PRELIMINARY SAFETY EVALUATION REPORT

NAC INTERNATIONAL, INC.

Modular Advanced Generation Nuclear All-purpose Storage (MAGNASTOR®) DRY CASK STORAGE SYSTEM

CERTIFICATE OF COMPLIANCE NO. 1031

AMENDMENT 2

DOCKET NO. 72-1031

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Summary

This Safety Evaluation Report (SER) documents the review and evaluation of an amendment to Certificate of Compliance (CoC) No. 1031 for the Modular Advanced Generation Nuclear All-purpose Storage (MAGNASTOR®) spent fuel dry cask storage system. By application dated March 22, 2010 (Agencywide Documents Access and Management System (ADAMS) accession number ML100830445), as supplemented March 30 (ML100910345), March 31 (ML100950172 – data cover letter & affidavit), June 8 (ML101610085 – cross reference matrix), July 1 (ML102880325), November 10 (ML103190427), November 19 (ML103260461); April 22 (ML11115A146), and May 17, 2011 (ML11143A101) the cask vendor, NAC International (NAC), submitted a request to the U. S. Nuclear Regulatory Commission (NRC) in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 72.244 to amend CoC No. 1031. To summarize, this amendment would allow:

- the addition of various boron-10 (^{10}B) areal densities for use with pressurized water reactor (PWR) and boiling water reactor (BWR) baskets;
- correction of the code reference in Table 2.1-2 of the Final Safety Analysis Report (FSAR), table entitled “ASME Code Alternatives for MAGNASTOR® components”;
- change of transportable storage canister (TSC) surface contamination limits for loose contamination;
- editorial corrections in the FSAR to reflect the various ^{10}B areal densities for use with PWR and BWR baskets
- replacement of item d) “Minimum fuel tube orthogonal (x, y) pitch” by “Minimum fuel tube outer diagonal dimension” in Section 4.0, Design Features, Subsection 4.1.1, Criticality Control (affected page is A4-1); and
- correction of the reference to 10 CFR 72.212(b)(2)(i)(C) to read 10 CFR 72.212(b)(5)(iii) in Section 5.5, Radiation Protection Program, item 5.5.3 on page A5-3.

In support of the amendment, NAC submitted Revision 10A and Revision 10C of the FSAR for the MAGNASTOR® system. Revision 10A also included changes, noted by italics and bold-faced text that were incorporated by the applicant through the 10 CFR 72.48 process as of March 22, 2010. These 10 CFR 72.48 changes are not part of this amendment request. Therefore, changes made under the 10 CFR 72.48 process were not evaluated by the NRC staff as part of this amendment and are not formally authorized as part of this certification action for the MAGNASTOR® system.

The NRC staff reviewed the amendment and supplements to the amendment using guidance NUREG-1536, “Standard Review Plan for Dry Cask Storage Systems,” Rev. 1, dated July 2010. Based on the statements and representations in the application, as supplemented, and the conditions specified in the CoC and technical specifications (TS), the staff concluded that the requested changes meet the requirements of 10 CFR Part 72.

1.0 General Description

In this second amendment to the MAGNASTOR® dry cask storage system, NAC requested the following:

1) Addition of various boron-10 (^{10}B) areal densities for use with PWR and BWR baskets;
2) Correction of the code reference in Table 2.1-2, ASME Code Alternatives for MAGNASTOR® components;
3) Change of transportable storage canister (TSC) surface contamination limits for loose contamination; and
4) Editorial changes to the FSAR to reflect addition of ^{10}B areal densities for use with PWR and BWR baskets.

Additionally, during the fabrication process, NAC found it difficult to measure the fuel tube orthogonal pitch accurately and requested a revised TS to ensure adequate controls of basket geometry for criticality safety. The new TS (4.1.1.d) defines the minimum fuel tube outer diagonal dimension for both PWR and BWR basket configuration. The TS administrative change references 10 CFR 72.212(b)(2)(i)(C). The ongoing 10 CFR Part 72 rule change (effective May 17, 2011) renumbers 10 CFR 72.212(b)(2)(i)(C) in the revised rule to 10 CFR 72.212(b)(5)(iii).

The chapters of the MAGNASTOR® Cask System Final Safety Analysis Report (FSAR), Revision 0, NAC International, February 2009 and appendices affected by this amendment request are:

- Chapter 1, General Description;
- Chapter 2, Principal Design Criteria;
- Chapter 6, Criticality Evaluation;
- Chapter 10, Acceptance Criteria and Maintenance Program;
- Chapter 13, Operating Controls and Limits;
- Technical Specifications
  - Appendix A, Technical Specifications and Design Features for the MAGNASTOR® system;
  - Appendix B, Approved Contents for the MAGNASTOR® system; and
  - Appendix C, Technical Specification Bases for the MAGNASTOR® system.

The amendment request also includes two revised license drawings associated with the requested changes. Drawing No. 71160-571, Details, Neutron Absorber, Retainer, MAGNASTOR® – 37 PWR, and Drawing No. 71160-572, Details, Neutron Absorber, Retainer, MAGNASTOR® – 87 BWR, have been revised to refer to the application for minimum effective areal density of the neutron absorber.

