February 15, 2007

Mr. Anthony L. Patko, Director
Licensing Engineering
NAC International, Inc.
3930 East Jones Bridge Road
Norcross, GA 30092

SUBJECT: REVIEW STATUS OF NAC INTERNATIONAL MAGNASTOR SYSTEM APPLICATION (TAC NO. L23764)

Dear Mr. Patko:

On August 31, 2004, NAC International (NAC) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a Certificate of Compliance (CoC) for a new dry cask storage system, the MAGNASTOR System, in accordance with 10 CFR Part 72. By letter dated January 26, 2007, NAC informed the NRC staff of its withdrawal of the MAGNASTOR application, and its intent to resubmit the application, upon revising it to address the remaining open issues identified by the staff. The purpose of this letter is to acknowledge your withdrawal of the application, and to provide you with information regarding the open issues that formed the basis for the staff's decision to suspend further review.

The NRC staff performed a technical review of the MAGNASTOR application and issued formal requests for additional information (RAIs) on May 23, 2005, and on April 6, 2006. NAC's responses to the RAIs were submitted on September 29, 2005, and August 25, 2006, respectively. Over the course of our review, the NRC staff has had extensive interactions with your staff, many of which have focused on the methods and approaches used by NAC for the structural analysis of the unique canister basket design. These interactions have included several meetings, numerous teleconferences, and the submittal and review of much supplemental information. Despite these extensive interactions, the NRC staff has determined that the information submitted by NAC is insufficient in certain areas for us to make the necessary safety findings to support issuance of a CoC at this time.

Enclosed with this letter is a summary of the staff's remaining concerns regarding NAC's structural analyses for the MAGNASTOR system, and certain other issues in the thermal and criticality review areas for which the staff was unable to reach a conclusion, based on the information provided to date. These issues were discussed with NAC in a public meeting at the NRC offices in Rockville, Maryland, on January 12, 2007.

We recognize the need to create a record of our extensive review of the MAGNASTOR application, and we intend to document the NRC staff's findings in a staff evaluation report, which will address both those areas where we were able to make a positive determination on your application, and those areas where insufficient information has been identified. This report will serve as a future reference for both NAC and the staff, relative to your anticipated resubmittal of the MAGNASTOR application.

Please note that your revised application will be treated as a new request and should clearly identify all changes and any new analyses in response to all of the outstanding issues identified by the NRC staff. Your resubmitted application may reference any pertinent information from the previous application or related NRC documents. We will notify you promptly of our new proposed review schedule, upon receipt of your resubmitted application.

Please refer to Docket Number 72-1031 and TAC No. L23764 in correspondence related to this action. If you have any questions regarding our review, you may contact me or James R. Hall of my staff at (301) 415-8500.

Sincerely,

/RA/

Robert A. Nelson, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 72-1031
TAC No. L23764

Enclosure: Summary of Open Issues

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Enclosure

NAC International
Proposed MAGNASTOR Dry Cask Storage System
Summary of NRC Staff Open Issues

On August 31, 2004, NAC International (NAC) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for a Certificate of Compliance (CoC) for a new dry cask storage system, the MAGNASTOR System, in accordance with 10 CFR Part 72. The proposed system consists of a welded stainless steel transportable storage canister (TSC), a transfer cask, and a concrete storage cask. The system is designed to store up to 37 pressurized water reactor (PWR) or 87 boiling water reactor (BWR) spent fuel assemblies.

The NRC staff issued formal requests for additional information (RAIs) on May 23, 2005, and on April 6, 2006. NAC's responses to the RAIs were submitted on September 29, 2005, and August 25, 2006, respectively. In addition to those RAI responses, the application was further supplemented by information submitted by NAC on October 25, 2004; January 31, March 16, November 11, and December 16, 2005; and February 9, April 3, May 8, September 26, October 19, and November 28, 2006. The NRC staff has reviewed all of the information provided to date, and has determined that several outstanding issues preclude NRC approval of the MAGNASTOR system at this time. These issues are identified below.

