists of a transportable storage canister, vertical concrete cask, and a transfer cask. The contents of the MPC are up to 36 intact Yankee Class pressurized-water reactor (PWR) spent fuel assemblies, reconfigured fuel assemblies and recaged fuel assemblies, including up to four fuel assemblies loaded in damaged fuel cans.

The damaged fuel can is a stainless steel container that confines a Yankee Class intact fuel assembly, damaged fuel assembly, recaged fuel assembly or a reconfigured fuel assembly. It has a stainless steel bottom plate and has screened openings on the top and bottom. The damaged fuel can lid is held in place by the damaged fuel shield lid.

The Yankee Class fuel consists of fuel assemblies manufactured by Westinghouse, United Nuclear, Exxon, and Combustion Engineering. The assemblies vary in nominal initial enrichment from 3.5 to 4.94 wt% ^{235}U, and the maximum burnup is 36,000 Mwd/MTU with a minimum of 8 years cool time. CE fuel with this burnup and cool time is the design basis fuel. Source terms include fuel neutron, fuel gamma, and gamma contributions from activated hardware. Dose rate evaluations include the effect of fuel burnup peaking on fuel neutron and gamma source terms.

No changes are being made in the types or quantities of radioactive effluents that may be released offsite, and there is no significant increase in public radiation exposure.

For the damaged fuel cans, the shielding evaluation of the damaged fuel considers the dispersion of 20 fuel rods in the fuel assembly bottom end fitting. Radial dose rates were calculated, with particular emphasis on the dose rates at the air inlets.

Shielding evaluations were performed with SCALE 4.3 for the PC (ORNL) and MCBEND (Serco Assurance). In particular, the SCALE shielding analysis sequence SAS2H was used to generate source terms for the design basis fuel, using the 27 group ENDF/B-IV library. Source terms were generated for both UO_2 fuel and fuel assembly hardware. The MCBEND shielding evaluations used the 28-group neutron and 22-group gamma energy structures embedded in the code. MCBEND is a three-dimensional Monte Carlo shielding code. The MCBEND code allows detailed modeling of the streaming paths of the air inlet and outlet vents.

Modeled accident conditions assumed a projectile impact and a loss of 6 inches of concrete shielding. Design basis intact fuel under normal conditions has a calculated maximum side dose rate of 44.1 mrem/hr at the fuel midplane and 75.5 mrem/hr on the top lid surface above the air outlets. The average dose rate over the top of the storage cask was computed to be 34.9 mrem/hr. Maximum surface dose rates of 116 mrem/hr and 191 mrem/hr were calculated at the surface of the outlet vent and at the entrance of the inlet vent with supplemental shielding, respectively. For the case of both intact and damaged fuel, the total air inlet dose rate with supplemental shielding in the inlet is 219 mrem/hr. The design basis dose rate for the air inlet and outlet vents is an average of the maximum values (219 and 116 mrem/hr) equal to 168 mrem/hr.

The predicted increase in the dose rates at the vents shown by the new MCBEND analysis is offset by the large amount of conservatism in the shielding methodology, the conservatism presented in the methodologies in Chapter 10 of the SAR, and the radiation protection program required for the cask user.

Conclusion

The staff reviewed the changes requested and determined that they meet the requirements of 10 CFR Part 72 for the NAC-MPC system. The basis of the staff's determination is the already approved design of the system, the conservatism in the shielding calculations, and the relatively small significance of the changes from a dose perspective. The MCBEND analysis provides further assurance that the applicant will meet the new technical specification limit of $\leq$200 mrem/hour (averaged over both the air inlet and air outlet vents).

Chapter 1 of the SAR provides a description of the shielding structures, systems, and components (SSCs) important to safety in sufficient detail to allow evaluation of their effectiveness. Chapter 5 of the SAR provides the shielding evaluation of the SSCs important to safety with the objective of assessing the impact on public health and safety.

The staff reviewed the fuel parameters listed in the SAR and has reasonable assurance that the design basis gamma and neutron source terms are adequate for the shielding analysis. The staff also reviewed the input files for the SAS2H and MCBEND analyses and has reasonable assurance that the materials and dimensions were appropriately modeled, and that the dose rates presented in the SAR are representative of dose rates which would occur at the site.