Revision 10A also included changes, noted by italics and bold-faced text that were incorporated by the applicant through the 10 CFR 72.48 process as of March 22, 2010. These 10 CFR 72.48 changes are not part of this amendment request. Therefore, changes made under the 10 CFR 72.48 process were not evaluated by the NRC staff as part of this amendment and are not formally authorized as part of this certification action for the MAGNASTOR® system.

1.1 MAGNASTOR® System Description and Operational Features

Section 1.3 of the MAGNASTOR® Final Safety Analysis Report (FSAR) provides a general description of the MAGNASTOR® system. It is a spent fuel dry storage system consisting of a concrete cask and a welded stainless steel canister (the transportable storage canister, or TSC) with a welded closure to safely store spent nuclear fuel. In the storage configuration, the TSC is placed in the central cavity of the concrete cask. The concrete cask provides structural protection, radiation shielding, and internal airflow paths that remove the decay heat from the TSC contents by natural air circulation. The concrete cask also provides protection during storage for the TSC against adverse environmental conditions. The system is designed to accommodate both the storage and transport of pressurized water reactor (PWR) and boiling water reactor (BWR) spent fuel (the transportation feature is not part of this amendment request and, therefore was not reviewed by the staff). The MAGNASTOR® system is designed to store up to thirty-seven (37) PWR or up to eighty-seven (87) BWR spent fuel assemblies in each TSC in separate fuel basket assemblies. In addition to the TSC and the concrete cask, the other principal component of the MAGNASTOR® system is the transfer cask. The transfer cask is used to move the TSC between the workstations during TSC loading and preparation activities, and to transfer the TSC to or from the concrete cask.

1.1.1 Transportable Storage Canister (TSC)

The TSC provides the confinement boundary for the stored fuel. The major components of the TSC assembly are the shell, base plate, closure lid, closure ring, and redundant port covers for the vent and drain ports. The stainless steel TSC assembly holds the fuel basket structure and confines the contents. The welded stainless steel bottom plate, welded closure lid, closure ring, and redundant port covers prevent the release of contents under normal conditions and off-normal or accident events.

Each TSC contains either a PWR or BWR fuel basket, which positions and supports the stored fuel. The fuel basket assembly provides the structural support and a heat transfer path for the fuel assemblies, while maintaining a subcritical configuration for all of the evaluated normal conditions and off-normal or accident events.

The TSC component dimensions and materials of fabrication, and the overall dimensions and design parameters for the two lengths of TSCs are provided in Tables 1.3-1 and 1.3-2 of the FSAR, respectively. The TSC stainless steel shell and bottom plate are dual-certified Type 304/304L. The closure lid, closure ring and port covers are stainless steel (Type 304).

The structural components of both the PWR and BWR fuel baskets are fabricated from carbon steel, and the assembled basket is coated with electroless nickel plating to minimize corrosion and combustible gas generation. The principal dimensions and materials of fabrication of the fuel basket are provided in Table 1.3-1 of the FSAR.

1.1.2 Storage Cask

The MAGNASTOR® concrete storage cask provides structural support, shielding, protection from environmental conditions, and natural convection cooling of the TSC during long-term storage. The concrete cask is the storage overpack for the TSC and is designed to hold both lengths of TSCs. The principal dimensions and materials of fabrication of the concrete cask are shown in Table 1.3-1 of the FSAR.

The concrete cask is a reinforced concrete structure with a structural steel inner liner and base. The reinforced concrete wall and steel liner provide the neutron and gamma radiation shielding for the stored spent fuel. Inner and outer reinforcing steel (rebar) assemblies are encased within the concrete. The reinforced concrete wall provides the structural strength to protect the TSC and its contents in natural phenomena events such as tornado wind loading and wind-driven missiles and during non-mechanistic tip-over events. A carbon steel and concrete lid is bolted to the top of the concrete cask. The lid reduces skyshine radiation and provides a cover to protect the TSC from the environment and postulated tornado missiles.

1.1.3 Transfer Cask

The transfer cask is designed, fabricated, and tested to meet the requirements of ANSI N14.6 as a special lifting device. The transfer cask provides biological shielding and structural protection for a loaded TSC, and is used to lift and move the TSC between workstations. The transfer cask also provides shielding during the vertical transfer of a TSC into a concrete cask or a transport cask. Table 1.3-1 of the FSAR provides the principal dimensions and materials of fabrication of the transfer cask.

The transfer cask is primarily made from low alloy steel, and incorporates a lead gamma shield and a solid borated polymer neutron shield. The transfer cask has retractable bottom shield doors, which are closed and secured during TSC loading and handling operations. After placement of the transfer cask on the concrete cask, the doors are retracted using hydraulic cylinders and a hydraulic supply. The TSC is then lowered into a concrete cask for storage. The transfer cask is provided with a number of additional penetrations to allow a cooling medium to be circulated through the cask annulus during TSC loading and preparation activities, as needed.

1.1.4 Basic Operation

The basic sequence of operations for the MAGNASTOR® system is as follows: (1) the transfer cask, with the TSC inside, is lowered into the spent fuel pool and the TSC is then loaded with spent fuel; (2) the transfer cask and loaded TSC are removed from the spent fuel pool and placed in the cask preparation workstation, where the TSC is welded closed, drained, dried, inspected, and backfilled with an inert gas; (3) the transfer cask is moved to the location of the concrete storage cask, placed on top of the concrete cask, the transfer adapter opens the transfer cask doors, and the TSC is lowered into the concrete cask; and (4) the concrete cask is moved to its designated location on the storage pad.

