UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

PRELIMINARY SAFETY EVALUATION REPORT

DOCKET NO. 72-1031
NAC INTERNATIONAL, INC.
MAGNASTOR® STORAGE SYSTEM
CERTIFICATE OF COMPLIANCE NO. 1031
AMENDMENT NO. 17
REVISION TO AMENDMENT NOS. 0 TO 16

SUMMARY

This safety evaluation report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's review and evaluation of the request to amend Certificate of Compliance (CoC) No. 1031, NAC International, Inc.'s (NAC, or the applicant) MAGNASTOR® storage system. By letter dated July 30, 2025 (NAC, 2025), as supplemented on March 4, 2026 (NAC, 2026a) and March 13, 2026 (NAC, 2026b), NAC submitted an application in accordance with Title 10 of the *Code of Federal Regulations* (10 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," to amend CoC No. 1031 for the MAGNASTOR® storage system. Specifically, the application requests changes to the design basis for the MAGNASTOR® storage system to correct an error with M5 fuel cladding material yield strength that was introduced in CoC No. 1031, Amendment No. 14 and the associated revisions to Amendment Nos. 0 through 13.

NAC requested that these changes be made in a new Amendment No. 17 to the CoC, and that these changes also be included in the existing Amendment Nos. 0 through 16 via a revision to these amendments. The amended CoC, when codified through rulemaking, will be denoted as Amendment No. 17 to CoC No. 1031. The revised CoCs, when codified through rulemaking, will be denoted as Initial Certificate, Revision 4; Amendment No. 1, Revision 4; Amendment No. 2, Revision 4; Amendment No. 3, Revision 4; Amendment No. 4, Revision 3; Amendment No. 5, Revision 3; Amendment No. 6, Revision 3; Amendment No. 7, Revision 3; Amendment No. 8, Revision 3; Amendment No. 9, Revision 3; Amendment No. 10, Revision 2; Amendment No. 11, Revision 2; Amendment No. 12, Revision 2; Amendment No. 13, Revision 2; Amendment No. 14, Revision 1; Amendment No. 15, Revision 1; and Amendment No. 16, Revision 1 to CoC No. 1031.

This SER documents the staff's review and evaluation of the proposed amendment. The NRC staff reviewed the amendment request using guidance in NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities - Final Report," dated April 2020 (NRC, 2020a).

For the reasons stated below and based on the statements and representations in NAC's application, as supplemented, and the conditions specified in the CoC and the technical specifications, the staff concludes that the requested changes meet the requirements of 10 CFR Part 72.

1.0 GENERAL INFORMATION

This SER documents the staff's review of proposed Amendment No. 17 and revision to Amendment Nos. 0 through 16 to CoC No. 1031 for the MAGNASTOR® storage system. The NRC staff determined that not all disciplines described in NUREG-2215 are affected by the requested amendment and revision. This amendment and revision only requires evaluations on Structural, as described in this SER.

In the application for Amendment No. 17 and revision to Amendment Nos. 0 through 16 for the MAGNASTOR®, the applicant submitted page changes labeled as Revision 25C of the final safety analysis report (FSAR). The applicant also submitted proprietary calculations supporting the requested changes. The NRC staff found that the changes do not affect the ability of the MAGNASTOR® to meet the requirements of 10 CFR Part 72.

2.0 STRUCTURAL EVALUATION

The purpose of the structural evaluation is to ensure that the structures, systems, and components of the MAGNASTOR® dry storage system (DSS) maintain their safety functions under all credible loads and load combinations for normal, off-normal, and accident conditions, including natural phenomena effects. This section describes the staff's evaluation of the proposed changes in structural analysis described in the "Summary" section of this SER and the staff's rationale for reaching reasonable assurance that the MAGNASTOR® DSS will maintain its intended safety functions.

The applicant indicated that a material parameter was incorrectly specified in the structural evaluation of pressurized water reactor (PWR) fuel rod cladding under the end drop and non-mechanistic tip-over accident conditions that constitute the licensing basis for the MAGNASTOR® resulting in the non-conservative calculation of stress values. The applicant corrected the errors and revised the structural evaluations for the fuel rods in section 3.8.1, 3.8.4, and 3.9 of the MAGNASTOR® FSAR (NAC, 2025). Additionally, the applicant submitted updated fuel rod end drop and tip-over evaluations, which also incorporated the cladding material property adjustment (NAC, 2025).

The staff evaluated the following to verify that the structural performance of the fuel rods contained in the MAGNASTOR® DSS meet the requirements of 10 CFR Part 72:

1) proposed FSAR changes in Chapter 3 (NAC, 2025),

2) calculation package 71160-2026, Rev. 2, "Fuel Assembly Structural Evaluation for the MAGNASTOR and UMS Storage End Drop Condition," (NAC, 2025), and

3) calculation package 71160-2049, Rev. 4, "Fuel Rod Evaluation for the MAGNASTOR Storage Tip-over Accident,"(NAC, 2025).