Structural issues

The staff is unable to make a safety finding on the structural adequacy of the fuel basket during the cask tip-over event. The staff believes that, when subject to the side impact g-loads of the non-mechanistic cask tip-over event, the canister and basket cross-section will tend to ovalize, potentially resulting in geometric instability of the basket tube assembly and the collapse or reconfiguration of the basket tubes. Considering the principal system design features for the PWR fuel as an example, summarized below are the key concerns regarding the finite element model displacement boundary conditions that have not adequately been addressed by NAC in determining design margins against geometric instability of the basket.

Principal Design Features

Fuel Basket: The carbon steel fuel basket is comprised of an array of square fuel tubes joined together to form a circular cross section. On the interior of the basket, the tubes are held together by pin-to-slot connections, and at the periphery, they are attached by bolting to an assembly of side and corner weldments. The fuel tubes function as individual cells, and also provide sidewalls for the formation of additional developed cells, both of which hold fuel assemblies. Together with the side and corner weldments, which also provide sidewalls to form developed cells, an array of twenty-one 9.76-inch square fuel tubes is used to provide a total of 37 loading positions for PWR fuel assemblies. At both ends of the 179.5-inch long by 70.76-inch diameter basket assembly, connecting pin assemblies are provided to mechanically tie adjacent tube pairs together.

Canister Body: The stainless steel transportable storage canister (TSC) is constructed with a 1/2-inch thick circular cylindrical shell, a 2.75-inch thick welded bottom plate and a 9-inch thick closure plate. The 180-inch long by 71-inch diameter cavity allows a tight fit of the basket assembly inside the TSC.

Concrete Cask: The 225.3-inch tall by 136-inch diameter concrete cask, as an overpack, includes a 26.5-inch thick concrete wall with a 1.75-inch thick carbon steel liner. At the upper part of the cask cavity, twenty-four equally spaced s-beams, 120 inches long by 3 inches wide, are welded to the liner, as standoffs, to facilitate TSC placement. The diametric distance of 73.5 inches between the s-beams results in a radial annulus space of 0.75 inches between the liner s-beam and the TSC.

Boundary Conditions and Design Margins Against Basket Geometric Instability

In Question No. 3-7, of RAI-2 (April 6, 2006), NAC was asked to consider the worst drop orientation, including arbitrary basket drop angles and those at 22.5° and 45°, to demonstrate fuel basket performance against geometric instability during the concrete cask tip-over event. Question No. 3-10 requested that safety margins be established for the fuel basket geometric instability consideration. Based on further meetings with the staff, in response to RAI-2 questions, NAC correctly interpreted the need for conducting sensitivity analyses to establish design margins against fuel basket geometric instability for four basket design features: (1) gaps at tube corner flats due to manufacturing tolerances, (2) tube-to-support weldment relative movement at the boss connection due to the missing shim plate, (3) load carrying capability of the pin-to-slot joint, and (4) ovalization of the canister/basket assembly.

In response to RAI-2, NAC submitted MAGNASTOR Safety Analysis Report (SAR), Revision 6C, Sections 3.10.6 and 3.10.8, which present the sensitivity analysis results. The LS-DYNA transient analyses evaluated "design margins" for the four design features individually, using the periodic finite element model representative of the canister/basket assembly cross-sectional attributes. For the model boundary conditions, the SAR states, in part, "The inner surface of the cask liner in the model is defined based on the maximum canister shell displacement during the cask tip-over accident. The maximum canister shell displacements are determined by the quasi-static ANSYS analysis for the canister for the cask tip-over condition (Section 3.7.1.3)." SAR Section 3.7.1.3 references Section 3.10.3 to simulate a bounding side inertia force of 40 g with a pressure-equivalent loading narrowly distributed over a 21° arc from the impact center line and along the canister circumferential direction. The load distribution assures adequate stress evaluations, but may not have lent itself to a realistic calculation of canister shell displacements, which must be conservatively estimated for evaluating the potential geometric instability of the fuel basket.