1.2 MAGNASTOR® License Drawings

Section 1.8 of the FSAR contains the drawings for the MAGNASTOR® system, which include drawings of the structures, systems, and components important to safety. The drawings of the neutron absorbers were changed to reflect the modifications requested by Amendment 2. The changes to the design of the neutron absorber are evaluated in Sections 7 and 8 of this SER.

1.3 MAGNASTOR® Storage System Contents

Section 1.4 of the FSAR describes the proposed contents for the MAGNASTOR® system. The system is designed to store up to 37 PWR fuel assemblies or up to 87 BWR fuel assemblies in a pressurized helium atmosphere. PWR fuel assemblies may be stored with inserted burnable poison rod assemblies, thimble plugs or control element assemblies. Stainless steel rod inserts for guide tube dashpots may also be inserted. BWR fuel assemblies may be stored with or without channels. Assemblies may contain solid filler rods or burnable absorber rods. Steel filler rods must be unirradiated. The design conditions and approved contents are specified in the CoC and the Appendices (Technical Specifications) for the MAGNASTOR® system.

1.4 Consideration of 10 CFR Part 71 Requirements

The MAGNASTOR® system is not being certified under 10 CFR Part 71 for use in transportation.

1.5 Evaluation Findings

The drawings of the neutron absorbers supplied in support of this amendment allowed staff to conclude that the information presented in Chapter 1, “General Information” of the FSAR continues to satisfy the requirements for the general description under 10 CFR Part 72. This finding is reached on the basis of a review that considered the regulation itself, Regulatory Guide 3.61, and accepted practices. Thus, based on the NRC staff's review of information provided for Amendment 2 for the MAGNASTOR® system, the staff determines the following:

F1.1 Drawings for structures, systems, and components (SSCs) important to safety are presented in Section 1.8 of the FSAR. Details of specific structures, systems, and components are evaluated in Sections 3 through 15 of this safety evaluation report.

2.0 Principal Design Criteria

The objective of evaluating the principal design criteria related to structures, systems, and components (SSCs) important to safety is to determine whether the principal design criteria comply with the relevant general criteria established in the *Code of Federal Regulations* (CFR) Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste and Reactor-Related Greater Than Class C Waste," Title 10, "Energy".

2.1 Structures, Systems, and Components Important to Safety

The principal design criteria for the MAGNASTOR® system are presented in Chapter 2 of the FSAR, and are specifically listed in Table 2.1-1. The MAGNASTOR® system is classified as important-to-safety and, therefore, the structures, systems, and components (SSCs) of the system are designed, fabricated, assembled, inspected, tested, accepted, and maintained in accordance with a quality assurance program. NAC classified each major component of the system with respect to its function and corresponding potential effect on safety. The safety classifications for the SSCs are provided in Table 2.4-1 of the FSAR and are based on the guidance in NUREG/CR-6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," February 1996.

2.2 Design Bases for Structures, Systems, and Components Important to Safety

The MAGNASTOR® system design criteria summary describes the allowed range of spent fuel configurations and characteristics, the enveloping conditions of use, and the bounding environmental conditions and natural phenomena.

2.2.1 Spent Nuclear Fuel Specifications

MAGNASTOR® is designed to safely store up to thirty-seven (37) undamaged PWR spent fuel assemblies, which may contain a flow mixer, burnable poison rod assembly, a control element assembly and/or solid stainless steel or zirconium-based alloy filler rods. MAGNASTOR® is also designed to safely store up to eighty-seven (87) undamaged BWR fuel assemblies, which may have a zirconium-based alloy channel up to 120 mil thick. Detailed specifications for each category of fuel assemblies are provided in Tables 2.2-1 and 2.2-2 of the FSAR. These include maximum and minimum enrichment, maximum average burnup, minimum cool time, maximum decay heat and detailed physical fuel assembly parameters. The limiting fuel specifications are based on the fuel parameters considered in the shielding, criticality, thermal and structural evaluations.

2.3 Design Criteria for Safety Protection Systems

In addition to the MAGNASTOR system design criteria summarized in FSAR Table 2.1-1, ASME Code alternatives are specified for selected components in Table 2.1-2. Analyzed load combinations for the concrete cask and the TSC are listed in Tables 2.3-1 and 2.3-2, respectively, and the structural design criteria used for TSC components are provided in Table 2.3-3.

2.3.1 General

Each major component of the MAGNASTOR® system is classified with respect to its function and corresponding potential effect on public safety. The safety classifications for the major system components are designated in Table 2.4-1 of the FSAR, in accordance with Regulatory Guide 7.10. The safety classification of the component's function and the assessment of the consequences of its failure are consistent with the guidelines of NUREG/CR-6407. The safety classification categories are defined as follows:

- Category A - Components critical to safe operation whose failure or malfunction could directly result in conditions adverse to safe operations, integrity of spent fuel, or public health and safety.
- Category B - Components with major impact on safe operations whose failure or malfunction could indirectly result in conditions adverse to safe operations, integrity of spent fuel, or public health and safety.
- Category C - Components whose failure would not significantly reduce the packaging effectiveness and would not likely result in conditions adverse to safe operations, integrity of spent fuel, or public health and safety.