2.1 Structural Evaluation of Fuel Rods for Tip-Over Accident

The applicant submitted a revised calculation for the PWR cask tip-over event (NAC, 2025) to update a material property employed in the evaluation. The applicant performed a conservative evaluation to represent the effects of this tip-over accident event on 33 PWR (7 fuel types) high burnup fuel assemblies, at a bounding fuel temperature of 400°C (752°F), the bounding maximum fuel temperature for normal storage conditions. The applicant also performed a

similar evaluation for the effects of the tip-over accident event on 3 PWR high burnup fuel assembly types in the MAGNASTOR Metal Storage Overpack (MSO).

For the PWR rod analyses, the applicant considered high burnup conditions and cladding alloys that are typical for PWR fuel. The fuel rod and fuel pellet material properties of elastic modulus, density and yield strength, as applicable, are taken from various references. The staff reviewed the applicant's selection of material properties for the cladding alloys to support the analyses. In addition, the staff reviewed information on cladding material properties not cited by the applicant including:

- Shimskey, R., et al. "FY2014 PNNL Zr Cladding Testing Status Report," PNNL-23594, August 30, 2014.
- Wells, B.E., et al. Evaluation of Increased Peak Temperatures for Spent Fuel Cladding Performance during Dry Storage," PNNL-30430, Rev. 1, September 2020.

The staff determined that the material properties for most of the PWR fuel cladding alloys used by the applicant were obtained by measurements on the irradiated cladding samples at elevated temperatures and were therefore acceptable.

The staff noted that the data used by the applicant for one of the PWR cladding alloys was obtained using tensile tests under non-quasi-static testing conditions. Zirconium-based fuel cladding alloys are known to strain harden as a function of the strain rate which, in turn, increases the measured yield strength. Thus, a higher strain rate results in higher yield strength. Based on the information provided in Shimskey et al. (2014) and Wells et al., (2020), the staff determined that the yield strength of the cladding alloy would increase by approximately 6 percent under the testing conditions in the reference cited by the applicant. The staff also determined that publicly available data for irradiated cladding material properties at elevated temperatures is limited and alternative references for properties for the alloy under quasi-static testing conditions are not available. After reviewing the available data and the applicant's analysis, the staff determined that the cited material properties for the cladding alloy were acceptable because: (1) the measurements were conducted using irradiated materials over a range of temperatures that include the applicant's analyzed maximum temperature for the cladding alloy, (2) the strain rates under tip-over accident conditions would be greater than quasi-static strain rates typically used to determine material properties, and (3) use of yield strength as an acceptance criteria is conservative because all zirconium-based cladding alloys strain harden above the yield stress and retain measurable ductility after irradiation.

The applicant determined the peak deceleration at the basket top support disk in the storage cask during the tip-over event using the LS-DYNA finite element program. The applicant performed a modal analysis of each fuel rod, following the general principles presented in section 2.3.5.2 of NUREG-2224 (NRC, 2020b), to determine a dynamic load factor versus the tip-over peak deceleration. The applicant conservatively applied the resulting acceleration value uniformly along the entire length of the damaged PWR fuel rods using the ANSYS program to determine the maximum fuel rod stresses from the tip-over accident.

For the PWR rod analyses performed for both types of overpack, (i.e., concrete or MSO), the factor of safety for all cladding stresses are greater than a value of one for all material types, as presented in FSAR section 3.8.4, "Tip-over Evaluation," indicating that the fuel rod cladding material meets the acceptance criteria during the tip-over accident event. Based on these results, staff finds the fuel rods to be structurally adequate for this accident event per 10 CFR 72.236(l).

2.2 Structural Evaluation of Fuel Rods for End Drop Accident

The applicant also submitted a calculation revised for the PWR cask end drop accident event (NAC, 2025) to update a material property employed in the evaluation. The applicant performed a conservative evaluation to represent the effects of this 24-inch end drop accident event on 7 PWR high burnup fuel assembly types, at a bounding fuel temperature of 350°C (662°F).

For the PWR rod analyses, the applicant considered high burnup conditions and cladding alloys that are typical for PWR fuel. The fuel rod and fuel pellet material properties of elastic modulus, density and yield strength, as applicable, are taken from various references, as described in SER section 2.1, above.

After reviewing the available data and the applicant's analysis, the staff determined that the cited material properties for the cladding alloy were acceptable because: (1) the measurements were conducted using irradiated materials over a range of temperatures that include the applicant's analyzed maximum temperature for the cladding alloy, (2) the strain rates under drop accident conditions would be greater than quasi-static strain rates typically used to determine material properties, and (3) use of yield strength as an acceptance criteria is conservative because all zirconium-based cladding alloys strain harden above the yield stress and retain measurable ductility after irradiation.

The fuel rod cladding bounding stresses resulting from the drop analyses were determined by applying an acceleration time history in LS-DYNA of a duration considered sufficient to capture the response of the fuel rods.

For the PWR rod analyses results tabulated in FSAR section 3.8.1, "PWR Fuel Rod Buckling Evaluation," the factor of safety for all fuel rod cladding stresses are greater than a value of one for the bounding material type, indicating that all fuel rod cladding materials meet the acceptance criteria during the storage cask 24-inch end drop accident event for PWR fuel rods. Based on these results, staff finds the fuel rods to be structurally adequate for this accident event per 10 CFR 72.236(l).

