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FINAL SAFETY EVALUATION REPORT

DOCKET NO. 72-1014
HOLTEC INTERNATIONAL
CERTIFICATE OF COMPLIANCE NO. 1014
HI-STORM 100 CASK SYSTEM
RENEWED AMENDMENT NO. 18

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. 1014 for the HI-STORM 100 Cask System. By letter dated December 15, 2021 (Agencywide Documents Access and Management System Accession No. ML21349B418), as supplemented in letters dated September 2, 2022 (ML22245A103), May 26, 2023 (ML23146A138), September 8, 2023 (ML23251A250), December 4, 2023 (ML23338A304), January 18, 2024 (ML24018A198) and February 15, 2024 (ML24046A254), Holtec International, from here on referred to as the "applicant" or "Holtec", requested that the NRC amend the CoC to include the following change:

> Incorporate the Holtec Report No. HI-2200343-A Topical Report (TR) entitled, "Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems," (ML24018A198), in the HI-STORM 100 Cask System Renewed Amendment No. 18.

The amended CoC, when codified through rulemaking, will be denoted as Renewed Amendment No. 18 to CoC No. 1014. This SER documents the staff's review and evaluation of the proposed amendment. The staff followed the guidance of NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities," when performing technical reviews of spent fuel storage and transportation packaging licensing actions.

The staff's evaluation is based on a review of the applicant's application and whether it meets the applicable requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72 for dry storage of spent nuclear fuel. The staff's evaluation focused only on modifications to the CoC, and technical specification (TS) requested in the amendment as supported by the submitted revised updated final safety analysis report (UFSAR) (ML21349B421, ML22245A107, ML23251A254, and ML23338A308) and did not reassess previous revisions of the UFSAR nor previous amendments to the CoC.

1.0 GENERAL INFORMATION

The objective of this chapter is to review the changes requested to CoC No. 1014 for the HI-STORM 100 Cask System to ensure that the applicant provided an adequate description of the pertinent features of the storage system and the changes requested in the application. The

staff finds that the description of the proposed changes requested by the applicant are adequate to allow staff's detailed evaluation as documented in the following SER sections (4, 5, 6, 8, 11 and 17). Note that SER sections 2, 13 and 14 are only applicable to site specific license reviews and are not applicable to CoC evaluations.

2.0 SITE CHARACTERISTICS FOR DRY STORAGE FACILITIES

This section is not applicable to CoC evaluations.

3.0 PRINCIPAL DESIGN CRITERIA EVALUATION

There were no changes to the applicant's principal design criteria requested in the amendment application.

4.0 STRUCTURAL EVALUATION

This section of the SER documents the staff's review and conclusions with respect to the structural evaluation.

The staff reviewed the "Change Control" subsection of section 1.0.3.1 of the UFSAR. In this subsection, Holtec described the process for implementing Holtec Report No. HI-2200343-A TR titled, "Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems," (ML24018A198). This process includes following the 72.48 change process for systems that do not match the invariant model in the TR.

As described in the first bullet of step 2d, the existing UFSAR temperatures bound the temperatures that are calculated and evaluated by either Holtec or the general licensee in steps 2b and 2c by using the candidate heat load pattern in the thermal "72.48 model." Using these bounding temperatures, the staff determined that the results of any subsequent structural evaluation would be bounded; therefore, no further structural evaluation is needed.

As described in the second bullet of step 2d, if the temperatures that are calculated and evaluated by Holtec or the general licensee in steps 2b and 2c by using the candidate heat load pattern in the thermal "72.48 model" are actually higher and are not bounded by the existing UFSAR temperatures, then the change process in 10 CFR 72.48 would be used to evaluate the actual temperatures. Revised structural analysis calculations would have to be performed by Holtec or the general licensee to demonstrate that the temperatures from steps 2b and 2c are acceptable and may result in not requiring NRC approval. If the structural evaluation changes are not acceptable under the 72.48 change process, the sub-bullet to the second bullet of step 2d describes that either the candidate heat load pattern must be changed and any changed candidate heat load pattern will repeat the process starting at step 1, or an application needs to be made to (and approved by) the NRC.