The NRC staff determined that areas of the previous safety evaluation (ML090350589) that are not affected by this amendment include: structural, thermal, shielding/confinement/radiation protection, operating procedures, and decommissioning.

2.3.2 Criticality

The criticality analysis is presented in Chapter 6 of the FSAR. The design criterion for criticality safety is that the effective neutron multiplication factor, including statistical biases and uncertainties, does not exceed 0.95 under normal conditions, or off-normal and accident events. The design features relied upon to prevent criticality are the fuel basket geometry and permanent neutron-absorbing materials. Four new alternate neutron-absorbing materials are proposed in this amendment; the evaluation is presented in Section 7 of this SER. The NRC staff finds the continued efficacy of the neutron-absorbing materials over a 20-year storage period is assured by the design of the system. The ^{10}B neutron absorbing material in the TSC will not be significantly depleted, due to the relatively low neutron flux experienced during the storage period.

2.3.3 Acceptance Tests and Maintenance

The acceptance testing and maintenance programs are presented in Chapter 10 of the FSAR. This chapter specifies the workmanship inspections, the acceptance test program, and the applicable inspection and test acceptance criteria to be implemented for the fabrication, use, and maintenance of the MAGNASTOR® system. According to NAC, inspections and tests will provide assurance that MAGNASTOR® components are fabricated, inspected, tested, accepted for use, and maintained under the conditions specified in the FSAR and the Certificate of Compliance.

2.4 Evaluation Findings

The staff concludes that the principal design criteria for the MAGNASTOR® system are acceptable with regard to meeting the regulatory requirements of 10 CFR Part 72. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. A more detailed evaluation of the design criteria and an assessment of compliance with those criteria are presented in Chapters 3 through 14 of the SER.

F2.1 The FSAR and docketed materials adequately identify and characterize the SNF to be stored in the MAGNASTOR® system in conformance with the requirements given in 10 CFR 72.236.

F2.2 The FSAR and the docketed materials relating to the design bases and criteria meet the general requirements as given in 10 CFR 72.122(a), (b), (c), (f), (h)(1), (h)(4), (i), and (l).

F2.3 The FSAR and docketed materials relating to the design bases and criteria for criticality safety meet the regulatory requirements as given in 10 CFR 72.124(a) and (b).

F2.4 The FSAR and docketed materials relating to the design bases and criteria for other SSCs not important to safety but subject to NRC approval meet the general regulatory requirements as given in the following subparts of 10 CFR Part 72: Subpart F, “General Design Criteria” 72.122, 72.124, and 72.126; and Subpart L, “Approval of Spent Fuel Storage Casks.”

3.0 Structural Evaluation

This amendment requests changes in the dimensional tolerances and minimum boron-10 content in previously approved neutron absorbing materials (MAGNASTOR® Amendment 0 and 1, respectively; ML090350589 and ML102910134). The staff finds that these changes only impact the criticality analysis of the package, and have no affect on structural integrity or materials of construction.

4.0 Thermal Evaluation

The modifications requested by NAC did not affect the thermal design and have not altered the staff's previous thermal evaluation of the MAGNASTOR® cask system. Therefore, the staff did not reevaluate this area for the amendment request.

5.0 Confinement Evaluation

The modifications requested by NAC did not affect the confinement design and have not altered the staff’s previous confinement evaluation of the MAGNASTOR® cask system. Therefore, the staff did not reevaluate this area for the amendment request.

6.0 Shielding Evaluation

The applicant has requested that the TS limits for loose (particulate) surface contamination on the TSC be decreased by half. The limit would change from 20,000 decays per minute (dpm) in a 100 cm^2 surface area for beta and gamma radiation and 200 dpm/100 cm^2 for alpha radiation to 10,000 and 100, respectively. Staff reviewed the applicant's analysis of offsite release exposures in FSAR Section 5.6.5. The analysis was based on the old limits and was previously accepted by NRC staff during the review prior to granting the initial CoC. The NRC staff's review of the applicant's previous analysis is documented in the Final Safety Evaluation Report, Section 5.4 (ML090350589). The resulting exposures are provided in FSAR Table 5.6.5-3. The applicant provided the proposed Technical Specifications which decrease the old limits by half in FSAR Appendix A Section 3.3.2.

NRC staff finds the applicant's proposed change to the Technical Specifications acceptable because it decreases the limit for loose surface contamination to half that which was previously accepted by NRC staff.

7.0 Criticality Evaluation

The NRC staff reviewed the proposed amendment to determine whether the MAGNASTOR® package would maintain its contents in a subcritical manner under all credible normal conditions and off-normal accident events encountered during handing, packaging, transfer, and storage. This amendment adds alternative neutron absorber sheet ^{10}B loadings for both the PWR and BWR systems. The NRC Staff reviewed the MAGNASTOR criticality safety analysis to determine compliance with 10 CFR 72.124 and 72.236.

