Non-Proprietary Request for Additional Information
Docket No. 72-1031
Certificate of Compliance No. 1031
Model No. MAGNASTOR® Storage System
Amendment No. 11

By letter dated July 14, 2020 (Agencywide Documents Access and Management System Package Accession No. ML20210M079), NAC International (NAC) submitted an application for Amendment No. 11 to the Model No. MAGNASTOR® storage cask. The application proposes to add a new concrete overpack, a light-weight transfer cask, and revised boiling-water reactor (BWR) fuel characteristics, including damaged BWR spent fuel.

This request for additional information identifies information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its review of the application. The requested information is listed by chapter number and title in the applicant's safety analysis report (SAR). The NRC staff used NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility — Final Report," in its review of the application. Each question describes information needed by the staff for it to complete its review of the application and to determine whether the applicant has demonstrated compliance with regulatory requirements.

Structural Evaluation

3.1 For the tip-over analysis, demonstrate how angular velocity alone will ensure that the g-loads at the top of the basket and at the top of the canister lid for the concrete cask (CC) number 7 model are essentially the same or bounded by the CC1 model.

The applicant did not perform a tip-over analysis for the CC7 in MAGNASTOR SAR Revision 20C that was submitted in support of Amendment No. 11 but stated that the g-loads were essentially the same or bounded by the g-loads for the CC1 model. The NRC staff had approved a tip-over analysis for the CC1 in the original licensing basis for the MAGNASTOR FSAR, Revision 0 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14176B275), that used a finite element model in the LS-DYNA computer software to calculate the g-loads.

Instead, the applicant appeared to have used a simplified approach that first calculated an angular velocity of the CC7, $\boldsymbol{\omega}_7$, and compared it with the angular velocity of the CC1, $\boldsymbol{\omega}_1$. The calculated ratio ($\boldsymbol{\omega}_7/\boldsymbol{\omega}_1$) was 1.000. Given the similar angular velocity and similar geometry between the CC7 and other concrete casks (CC1, CC3, CC5, CC6), the applicant concluded that no tip-over analysis using LS-DYNA was needed.

However, previous experience with Cask No. CC5 has shown that ratioing angular velocities can lead to erroneous cask g-loads when compared to LS-DYNA due to the complex nature of nonlinear impact dynamics. For angular velocity alone to be used as a generic screening approach to calculate cask g-loads, it has to be shown to produce essentially the same results when compared to LS-DYNA results for model CC1. A benchmarking effort (compared LS-DYNA results) to develop the data to demonstrate this would be one approach, coupled with clear limits defined for the appropriate configuration parameters to ensure that the g-loads remain essentially the same or bounded by the previous licensing approach (LS-DYNA). The proposed approach does not address the below configuration parameters:

- materials properties (soils underneath the ISFSI pad, pad concrete, cask concrete, cask reinforcement, pad reinforcement, steel liner, basket, and fuel);
- mass distribution;
- geometric and material nonlinear behavior under time-dependent dynamic impact loading conditions; and
- Interaction between soil-to-pad, pad-to-cask, and cask-to-internals (liner, basket and fuels) based on impact physics that handles phenomena such as: stress wave generation, stress wave reflection, stress wave oscillation, local deformation, transient stresses, and transient forces.

Since the above factors may affect the design of the CC7, provide the change in values on the design basis g load factors used for CC1 and how they will envelope previously analyzed CC1 results. Confirm that the stress analysis of CC7 has been updated based on analysis as necessary.

The staff needs this additional information to be able to conclude that the g-loads at the top of the basket and top of the canister for the CC7 model are essentially the same or bounded by the CC1 model under a tip-over event for the proposed approach.

This information is needed to determine compliance with 10 CFR 72.236(b).

Thermal Evaluation

4-1 Discuss the omission of 2-Phase flow (boiling) from the FLUENT analysis during the first 85 seconds of the transient analysis of the transportable storage canister (TSC) during helium cooldown and address what effect the inclusion of 2-Phase flow in the analysis model might have on component temperatures for the TSC including fuel cladding temperatures.