As described in the first bullet of step 2b, Holtec or the general licensee ensures that pressure results from the "72.48 model" are lower than the pressure limits listed in the UFSAR. These bounding pressures have been evaluated in the structural analyses of the storage system as described in the UFSAR. Using these bounding pressures, the staff determined that the results

of any subsequent structural evaluation would be bounded; therefore, no further structural evaluation is needed.

4.1 Evaluation Findings

Based on the staff's review of step 2d in section 1.0.3.1 of the UFSAR as described above, the staff finds the approach to implementing the Holtec Report No. HI-2200343-A TR through Holtec's or the general licensee's structural evaluation associated with the use of the thermal, "72.48 model," as described in step 2d of section 1.0.3.1 of the UFSAR, to be acceptable.

5.0 THERMAL EVALUATION

The HI-STORM 100 Cask System Renewed Amendment No. 18 proposed to incorporate the Holtec Report No. HI-2200343-A TR entitled, "Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems," (ML24018A198), in the HI-STORM 100 Cask System Renewed Amendment No. 18, Docket No. 72-1014.

5.1 Limitations of Holtec Report No. HI-2200343-A TR in the Final Safety Evaluation (SE)

This SER only applies to the HI-STORM 100 Cask System Renewed Amendment No. 18. This SER does not apply to the HI-STORM 100U storage Vertical Ventilated Module (VVM) (i.e., the staff ensured the HI-STORM 100 Cask System Renewed Amendment No. 18 TS appendices C and D did not refer to the TR) and does not apply to the HI-STORM FW system, Docket No. 72-1032.

The NRC staff found the TR to be acceptable for incorporation in a HI-STORM 100 Cask System CoC amendment to the extent specified and under the limitations delineated in the TR and in the final safety evaluation (SE), by letter dated September 14, 2021 (ML21125A191). Therefore, based on the date of the applicant's TR review request letter, March 19, 2020, this SER only applies to HI-STORM 100 Cask System multipurpose canisters (MPCs), overpacks, and transfer casks (TCs) licensed based on the content in the UFSAR (Rev. 20) (ML20167A015), dated June 12, 2020, under the HI-STORM 100 Cask System initial issuance and Renewed Amendment Nos. 1 – 14; this is further addressed below within this section of the SER. The TR SE (ML24018A198), further described limitations in section 4.0, "Limitations" of the SE. Those limitations in the TR SE for the HI-STORM 100 Cask System specifically include:

> L4.1 The approval for use of the evaluations in the TR is not intended to provide a generic approval for the use of those evaluations, including supporting thermal models, beyond selecting alternate heat load patterns for the HI-STORM 100 Cask System.
>
> L4.2 The previously approved thermal models for the design configurations listed in appendix 1 of this SE were identified as invariant, which means that no changes to the models, modeling choices, boundary conditions, other inputs, or thermal model manipulations are allowed if used with the TR. The only exceptions to altering the thermal models are: (1) the use of mirror symmetry of the existing model formulation, and (2) changes to the per cell decay heat values identified for a given candidate heat load pattern.
>
> L4.3 The thermal models that predict the calculated temperatures, and subsequently system pressures, used to compare with the acceptance criteria must have reasonable

accuracy for their intended purpose; therefore, the thermal models cannot be used with decay heat inputs that may render the thermal models as outside their range of applicability.

L4.4 Acceptability of cask and fuel assembly heat loads are solely determined by safety evaluations performed by the user of this TR and the established temperature and pressure acceptance criteria. Any heat load pattern that does not comply with all applicable safety limits under any design basis condition (normal, off-normal, accident or short-term operations) is not a qualified heat load pattern.

As highlighted in the TR SE limitation L4.2, the methodology in the SE is considered applicable to and limited to the following design variants for the HI-STORM 100 Cask System:

MPCs - 24/24E/24EF
MPCs - 32/32F
MPCs - 68/68F/68FF/68M
HI-TRAC Transfer casks 100/125/100D/125D/100G
HI-STORM 100 overpacks 100/100S/100S Version B/100A

The staff notes that the HI-STORM 100 Cask System MPC-32 Version 1, MPC-32M, and MPC-68 Version 1 canisters (each from the HI-STORM 100 Cask System Renewed Amendment No. 15) are not included on the list of MPCs; therefore, the TR cannot be used with those MPCs in the HI-STORM 100 Cask System.