The major components of the MAGNASTOR system are a transportable storage canister (TSC), a concrete storage cask, and a lead-shielded transfer cask. Criticality safety in the system design is provided by a combination of fissile mass controls, geometry control, fixed neutron absorbers in the basket, and for the PWR fuel, dissolved boron in the water used to flood the canister. This amendment requested changes to the boron loading of the absorber plates and adjusted the other parameters for the different absorber plate boron loadings as necessary. The TSC contains either a basket that holds 37 PWR fuel assemblies or a basket that holds a maximum of 87 BWR fuel assemblies. The fixed neutron absorber sheets are attached to the walls of the fuel assembly tubes and are positioned between each of the fuel assemblies in the basket. For PWR fuel, a minimum dissolved boron concentration is maintained during loading and unloading operations depending on the fuel assembly type and the initial enrichment of the fuel loaded. For the BWR fuel, either 87 or 82 fuel assemblies are allowed to be stored in the canister, depending on the fuel assembly type and initial enrichment.

The original analysis for the MAGNASTOR package evaluated neutron absorber sheet minimum effective ^{10}B loadings of 0.036 g/cm^2 for the PWR basket system and 0.027 g/cm^2 for the BWR basket system. Under this amendment the minimum effective boron areal density loadings have been expanded to include two new loadings for the PWR system of 0.030 g/cm^2 and 0.027 g/cm^2, as well as two new loadings for the BWR system of 0.0225 g/cm^2 and 0.020 g/cm^2 using the same methodology that was previously approved by the NRC staff. These new ^{10}B loadings result in new loading criteria tables for each fuel type based on key physical characteristics, maximum initial enrichment, and for PWR fuel types, the soluble boron concentration requirements as shown in Tables 6.1.1-1 through 6.1.1-4 of the FSAR. The design includes the option of three different absorber plate materials (i.e., Boral, borated aluminum alloy, and borated metal matrix composite [MMC]) for use in the MAGNASTOR cask. Boral is given credit for 75% of its ^{10}B content, with the other materials taking credit for 90% of the ^{10}B content. To justify the higher credit for ^{10}B content the applicant subjects the plates made of these materials to a comprehensive program of qualification and acceptance testing. Specifications for the minimum boron concentrations in the water during wet loading and unloading of the PWR basket are given in Table B2-4 of Appendix B to the Technical Specifications as a function of initial uranium enrichment and neutron absorber sheet effective areal ^{10}B density. Specifications for the loading and unloading of the BWR basket are given in Table B2-12 of the TS, Appendix B as a function of initial uranium enrichment and neutron absorber sheet effective areal ^{10}B density.

The applicant used the MCNP5 three-dimensional Monte Carlo code with continuous neutron energy cross-sections to model both the PWR and BWR storage and transfer casks containing a full load of fuel assemblies under the following assumptions, which the staff determined are conservative:

1) fresh, undamaged, unburned fuel;
2) fuel pellet density at 96% of theoretical;

3) homogeneous, peak-planar average enrichment in the BWR fuel;
4) all non-fuel components placed into the guide tubes are specifically addressed;
5) fuel assemblies and the basket do not deform significantly in accidents;
6) no integral burnable poisons; and
7) 75% credit for the ^{10}B content in Boral and 90% credit for the ^{10}B content in the borated aluminum and MMC absorber plates, as was done in the previous analysis.

In addition, the borated plates were evaluated using conservative thickness tolerances for both the PWR and BWR absorber plates. After performing parametric sensitivity analyses to determine the most reactive basket configuration, the applicant established bounding conditions, which included fresh water flooding in the pellet-to-clad gap, maximum pellet OD, minimum fuel rod OD, minimum clad thickness, maximum fuel rod pitch, maximum channel thickness, minimum fuel tube cross-section, maximum fuel tube thickness, maximum poison plate thickness, minimum poison plate width, all fuel assemblies shifted toward the basket center, and full density water in the TSC with no significance to partial flooding, and full water density outside the transfer cask.

NRC staff used the CSAS/KENO-VI codes in the SCALE suite of analytical codes to perform confirmatory analyses using the 44-group and the 238-group (ENDF/B-V) cross-section sets. The staff's confirmatory analyses included both PWR and BWR baskets, several fuel types, and several boron concentration and enrichment combinations in order to verify that the new neutron absorber plate variations were adequately modeled by the applicant. The results of the staff's confirmatory calculations were in close agreement with the applicant's results. All of the staff's results fell below the acceptance criterion of k_{eff} less than 0.95.

Based on review of TS 4.1.1, CoC No. 1031 had a limitation defined by the minimum fuel tube orthogonal pitch for both the PWR and BWR basket configurations. During the fabrication process, the applicant found that it was difficult to measure this dimension accurately, and requested a replacement TS. The new TS (4.1.1.d) defines the minimum fuel tube outer diagonal dimension for both the PWR and BWR basket configurations. Additional criticality analyses were performed by the applicant to evaluate the impact of assembly tolerance variations on the interface width and to confirm that this is the primary criticality control dimension. Subsequent analyses were performed that shifted the assemblies away from the expected "as built" configuration of 45° alignment as well as determined that system tolerances associated with the tube and tube-to-weldment interface and demonstrated that these changes do not adversely affect the reactivity of the system. NRC staff reviewed the proposed changes to the TS and the MCNP5 outputs that evaluated the changes and concludes that based on these studies the outer diagonal dimension is a valid controlling parameter with regards to assembly spacing and system reactivity.