The staff concludes that the applicant's shielding evaluation for the NAC-MPC storage system will maintain occupational dose requirements in the owner controlled area. The higher weight assemblies, nominal changes to fuel parameters, changing the design basis maximum surface dose rate for the air inlet/outlets to $\leq$ 200 mrem/hr, and the use of a damaged fuel canister similar to those already approved in other systems will continue to maintain dose rates ALARA and meet the dose limits or 10 CFR Part 20. Additionally, the applicant demonstrated that the changes result in no off-site dose impact to the public and meet the radiation protection requirements of 10 CFR 72.104 and 72.106. The staff reviewed the analyses provided in the amendment request and has reasonable assurance that it is acceptable.

CRITICALITY SAFETY

Summary

The amendment proposes to revise the CoC to include re-caged fuel assemblies and damaged fuel cans as allowable contents in the NAC-MPC storage system. Re-caged fuel assemblies consist of fuel rods removed from a United Nuclear fuel assembly and placed in an empty Combustion Engineering fuel cage. A criticality evaluation of the re-caged fuel assembly in any basket position, presented in Section 6.4.3.1 of the SAR, did not result in a statistically significant difference in reactivity from the United Nuclear Type A or Type B assembly.

Discussion

The damaged fuel can is included in order to accommodate Yankee Class fuel assemblies with up to 20 missing or damaged fuel rods. The damaged fuel can includes screened openings at the top and bottom to allow water flow while precluding the release of pellets and gross particles into the canister cavity. An analysis is presented in Section 6.4.3.7 of the SAR, which considers four damaged fuel cans in the corner positions of the NAC-MPC canister, containing Yankee Class fuel assemblies missing up to 20 rods with 100% dispersal of these rods into the can. This analysis models the dispersed fuel as a homogeneous mixture of UO_2 and water, which is evaluated between the remaining rods of the most reactive missing rod geometry, as well as above and below the active fuel region and neutron absorber plates. The most reactive condition for dispersed fuel is when it is present above and below the neutron poison plate coverage, as modeling dispersed fuel between remaining intact rods will cause the system to be further undermoderated.

Section 6.4.3.8 of the SAR presents an analysis considering preferential flooding and uneven drain-down of the damaged fuel can. The applicant evaluated the canister and damaged fuel can containing various moderator densities, and found that the most reactive condition is with the damaged fuel can and canister cavity fully flooded.

The damaged fuel can analyses resulted in a maximum k_{eff} of 0.92625, for a NAC-MPC canister with 32 intact United Nuclear Type A assemblies and four damaged fuel cans, each containing United Nuclear Type A assemblies with 20 missing rods, in the corner guide tube positions. This k_{eff} is less than the calculated upper subcritical limit of 0.9361.

The applicant also proposes to revise the SAR to include Yankee Class fuel assemblies containing non-solid replacement rods. These replacement rods consist of hollow Zircaloy rods containing stainless steel or Zircaloy slugs, which may be present in up to nine fuel rod positions within an assembly, and do not displace an equal or greater amount of moderator as the nominal fuel rods. The applicant modeled United Nuclear Type A assemblies with 12 such replacement rods of varying diameters, with the gap between the cladding and the slug or pellets in all rods flooded. For replacement rods containing stainless steel slugs with a minimum diameter of 0.265 inches, reactivity is significantly decreased, while replacement rods containing Zircaloy slugs with a minimum diameter of 0.290 inches do not significantly impact reactivity.

Conclusion
The NRC staff has reviewed the assumptions used in the revised analyses contained in the NAC-MPC SAR for Yankee Class fuel, and agrees with the applicant's results and conclusions. The staff also notes that the damaged fuel contents are similar to those previously approved under 10 CFR Part 72 for other spent fuel storage systems. Based on a review of Revision MPC-02B of the NAC-MPC SAR, the staff concludes that the NAC-MPC with revised Yankee Class contents continues to meet the criticality safety requirements of 10 CFR Part 72.