The staff notes that the HI-STORM 100SA (from HI-STORM 100 Renewed Amendment No. 1), HI-STORM 100S-185 (from HI-STORM 100 Renewed Amendment No. 4), and the HI-STORM 100S Version E (from the HI-STORM 100 Cask System Renewed Amendment No. 15) overpacks are not included on the list of HI-STORM 100 Cask System overpacks; therefore, the TR cannot be used with those overpacks. The HI-STORM 100 Version UVH, which stands for unventilated, overpack proposed in HI-STORM 100 Cask System Renewed Amendment 16 has not been approved by the NRC and is not on the list of allowable design variants; therefore, the TR cannot be used with that overpack.

The staff notes that the HI--TRAC 100D Version IP1 (from HI-STORM 100 Cask System Renewed Amendment No. 4) transfer cask is not included on the list of HI-STORM 100 Cask System TCs; therefore, the TR cannot be used with that transfer cask. The staff also notes that the HI-TRAC MS, which stands for maximum shielded, (from HI-STORM 100 Cask System Renewed Amendment No. 15) is not included on the list of HI-TRAC TCs; therefore, the TR cannot be used with that transfer cask.

The HI-STORM 100U storage system (from HI-STORM 100 Cask System Renewed Amendment No. 7) is not included on the list of HI-STORM 100 Cask System and only the aboveground overpack was described in sections 2.3.2.1 and 2.3.2.2.2 of the TR; therefore, the TR cannot be used with the HI-STORM 100U storage system.

The staff notes that a revision of L4.2 of the TR SE based on this amendment request is discussed in section 5.3 of this SER.

5.2 Decay Heat and 10 CFR 72.236(a)

The HI-STORM 100 Cask System TS, appendix A, table 3-1a, note 9 states, in part, "Alternative heat load limits may be developed following the methodology in Topical Report HI-2200343-A. These patterns must have a total MPC heat load less than or equal to 50 kW. […]." The TR is a stand-alone document which contains the information necessary to fully evaluate a range of decay heat load patterns for the HI-STORM 100 Cask System; however, 10 CFR 72.236(a) and the methodology in the TR (i.e., section 2.3.12) does not allow for expanding the use of the thermal models to higher total decay heats than the system is designed to be dissipated, or in other words, to develop alternate total decay heat limits that are higher than those currently in the TS.

The licensee's evaluation of the proposed heat load pattern using the methodology of evaluation within the TR is critical for the acceptability of a specific decay heat load. Any proposed decay heat load (50 kilowatts [kW] or less) would need to comply with the pressure and temperature limits acceptance criteria in the TR. This is explicitly stated in the TR SE within the limitation on the methodology of evaluation, L4.4, that is also restated within section 5.1 of this SER. The licensee's evaluations of compliance with the temperature and pressure limits are reported in the configuration-controlled qualification report will be subject to inspection because it is referenced in the 72.212 report. The NRC considers the high-end (with a maximum decay heat of 50 kW) decay heat load could be very challenging and possibly result in unqualifiable heat load patterns and would therefore be unacceptable for some HI-STORM 100 Cask System CoC amendments that are currently approved at the lower total maximum decay heat load values (i.e., 23.88 kW, or higher).

The heat load pattern that is developed by the general licensee and evaluated using the TR will have specific per assembly decay heats for that specific loading pattern, which is provided in the configuration-controlled qualification report. As stated in section 1.0.3.1, step 3, of the UFSAR, the configuration-controlled qualification report required by 10 CFR 72.212(b)(7) is referenced in the inspectable 72.212 report.