7.1 Evaluation Findings

Based upon a review of the information presented in the application and independent, confirmatory analyses, the staff makes the following findings:

F7.1 Structures, systems and components important to criticality safety are described in sufficient detail in Chapters 1, 2, and 6 of the FSAR to enable an evaluation of their effectiveness.

F7.2 The MAGNASTOR cask system, including the TSC, the concrete storage cask and the transfer cask are all designed to remain subcritical under all credible conditions.

F7.3 The criticality design is based upon favorable geometry, fixed neutron poisons (boron-based neutron absorber plates) and, for PWR fuel assembly contents, soluble boron in the spent fuel pool. Based on the NRC staff materials evaluation, the neutron absorber plates will continue to perform their function effectively and will be able to do so for the 20-year storage period with no credible way to lose their efficacy; therefore, there is no need to provide a positive means to verify continued efficacy as required by 10 CFR 72.124(b).

F7.4 The analysis and evaluation of the criticality design and performance have demonstrated that the cask will enable the storage of spent fuel for a minimum of 20 years with an adequate margin of safety.

F7.5 The staff concludes that the criticality design features for the MAGNASTOR cask system are in compliance with 10 CFR Part 72 and the applicable design criteria have been satisfied. The evaluation of the criticality design provides reasonable assurance that the cask system will allow for the safe storage of spent nuclear fuel. This finding is reached based upon a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, appropriate risk-informed considerations, and accepted engineering practices.

8.0 Materials Evaluation

The amendment requests changes in the dimensional tolerances and minimum boron-10 content in previously approved neutron absorbing materials. Based on its review, the staff finds that these changes only impact the criticality analysis of the package, and have no affect on materials. The amendment also requests the use of Article 24 of Section V of the ASME Code as part of the liquid penetrant examination of the package. The staff finds this acceptable, since Article 24 is incorportated (by reference) into Article 6 of Section V of the ASME Code, which was already approved in ML090350589 and ML102910134 and is in use. The amendment also includes Article 25, "Magnetic Particle Standards" of Section V of the ASME Code which the staff finds acceptable. The staff finds that the ASME Code, although not directly referenced in Part 72 of the *Code of Federal Regulations*, provides an adequate basis for determining standards for magnetic particle testing.

9.0 Operating Procedures Evaluation

The modifications requested by NAC did not affect the operating procedures and have not altered the staff's previous operating procedures evaluation of the MAGNASTOR® cask system. Therefore, the staff did not reevaluate this area for the amendment request.

10.0 Acceptance Tests and Maintenance Program Evaluation

The objective of the staff's review is to determine whether the applicant's FSAR includes the appropriate acceptance tests and maintenance programs for the dry cask storage system. The applicant addressed this area in Chapter 10 of the MAGNASTOR® system FSAR, "Acceptance Criteria and Maintenance Program." The following sections summarize the staff's findings and conclusions.

Italicized and boldfaced text in the following paragraphs reflects actions taken by the vendor through the 10 CFR 72.48 process and are not part of this amendment request. Therefore, changes made under the 10 CFR 72.48 process were not evaluated as part of this amendment and are not formally authorized as part of this certification action for the MAGNATOR system. Use by a general licensee of the MAGNASTOR cask must satisfy the criteria of 10 CFR 72.48, and is subject to NRC inspection. If the general licensee cannot satisfy the criteria of 10 CFR 72.48, it must seek approval from the NRC prior to using the MAGNASTOR cask.

10.1 Acceptance Tests

The applicant has indicated that the MAGNASTOR® system is classified as important-to-safety and, therefore, the structures, systems, and components (SSCs) are designed, fabricated, assembled, inspected, tested, accepted, and maintained in accordance with an appropriate quality assurance program. According to NAC, the controls, inspections and tests applied to the system are intended to ensure that the system will perform its required safety functions during normal conditions and off-normal and accident events to maintain confinement of radioactive material, maintain subcriticality, adequately transfer decay heat from the radioactive material contents, and limit radiation exposure to workers and the public.

10.1.1 Visual Inspection and Nondestructive Examination

Chapter 2 of the FSAR specifies the applicable design criteria, codes, and standards for the performance of fabrication, inspecting and testing of system components. Section 10.1.1 of the FSAR provides an extensive list of the fabrication controls and inspections to be performed.

Changes associated with this amendment include:

a) Materials of construction for the MAGNASTOR system are identified on the license drawings and shall be procured with certification and supporting documentation as required by the ASME Code, Section II, when applicable; and the requirements of ASME Code, Section III, Subsection NB, Subsection NF and Subsection NG, when applicable.