Based on the reviews of the statements, analyses and evaluations provided in the amendment application, the staff determined that the structural evaluation for the high burnup PWR fuel rods contained in the MAGNASTOR® cask adequately demonstrates that they will retain their structural integrity during the storage design basis cask end drop event condition.

2.3 Evaluation Findings

The staff reviewed and evaluated the applicant's statements, representations in the amendment application. Based on the reviews and evaluations, the staff concludes that the PWR fuel rods contained in the MAGNASTOR® cask are adequately analyzed and evaluated to demonstrate that their structural capability and integrity meet the regulatory requirements of 10 CFR Part 72.

3.0 CONDITIONS

The following conditions were revised in the Amendment Nos. 0 through 16:

The Revision No. was increased by 1.

Added, or revised, Condition No. 9 to each CoC for Amendment Nos. 0 through 16, as follows:

> CONTINUED USE OF PREVIOUS VERSION OF AMENDMENT NO. [0 through 16]:
>
> > A general licensee may continue to use the previous version of this certificate, Amendment No. [applicable amendment No. 0 through 16, Revision X], dated [effective date of previous version], until **{insert date 6 months after effective date}**. By **{insert date 6 months after effective date}**, general licensees using Amendment No. [applicable amendment No. 0 through 16, Revision X], must have implemented the changes authorized by this revision and completed the evaluation described below.
> >
> > The general licensee shall perform written evaluations before use and before applying the changes authorized by this revised certificate which establish that the cask, once loaded with spent fuel or once the changes authorized by this revised certificate have been applied, will conform to the terms, conditions, and specifications of this revised certificate. The results of this review shall be documented in accordance with 10 CFR 72.212(b)(5) no later than **{insert date 6 months after effective date}**.

General licensees using the specific CoC amendments that are being revised are required to meet the conditions of the revised CoCs. The NRC added a condition to the revised CoCs that requires the general licensees to implement the revised CoCs within six months and perform written evaluations in accordance with 10 CFR 72.212(b)(5), which establish that the cask will conform to the terms, conditions, and specifications of the revised CoCs. The six-month timeframe in the condition is considered a standard timeframe for implementation, consistent with the information in Regulatory Issue Summary 2017-05, “Administration of 10 CFR Part 72 Certificate of Compliance Corrections and Revisions,” (NRC, 2017) and the applicant did not request an alternate timeframe.

4.0 TECHNICAL SPECIFICATIONS

There were no changes to the certificate’s technical specifications.

5.0 REFERENCES

(NAC, 2025) Letter from Heath Baldner (NAC) to the NRC, “Initial Submission of an Amendment Request for the NAC International MAGNASTOR® Cask System Amendment No. 17,” dated July 30, 2025 (ML25211A197).

(NAC, 2026a) Letter from Heath Baldner (NAC) to the NRC, “Submission of a Supplement to Amendment Request No. 17 for the NAC International MAGNASTOR Cask System,” dated March 4, 2026 (ML26064A039).

(NAC, 2026b) E-mail from Heath Baldner (NAC) to the NRC, NAC International Supplement to MAGNASTOR® Amendment No. 17, dated March 13, 2026 (ML26075E865).

(NRC, 2017) NRC, Regulatory Issue Summary 2017-05, “Administration of 10 CFR Part 72 Certificate of Compliance Corrections and Revisions,” dated September 13, 2017 (ML17165A183).

(NRC, 2020a) NRC, NUREG-2215, “Standard Review Plan for Dry Cask Storage Systems and Facilities – Final Report,” Revision 0, dated April 2020 (ML20121A190).

(NRC, 2020b) NRC, NUREG-2224, “Dry Storage and Transportation of High Burnup Spent Nuclear Fuel – Final Report,” Revision 0, dated November 2020 (ML20191A321).

CONCLUSION

The staff has performed a comprehensive review of the application for Amendment No. 17 and the revision to Amendment Nos. 0 through 16 of CoC No. 1031 for the MAGNASTOR® storage system, during which it evaluated the requested changes to the licensing basis for the MAGNASTOR® storage system to correct an error with M5 fuel cladding material yield strength.

Based on the statements and representations provided by the applicant in its amendment application, as supplemented, the staff concludes that the changes described above to the MAGNASTOR® storage system will meet the requirements of 10 CFR Part 72. Amendment No. 17 and the revision to Amendment Nos. 0 through 16 for the MAGNASTOR® storage system should be approved.

Issued with CoC No. 1031, Initial Certificate, Revision 4; Amendment No. 1, Revision 4; Amendment No. 2, Revision 4; Amendment No. 3, Revision 4; Amendment No. 4, Revision 3; Amendment No. 5, Revision 3; Amendment No. 6, Revision 3; Amendment No. 7, Revision 3; Amendment No. 8, Revision 3; Amendment No. 9, Revision 3; Amendment No. 10, Revision 2; Amendment No. 11, Revision 2; Amendment No. 12, Revision 2; Amendment No. 13, Revision 2; Amendment No. 14, Revision 1; Amendment No. 15, Revision 1; Amendment No. 16, Revision 1; and Amendment No. 17
On _____.