CONNECTICUT YANKEE FUEL ASSEMBLY TABLES

Summary
NAC has proposed an amendment revision to correct minor inconsistencies with the FSAR and CoC Tables B2-3, Connecticut Yankee Fuel Assembly Limits and B2-4 Connecticut Yankee INTACT FUEL ASSEMBLY Characteristics. The proposed revision would better reflect the actual analysis that was performed in support of the thermal, shielding, criticality, and radiation protection sections of the NAC-MPC FSAR.

Discussion
The parameters to be revised in both tables are the maximum initial enrichment for stainless steel clad fuel assemblies, maximum initial uranium mass for the CY-MPC damaged fuel cans and maximum burnup. The content of tables originally reflected the specific CY fuel characteristics and parameters that were available from and provided by the Connecticut Yankee Atomic Power Company for the Haddam Neck Plant. However, NAC determined, based on its experience with other licensees, that the analysis would not only bound the actual CY fuel characteristics and parameters, but would also include additional margin to ensure that any minor fuel characteristic and parameter deviations would be addressed by the existing analysis.

NAC has utilized combinations of the worst-case fuel characteristics and parameters to perform the thermal, shielding, criticality, and radiation protection evaluations presented in the FSAR. Consequently, in a number of cases, the actual CY fuel characteristics and parameters are not specifically reflected in the respective FSAR sections. Instead, combinations of the worst-case fuel characteristics and parameters were utilized to develop "design basis" fuel that bounded all of the CY fuel. As a result, the "design basis" fuel utilized in the actual analysis performed to support the thermal, shielding, criticality, and radiation protection sections of the FSAR, may not be readily identifiable with the actual CY fuel characteristics and parameters. However, the specific calculations performed by NAC in support of the FSAR for CY in the areas of thermal, shielding, criticality, and radiation protection bound all of the actual CY fuel characteristics and parameters.

The proposed revisions to CoC Tables B2-3 and B2-4 are supported by existing analysis that utilized worst-case fuel characteristics and parameters associated with CY fuel. The revisions provides a more realistic summary of the fuel characteristics and parameters that NAC utilized in it's analysis.

Conclusion
The staff agrees that the applicant's analysis in support of the thermal, shielding, criticality and radiation protection sections of the FSAR bounds the CY fuel characteristics and parameters.

Therefore the revision of the fuel tables to reflect the "design basis" fuel from the analysis in lieu of actual CY fuel characteristics is considered a correction. The staff concludes that the proposed table revisions are consistent with the existing analyses referenced in the FSAR and continue to meet the requirements of 10 CFR Part 72.

EDITORIAL CHANGES

Summary

NAC has identified various editorial and administrative changes to the CoC and its attachments. The changes provide clarification and consistency, remove inaccuracies, and rectify minor omissions in the wording of the CoC; Appendix A, Technical Specifications; and Appendix B, Approved Contents and Design Features for the NAC-MPC system. The proposed changes do not introduce any significant changes and are either editorial or administrative in nature.

Discussion

The editorial and administrative clarifications and changes are listed in the following table.

Section	Page	Description of Change	Justification for Change
Certificate of Compliance	2	Paragraph 3; line 11: the word 'and' has been added	Editorial
Certificate of Compliance	2	Paragraph 3; line 12: the word 'and' has been deleted; the words 'covered by' have been added	Editorial clarification
Appendix A – Table of Contents	A-2	Last line: 'Table A5-1' has been deleted	Not needed
Appendix A	A1-1	Paragraph 6; line 7: the words 'CY-MPC' have been added; the words damaged fuel can have been changed to all capital letters	Editorial clarification
Appendix A	A1-2	Paragraph 7; lines 2 and 3: spacing adjusted	Administrative
Appendix A	A1-3	Paragraph 7; lines 3 and 4: the words 'during normal and accident conditions of transport' have been deleted	Removed extraneous phrase
Appendix A	A1-4	Paragraph 3; line 11: revision bar added	Editorial
Appendix A	A1-4	Paragraph 5; line 1: revision bar added	Editorial
Appendix A	A1-4	Paragraph 6; line 4: spacing adjusted; revision bar added to entire paragraph	Editorial
Appendix A	A1-6	Paragraph 1; line 2: the word 'lattice' has been changed to all capital letters	Editorial consistency
Appendix A	A3-4	LCO 3.1.1; line 1 of No. 2: the words; 'a minimum of 24 hours of' have been added	Need to define required length of cooling time (based on thermal analyses)