- The specific per assembly decay heat values in the configuration-controlled qualification report become the per assembly decay heat limits for that specific loading pattern only.
    - HI-STORM 100 Cask System TS, appendix A, table 31a, note 9, states in part with underlining for emphasis, "Alternative <u>heat load limits</u> may be developed following the methodology in Topical Report HI-2200343-A. These patterns must have a total MPC heat load less than or equal to 50 kW. […]."
- HI-STORM 100 Cask System TS, appendix A, table 3-3, note 2 and table 3-4 also state, "… For heat load patterns developed in accordance with Table 3-1a, Note 9, these limits do not apply.," referring to per assembly decay heat limits; however, the per assembly decay heat limits that do apply are the specific per assembly decay heats for that specific loading pattern, which is provided in the configuration-controlled qualification report.
- The HI-STORM 100 Cask System TS, appendix B, section 2.4.2 has also been revised to state with underlining for emphasis, "Alternatively to the heat load patterns in Sections 2.4.1 and 2.4.2, per cell allowable heat <u>loads</u> may be determined per Topical Report HI-2200343-A," yet section 2.4.2 is describing heat load <u>limits</u>. As described in the bullet above, the per assembly decay heat limits that do apply and are inspectable are the

specific per assembly decay heat loads for that specific loading pattern, which is provided in the configuration-controlled qualification report.

The staff finds the proposed decay heat (heat load), and heat load limits TS changes described above to be acceptable based on the staff's review and discussion in section 5.2 of this SER.

5.3 Change Control

Based on the applicant's description in section 1.0.3.1 of the UFSAR and illustrated in figure 1.0.1 of the UFSAR, to determine if a candidate heat load pattern can be implemented through use of the TR, the following steps will be performed.

1. HI-STORM 100 Cask System Renewed Amendment No. 18 site (general licensee) develops a candidate heat load pattern for use with the HI-STORM 100 Cask System Renewed Amendment No. 18 CoC.
2. The general licensee and Holtec determines if the HI-STORM 100 Cask System used, and contents being loaded matches the thermal, "Invariant model," in the TR (i.e., in the limitation L4.2 of the TR SE). In this process, both the general licensee and Holtec work together due to the exchange of proprietary information when comparing site model information from the general licensee and the proprietary thermal invariant model from Holtec. As noted by the applicant in the response to request for additional information (RAI) 4-4 (ML23146A140), any changes to any aspect of the CoC (including content) would need to go through the NRC review and approval process, prior to loading. If the HI-STORM 100 Cask System used, and contents being loaded, matches the thermal invariant model in the TR, the general licensee follows the TR, ensures all TR acceptance criteria are met — that includes all temperatures and pressures from tables 2.1 and 2.2 of the TR — and continues to step 3.
    a. If the HI-STORM 100 Cask System does not match the thermal invariant model in the TR, Holtec ensures the variations in the TR thermal model are part of a thermal, "72.48 model," and processes the variations using Holtec's 10 CFR 72.48 program.
        i. If Holtec's 72.48 process shows that prior NRC approval of any of the variations is necessary, the application must be made to the NRC and approved by the NRC prior to the use of the HI-STORM 100 Cask System.
    b. Once step 2a is met, Holtec, or the general licensee, evaluates the candidate heat load pattern from step 1 in the thermal, "72.48 model," which is the invariant thermal model in the TR with the addition of all 72.48 modifications that are applicable to the planned loaded canisters.
        i. The results of the thermal, "72.48 model," must show that all components, which includes the peak cladding temperature (PCT), have temperatures and pressures that are lower than the acceptance criteria of the TR (ML24018A198).
        ii. The PCT result of the thermal, "72.48 model," is then compared to the results from step 2c. The applicant described in the response to RAI 4-1d

(ML23146A140), that this is an additional metric for comparison to demonstrate that the thermal, “invariant model,” bounds the thermal, “72.48 model.” The staff concludes that this additional step will demonstrate that the PCT is bounding in the thermal, “invariant model,” but will not demonstrate that other component temperatures in the thermal, “invariant model,” are necessarily bounding. Because the TR can be used with the thermal, “72.48 model,” in step 2bi described above to ensure that the TR acceptance criteria are met with the candidate heat load pattern, the staff finds this additional metric for comparison to be acceptable.