In a November 16, 2006, conference call between NRC and NAC, the staff noted that the Case B8 boundary condition, which allows a maximum canister ovalization conforming with the restraint provided by the as-built liner plate, should be used as the baseline boundary condition for all sensitivity analyses. In its November 28, 2006, response, however, NAC contended, "The basket displacement boundary is controlled by the canister shell and not the cask inner liner," contrary to the staff's observation. In the January 12, 2007, public meeting, NAC discussed additional conservatisms involved in using the essentially two-dimensional periodic model to represent the 179.5-inch long three-dimensional basket assembly, which is held together at its two ends with connecting pin assemblies. Also discussed were results of a sensitivity analysis for varied pressure distribution angle, suggesting that the load distribution in an arc greater than 21° would have minimal effects on canister ovalization potential. This sensitivity analysis has not been reviewed by the staff. However, the staff notes that, as identified in NAC's January 31, 2005, supplemental SAR submittal, the PWR basket is seen to undergo a substantial radial displacement of up to 0.485 inches at the location 90° away from the impact centerline. This is markedly different from the minimal displacement currently considered in the SAR or presented in the January 12, 2007, meeting.

On the basis of the above, the staff continues to believe that, because the fuel tubes and side/support weldments tend to deform laterally to result in further canister shell ovalization, NAC must also consider the basket deformation and its interaction with the canister shell as a basis for calculating the displacement boundary conditions suitable for evaluating geometric instability of the fuel basket.

Thermal issues

Thermal Cycling During Vacuum Drying

NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," Section 4.0, "Thermal Evaluation," specifies the review criteria to be used by NRC staff in performing technical evaluations of applications under 10 CFR Part 72. The NRC reviewer must confirm that the application provides sufficient assurance that the cask system is designed to prevent fuel cladding degradation under normal, off-normal and accident conditions. Interim Staff Guidance document ISG-11, Revision 3, provides more specific guidance on the analysis of fuel cladding temperature limits for all conditions of cask loading and storage.

The staff has determined that the applicant has not demonstrated that the temperature differential criterion of ISG-11, Revision 3, will be met for all operating conditions described in the MAGNASTOR SAR, through Revision 6D. Specifically, the vacuum drying time limits in Table 9.1.3 of the SAR may not ensure that the maximum cladding temperature differential of 117°F will be met if thermal cycling (repeated heatup/cooldown cycles) occurs during vacuum drying operations. The 117°F temperature criterion is based upon limiting the degree of super-saturation required for the precipitation of hydrides and subsequent cladding failures, during short thermal cycles. The operating procedures described in Chapter 9 of the SAR do not address this criterion. In addition, Table 4.4-4 of the SAR presents the predicted maximum fuel cladding temperatures for the different transfer phases during canister loading and preparation activities. This table shows that the vacuum phase peak temperature is 715°F, the helium phase peak temperature is 487°F, and the canister loading into the storage cask phase peak temperature is 690°F. Thus, normal operation appears to result in exceeding the temperature differential criterion of ISG-11, Revision 3.

The SAR should provide appropriate supporting analyses to demonstrate with reasonable assurance that this limit will not be exceeded, given the description of the various loading operations and the proposed vacuum drying times in Chapters 8 and 9 of the SAR.

Transfer Cask Heat-up Rate

Section 4.4.1.5 of the MAGNASTOR SAR describes the applicant's thermal evaluation for moving the loaded canister from the transfer cask to the storage cask. The SAR indicates that during this phase, operations are time-limited, as only natural convection is relied upon to ensure that the fuel cladding is maintained at acceptable temperatures. The applicant compares this phase to the case of the canister in the concrete storage cask, with all vents blocked, and indicates that the peak fuel clad temperature calculated for the latter case is bounding for the canister in the transfer cask.