Appendix A	A3-5	LCO 3.1.1; Action A.2.1: the words ‘and maintain it for a minimum of 24 hours’ have been added	Need to define required length of cooling time (based on thermal analyses)
Appendix A	A3-5	LCO 3.1.1; Action A.2.2: the words ‘and maintain it for a minimum of 24 hours’ have been added	Need to define required length of cooling time (based on thermal analyses)
Appendix A	A3-7	LCO 3.1.2; SR 3.1.2.1: the word ‘Once’ has been added; the ‘p’ in ‘prior’ has been changed to lower case	Clarification of requirement
Appendix A	A3-8	LCO 3.1.3; SR 3.1.3.1: the word ‘Once’ has been added; the ‘p’ in ‘prior’ has been changed to lower case	Clarification of requirement
Appendix A	A3-9	LCO 3.1.4; line 1 of No. 2: the words ‘a minimum of 24 hours of’ have been added	Need to define required length of cooling time (based on thermal analyses)
Appendix A	A3-10	LCO 3.1.4; Action A.1.1: the words ‘and maintain it for a minimum of 24 hours’ have been added	Need to define required length of cooling time (based on thermal analyses)
Appendix A	A3-10	Action A.1.2: the words ‘and maintain it for a minimum of 24 hours’ have been added	Need to define required length of cooling time (based on thermal analyses)
Appendix A	A3-22	LCO 3.2.2; SR 3.2.2.1: frequency line 4: the words ‘, or at the’ have been added	Clarify when the surveillance may be done
Appendix A	A5-4	A 5.5; Paragraph c; line 1: the words ‘in the vertical orientation’ have been added	Clarify transfer cask lifting requirements
Appendix A	A5-4	A 5.5; Paragraph c; line 4; the sentence ‘The TRANSFER CASK is not permitted to be lifted in the horizontal orientation.’ has been added	Clarify transfer cask lifting requirements
Appendix A	A5-5	Table A5-1 has been deleted	Not needed. Section A 5.5 includes all of the requirements.
Appendix B	B2-5	Table B2-1; Paragraph G; line 2: the words ‘as shown in Figure 12A2-1' have been deleted	Remove the nonrelevant reference
Appendix B	B2-8	Table B2-3, Section 2c; line 3: the words ‘CY-MPC’ have been added; the words ‘damaged fuel can’ have been changed to all capital letters	Editorial consistency
Appendix B	B2-8	Table B2-3, Section 2c; the words ‘’ 674 Watts’ have been aligned with the first line of 2c	Editorial

Appendix B	B2-14	Table B2-4; parameter 9: the word 'Maximum' has been added	Editorial for consistency with other table values
Appendix B	B3-2	Space added between paragraphs	Editorial
Appendix B	B3-5	Table B3-1; last column; line 13: the sentence 'The vent port and drain port cover welds are not pressure tested, but are tested to the leak-tight criteria of ANSI N14.5.' has been added	Clarify weld leak test criteria

Conclusion
The staff has reviewed the proposed changes and agrees that the changes are clarifications or editorial enhancements. The staff concludes that the proposed wording changes are consistent with the existing Technical Specifications and Approved Contents and Design Features and continue to meet the requirements of 10 CFR Part 72.

OVERALL CONCLUSION

The NRC staff has reviewed the amendment to the SAR for the NAC-MPC system. The Certificate of Compliance has been revised to include the NAC requested changes. Those changes include (1) fuel enrichment tolerances; (2) damaged fuel rods, recaged assemblies, YR damaged fuel can, and assembly weights up to 950 pounds; (3) average surface dose rate limits; (4) ASME Code Alternatives; (5) CY fuel table correction; and (6) to incorporate editorial and administrative changes. Based on the statements and representations contained in the application, as supplemented, the staff concludes that these changes do not affect ability of the NAC-MPC Storage System to meet the requirements of 10 CFR Part 72.

Issued with Certificate of Compliance No. 1025, Amendment No. 3 on October 08, 2003.