b) Page 10.1-2: <u>item h) – changed "Articles 1 and 6" to "Articles 1, 6 and 24" in 2 places</u>
Visual examinations of the welds of the confinement boundary shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, with acceptance per Section III, Subsection NF, Article NF-5360. The final surface of TSC shell welds shall be dye penetrant examined (PT) in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance per Section III, Subsection NB, Article NB-5350. The TSC shell longitudinal and circumferential welds shall be radiographic examined (RT) in accordance with ASME Code, Section V, Articles 1 and 2, with acceptance per Section III, Subsection NB, Article NB-5320. The weld of the TSC baseplate to the TSC shell shall be ultrasonic examined (UT) in accordance with ASME Code, Section V, Articles 1 and 5, with acceptance per Section III, Subsection NB, Article NB-5330. In accordance with ISG-15 [14], the TSC closure lid to shell weld, performed following fuel loading, shall

be dye penetrant (PT) examined at the root, mid-plane and final surface in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance per Section III, Subsection NB, Article NB-5350. The closure ring to TSC shell and the closure ring to closure lid welds shall be PT examined in accordance with the same code and acceptance criteria as the closure lid to TSC shell weld, except that only the weld final surface will be examined. The inner and outer (redundant) port covers to closure lid welds shall be PT examined at the final surface in accordance with the same code and acceptance criteria as for the closure lid to shell weld. Repairs to TSC vessel welds shall be performed in accordance with ASME Code, Section III, Subsection NB, Article NB-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

c) Page 10.1-2: item i) – changed "Articles I and 7" to "Articles 1, 7 and 25"
Visual examinations of the welds of the fuel basket and basket supports shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, with acceptance per Section III, Subsection NG, Article NG-5360. The fuel tube welds shall be magnetic particle examined (MT) in accordance with ASME Code, Section V, Articles 1, 7 and 25, with acceptance criteria per Section III, Subsection NG, Article NG-5340. Repairs to fuel basket welds shall be performed in accordance with ASME Code, Section III; Subsection NG, Article NG-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

d) Page 10.1-2: item k) – changed "Articles 1 and 6 for PT and Articles 1 and 7 to MT" to "Articles 1, 6 and 24 for PT and Articles 1, 7 and 25 for MT"
Visual examination of the welds of the transfer cask shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, or ANSI/AWS D1.1, Section 6.9, with acceptance per Section III, Subsection NF, Article NF-5360. Following structural load testing of the transfer cask, the final surface of all critical load-bearing welds shall be either dye penetrant (PT) or magnetic particle (MT) examined in accordance with ASME Code, Section V, Articles 1, 6 and 24 for PT and Articles 1, 7 and 25 for MT. The acceptance criteria for the weld examinations shall be in accordance with Section III, Subsection NF, Article NF-5350 for PT and NF-5340 for MT. Repairs to the transfer cask vertical loadbearing welds shall be performed in accordance with ASME Code, Section III, Subsection NF, Article NF-4450 or ANSI/AWS DI. 1. Repaired welds shall be reinspected per the original acceptance criteria applicable to the examination method.

10.1.2 Structural and Pressure Tests

10.1.2.1 Load Testing of Concrete Cask Lifting Lugs and Anchors

a) Page 10.1-4: Section 10.1.2.2, 2nd paragraph, last sentence – revised throughout.
The concrete cask lifting lug load test shall be performed on the lugs independently of the concrete cask. ***The test*** will consist of applying a vertical load ***to the individual lugs at a value*** that is equal to ***one-half of*** 150% of the maximum concrete cask ***weight***. The test load shall be applied for a minimum of 10 minutes. After the release of the test load, the accessible portions of the lifting anchors shall be visually examined to verify no deformation, distortion, or cracking occurred. Critical load-bearing welds of the lifting anchors shall be magnetic particle (MT) examined in accordance with ASME Code, Section V, Articles 1, 7 and 25, or liquid penetrant (PT) examined in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance criteria per Section III, Subsection NF, Article NF-5340 ***or NF-5350***.

10.2 Evaluation Findings

The staff determines the following:

F10.1 The applicant/licensee will examine and/or test the MAGNASTOR® system to ensure that it does not exhibit any defects that could significantly reduce its confinement effectiveness. Chapter 10 of the FSAR describe(s) this inspection and testing.

11.0 Radiation Protection Evaluation

The modifications requested by NAC did not affect the radiation protection and have not altered the staff's previous radiation protection evaluation of the MAGNASTOR® cask system. Therefore, the staff did not reevaluate this area for the amendment request.

12.0 Accident Analysis Evaluation

The modifications requested by NAC did not affect the accident analysis and have not altered the staff's previous accident analysis evaluation of the MAGNASTOR® cask system. Therefore, the staff did not reevaluate this area for the amendment request.

13.0 Technical Specifications and Operating Controls and Limits Evaluation

Changes to Technical Specifications, Appendix A and Appendix B, of MAGNASTOR® FSAR, Revision 10A are listed below.

Technical Specifications, Appendix A: Proposed Changes

- Pages A3-14 & A3-15 – added new Section 3.3.2, TSC Surface Contamination
- Page A4-1, Section 4.1.1 a), Criticality Control – revised neutron absorber areal density table throughout
- Page A4-1, Section 4.1.1 d), Added the minimum fuel tube outer diagonal dimensions for PWR and BWR baskets
- Page A4-2, 1st line – changed "3.25 inches of lead gamma shielding" to "3.2 inches of lead gamma shielding"
- Page A5-1, Section 5.1, Radioactive Effluent Control Program – revised Subsection 5.1.2 throughout and added Subsection 5.1.3
- Page A5-3, correction of the reference to 10 CFR 72.212(b)(2)(i)(C) to read 10 CFR 72.212(b)(5)(iii) in Section 5.5, Radiation Protection Program, item 5.5.3
- Page A5-3, Section 5.5, Radiation Protection Program – revised Subsection 5.5.4 adding new 2nd sentence
- Page A5-4, Section 5.8, Preoperational Testing and Training Exercises – revised last paragraph by adding new last sentence.