The NRC staff finds that the applicant has not sufficiently demonstrated that the results of the concrete storage cask blocked-vent configuration conservatively represent the heat-up rate of spent fuel for all cases during transfer of the TSC from the transfer cask into the storage cask. The heat-up rate is important in determining the allowable completion times for transfer without exceeding short-term cladding temperature limits. The SAR needs to include a comparison of heat-up rates using separate transfer cask and storage cask thermal models to demonstrate that the blocked-vent storage cask scenario is bounding for all cases. A comparison of the thermal conductivities of the transfer and storage casks is not sufficient by itself, because other complex phenomena and properties of both casks, such as cask heat capacities, need to be considered in the thermal performance analyses.

Drying Criteria and Bases for MAGNASTOR Drying Systems

In conjunction with the two issues discussed above, the SAR needs to be revised to clarify the bases for (1) the vacuum drying pressure criteria; (2) the helium drying dew point and temperature criteria; and (3) the Pressurized Helium Drying System functional description and acceptance testing. NAC provided an information supplement on November 28, 2006, that generally addressed these issues. The technical bases provided within this information supplement should be incorporated into the SAR, as appropriate.

Criticality issues

The following is a summary of the remaining open issues regarding the criticality evaluation as described in the MAGNASTOR SAR through Revision 6D. NAC submitted proposed responses to several of these criticality issues on November 28, 2006; these proposed responses should be reflected in the revised SAR to be provided as part of the resubmitted application.

The SAR must demonstrate that the fuel assemblies will remain in their intact configuration under all normal, off-normal, and accident conditions. The structural analysis should show that the fuel assemblies do not bear any loading which could cause any deformation or damage. The configuration of the fuel in the accident analysis should be maintained and be consistent with the configuration assumed in the criticality model and analysis.

The SAR should verify that the specifications for the maximum allowed initial enrichment for each fuel assembly type were determined by calculations where the optional poison plates have been left out and the redesigned (increased) number of weld posts for mounting the poison plates have been included. Along with this verification, an input file should be formally submitted which shows how the revised modeling was performed.

The SAR should justify the change in data used to establish the trends in the benchmark evaluation with respect to the nine different parameters. The response to RAI 6-6 in the second round of RAIs raises an inconsistency. The revised plots (Figures 6.7.7-1 through 6.7.7-9) of the benchmark data and linear fits to the data appear to show additional data points which were not present in the previous version of the figures as well as some data points now missing that were in the previous figures. The list of benchmark data has not changed and the text states that only three points were deleted for the revised analysis. Clarification of the difference between the plots in the original SAR and the response to the second round of RAIs (beyond that supplied in the November 28, 2006 email from NAC) is needed. An indication of which data points were included in the trend analysis for each parameter and how the applicable points were determined should be provided.

The SAR should show that the minimum center-to-center cell spacing will be maintained under normal and accident conditions, and should also confirm that the minimum center-to-center fuel cell spacing added to the Technical Specifications is the same as used in the criticality analysis. A minimum fuel cell spacing dimension has been added to the Technical Specifications as requested in RAI 13-1. The structural analysis should show that this minimum spacing is maintained under normal, off-normal, and accident conditions. The SAR states that the minimum spacing now in the Technical Specifications is consistent with the criticality analysis, but the details in the model provided in the example input files show a larger cell spacing. Verification that the minimum spacing was used in the calculations for determining the maximum allowed enrichments for each fuel type is needed. In addition, the input file provided via the November 28, 2006, NAC email has not been evaluated and needs to be submitted formally for review.

Editorial Items:

Provide consistent page numbering for Appendix A to Chapter 1. In the response to RAI 1-1, it appears that to be consistent with the other parts of the SAR, the page numbers in Appendix A to Chapter 1 should follow the pattern 1A-1, 1A-2, and 1A-3, not A-1, A-2, and A-3.

Correct the cross references in Section B2.1.1 of the proposed Technical Specifications. The response to RAI 13-3 missed correction of one cross reference. The cross references on page B2-1 of the Technical Specifications need to be changed from Tables 6.4-1 and 6.4-2 to Tables 1-A-1 and 1-A-2, respectively.