The ANSYS and ANSYS FLUENT models that were developed for the thermal analysis of the MAGNASTOR system are described in the SAR (Page 4.11.1-1) as follows:

"For the TSC transfer operations, two types of three-dimensional models are used for each of PWR [pressurized-water reactor], BWR and BWR DF [damaged fuel] configurations: (1) three-dimensional FLUENT models for the transfer cask and the TSC model as described in Section 4.11.1.4 and (2) three-dimensional ANSYS models for the loaded TSC as presented in Section 4.11.1.5. The FLUENT models are used to perform steady state or transient analyses for the water or helium backfilled phases of the TSC. The ANSYS models are used to perform transient analyses for the vacuum drying conditions of the transfer operation. Note that these thermal models consider a water inlet temperature of 70°F and a flowrate of 40 GPM (upflow) for the ACWS (Annulus Circulating Water cooling System) used during TSC transfer operation."

Considering the following MAGNASTOR computational fluid dynamics (CFD) analysis models described in the Calculation Package No. 71160-3065, Rev 1, "MAGNASTOR Transfer Cask Transient Thermal Analyses for BWR Preferential Loading" Appendix F, for the transient analysis of the TSC during helium cooldown, with use of annulus cooling, a review of the FLUENT analysis results indicates that water in the annular gap between the TSC and the transfer cask would boil during the first 85 seconds of the transient; however, boiling of water (2-Phase flow) is not included in the FLUENT model, nor is it discussed in the SAR analysis. The indicated water temperature in the annular gap is more than 400 K (with a maximum of 439 K) and boiling of water occurs at 373K. The given approach may underpredict the amount of heat transfer during the time that the water in the annulus is boiling and therefore the reported temperature transient could be in error, as it is not known how long the boiling of the water will last.

This information is needed to determine compliance with 10 CFR 72.236(b) and 72.236(f).

4-2 Compare and provide a discussion of the total heat transferred in the two-dimensional (2-D) axisymmetric model presented in Section 4.11.1.1 of the SAR and the quarter-symmetry three-dimensional (3-D) model of the TSC presented in Section 4.11.1.2 of the SAR. Provide a justification for the efficacy of applying heat transfer coefficients calculated from the 2-D axisymmetric model to the 3-D model of the TSC. Provide a discussion of the 3-D model temperature results (including the peak cladding temperature) in light of any discrepancies identified between the two models.

The ANSYS FLUENT models that were developed for the thermal analysis of the MAGNASTOR system are described in the SAR (Page 4.11.1-1) as follows:

"Two-dimensional axisymmetric models are used for TSC and the concrete cask (for storage conditions) to generate the boundary conditions for three-dimensional quarter-symmetry model for TSC with PWR fuel and the eighth-symmetry model for TSC with BWR fuel. The need for the three-dimensional symmetry models is to accurately model the significant variation of the fuel assembly heat load in the basket.

Section 4.11.1.1 describes the two-dimensional axisymmetric models of the concrete cask and TSC for PWR and BWR configurations. The models are used to perform steady state FLUENT analysis for the normal, off-normal and accident conditions of storage. The TSC temperature profile from these analyses are applied as the boundary conditions on the three-dimensional quarter-symmetry (PWR) or eighth-symmetry (BWR) model of the TSC."

As described above and further in Section 4.11.1.2 of the SAR, a quarter-symmetry 3-D model of the TSC was developed to calculate peak cladding temperature (PCT) of the stored fuel and this section also states: "The temperature profile at the TSC outer surfaces from the two-dimensional axisymmetric models discussed in Section 4.11.1.1 are applied as the boundary conditions in three-dimensional models." Based on an examination of the 3-D fluent model, heat transfer coefficients calculated using the 2-D axisymmetric model were applied to the 3-D model instead of a temperature profile as stated in the SAR.

Considering the following MAGNASTOR CFD analysis models described in the calculation package: 71160-3085 Rev 1, "*MAGNASTOR Concrete Cask and PWR Canister Thermal Evaluation for High Heat Loads*", Chapter 6, the 3-D ANSYS FLUENT case, however, does not use a temperature profile but instead uses heat transfer coefficients which are obtained from the 2-D analysis results. The heat distribution between these two models (the 2-D and 3-D) should be very similar; however, in reviewing the heat distribution between the two models, the staff noted some inconsistencies. For example: for the total heat transferred radially from the fuel, there is a difference of about 1271 W between the two models. For the heat transferred out the top and bottom TSC surfaces the differences are about 731 W and 502 W, respectively. Overall, there is a heat balance in the two models; however, given the small margin to the allowable limit for PCT, the discrepancies in the heat distribution between the two models should be explained.

This information is needed to determine compliance with 10 CFR 72.236(b) and 72.236(f).