Technical Specifications, Appendix B: Proposed Changes

- Page B2-2, Table B2-1 – revised I.A.1.b throughout to add new table and revise other table numbers; revised I.C to change "Table B2-4" to "Table B2-5"
- Page B2-3, Table B2-1 – revised I.C to change table numbers in 2 places from "Tables B2-5 and B2-6" to "Tables B2-6 and B2-7"; revised I.F to change "Table B2-7" to "Table B2-8" [editorial change]
- Page B2-5, Table B2-3 - revised format throughout; former footnote 2 deleted, so former footnote 3 becomes footnote 2
- Page B2-6 – added new Table B2-4
- Page B2-7 – revised table number and table numbers listed in Note [editorial change]
- Page B2-8 – revised table numbers for 3 tables [editorial change]
- Page B2-10, Table B2-9 – revised I.A.1 table numbers; revised I.A.1.b throughout to add new table and revise other table numbers
- Page B2-11 – revised I.E to change table number from "Table B2-10" to "Table B2-11 [editorial change]
- Page B2-12 – revised table number [editorial change]
- Page B2-13, Table B2-11 – revised format throughout
- Page B2-14 – added new Table B2-12
- Page B2-17 – revised table number for 2 tables [editorial change]
- Pages B2-18 thru B2-22 – changed "Table B2-13" to "Table B2-15" [editorial change]
- Pages B2-23 thru B2-30 – changed "Table B2-14" to "Table B2-16" [editorial change]
- Pages B2-31 thru B2-35 – changed "Table B2-15" to "Table B2-17" [editorial change]
- Pages B2-36 thru B2-43 – changed "Table B2-16" to "Table B2-18" [editorial change]
- Pages B2-44 thru B2-48 – changed "Table B2-17" to "Table B2-19" [editorial change]
- Pages B2-49 thru B2-56 – changed "Table B2-18" to "Table B2-20" [editorial change]
- Pages B2-57 thru B2-61 – changed "Table B2-19" to "Table B2-21" [editorial change]

- Pages B2-62 thru B2-69 – changed "Table B2-20" to "Table B2-22" [editorial change]
- Pages B2-70 thru B2-74 – changed "Table B2-21" to "Table B2-23" [editorial change]
- Pages B2-75 thru B2-82 – changed "Table B2-22" to "Table B2-24" [editorial change].

In accordance with the proposed Appendix A and Appendix B Technical Specification changes, Appendix C, Technical Specification Bases for the MAGNASTOR SYSTEM, Section 13 of the MAGNASTOR FSAR (including the Table of Contents), is being revised as follows:

- Page 13C-2, Section 2.0, Approved Contents, Subsection 2.1, Fuel Specifications and Loading Conditions – Background, 3rd paragraph – changed "Table 2-1 and 2-8" to "Tables 2-1 and 2-9"; Approved Contents, 1st sentence – changed "Tables 2-1 and 2-8" to "Tables 2-1 and 2-9"; 3rd sentence – changed "Tables 2-2 through 2-7 and Tables 2-9 through 2-12" to "Tables 2-2 through 2-8 and Tables 2-10 through 2-14"
- Pages 13C-24 thru 13C-26 - added new Section 3.3.2, TSC Surface Contamination.

13.1 Evaluation Findings

F13.1 The staff concludes that the conditions for use for MAGNASTOR® storage cask system identify necessary technical specifications to satisfy 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The proposed TS, if properly implemented, provide reasonable assurance that the MAGNASTOR® storage cask system will allow safe storage of SNF. This finding is based on the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices.

F13.2 For criticality safety, the staff concludes that the conditions for use of the MAGNASTOR® storage cask system identifies the necessary technical specifications to satisfy 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The proposed TS provide reasonable assurance that the MAGNASTOR® cask will allow safe storage of SNF. This finding is based on the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices. The technical specifications pertinent to criticality safety that were changed by the applicant include the following:

Appendix A, Section 4.1.1, Criticality Control, where the minimum ^{10}B loading of the various neutron absorber material were described; and Appendix B, Tables B2-4 and B2-12 that establish PWR and BWR fuel assembly loading criteria.

Appendix A, Section 4.1.1, Criticality Control, where the minimum fuel tube outer diagonal dimensions for the PWR and BWR baskets were defined.

14.0 Quality Assurance Evaluation

The modifications requested by NAC have not altered the staff's previous quality assurance evaluation of the MAGNASTOR® cask system. Therefore, the staff did not reevaluate this area for the amendment request.

15.0 Conclusion

The staff performed a detailed safety evaluation of the application for an amendment to the 10 CFR Part 72 Certificate of Compliance (CoC) for the MAGNASTOR® System. The staff performed the review in accordance with the guidance in NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," Rev. 1, dated July 2010. Based on the statements and representations contained in the application and the MAGNASTOR® Final Safety Analysis Report, Revision 10A and Revision 10C, and the conditions established in the CoC and its Appendices (Technical Specifications), the staff concludes that these changes do not affect the ability of the MAGNASTOR® System to meet the requirements of 10 CFR Part 72.

Issued with CoC No. 1031, Amendment No. 2,
on **TBD**