c. Holtec, or the general licensee, then evaluates the candidate heat load pattern from step 1 using the thermal, “Invariant model,” in the TR. This evaluation must demonstrate that all TR acceptance criteria are met that includes all temperatures and pressures from tables 2.1 and 2.2 of the TR (ML24018A198). This evaluation must also show a higher PCT than step 2b. If either of these conditions are not met, the candidate heat load pattern must be revised and steps 2b and 2c are repeated. Therefore, if steps 2b and 2c are repeated based on the revision of the candidate heat load pattern, this would make the original candidate heat load pattern from step 1 not eligible for loading.
d. Holtec, or the general licensee, then compares the temperature results from steps 2b and 2c to the structural evaluation in the UFSAR. This step 2d is evaluated in section 3.1 of this SER.
    i. If the UFSAR structural evaluations use temperatures that bound the calculated temperatures in steps 2b and 2c, no further structural evaluations are needed.
    ii. If the UFSAR structural evaluations use temperatures that do not bound the calculated temperatures in steps 2b and 2c, an additional 72.48 must be performed to demonstrate that the new temperatures are acceptable without NRC approval.
        1. If the structural evaluation changes are not acceptable under the 72.48 change process then either the candidate heat load pattern must be changed (and as in step 2c, the original candidate heat load pattern from step 1, or the revised candidate heat load from step 2c, would not be eligible for loading, and any changed candidate heat load pattern will repeat the process starting at step 1), or an application needs to be made to (and approved by) the NRC.

3. After all items and acceptance criteria in steps 2a through 2d are satisfied, Holtec, or the general licensee, documents the evaluation performed in steps 2b and 2c in the site’s qualification report and referenced in the general licensee’s 72.212 report as required by 10 CFR 72.212(b)(7). If the modification under 10 CFR 72.48 is a generic change to the system, the FSAR must be updated with new temperature results to document the bounding temperature results. However if, at a specific site, a modification is made that is not generically approved, those results may not be included in the FSAR.

4. The site chooses fuel to meet the qualified heat load pattern, confirming that the fuel also meets the CoC requirements.
5. The site ensures the loading procedures have accurate restrictions for:
    a. helium backfill described in HI-2200343-A section 2.3.6,
    b. time to boil described in HI-2200343-A section 2.3.8, and
    c. duct blockage allowable clearance time or temperature monitoring limit described in HI-2200343-A section 2.3.12, and further clarified in the HI-STORM 100 Cask System TS, appendix A, section 3.1.2, surveillance requirement (SR) 3.1.2 and page B 3.1.2-9 of the UFSAR.

The staff reviewed the description of the implementation of the Holtec Report No. HI-2200343-A TR and implementation of change control through use of 10 CFR 72.48 that is described in section 1.0.3.1 and shown in the associated figure 1.0.1 of the UFSAR. In order for the general licensee and Holtec to use the thermal, "72.48 model," described in section 1.0.3.1 of the HI-STORM 100 Cask System UFSAR with the TR, the staff has modified the TR SE L4.2 to state, with underlining to emphasize the difference between L4.2 from the TR SE (ML24018A198),

> *L4.2 The previously approved thermal models for the design configurations listed in Appendix 1 of this SE were identified as invariant, which means that no changes to the models, modeling choices, boundary conditions, other inputs, or thermal model manipulations are allowed if used with the TR. The only exceptions to altering the thermal models are: (1) the use of mirror symmetry of the existing model formulation, (2) changes to the per cell decay heat values identified for a given candidate heat load pattern, and (3) use of a thermal, "72.48 model," as described in section 1.0.3.1 of the HI-STORM 100 UFSAR, that is based on the TR thermal, "invariant model," as a starting point.*

The applicant clarified in the response to RAI 4-1e (ML23146A140), that the thermal, "72.48 model," includes all applicable 72.48 modifications along with the candidate heat load pattern. The staff notes that this is an important clarification because the TR can be used multiple successive times for different candidate heat load patterns, each thermal, "72.48 model," must be based on the TR thermal, "invariant model," as a starting point, and include all applicable 72.48 modifications along with the candidate heat load pattern that is being evaluated. In other words, existing 72.48 changes have to be incorporated in the thermal, "invariant model," again for a subsequent candidate heat load pattern after the implementation of one or more candidate heat load patterns. Based on the staff's modification to the TR SE L4.2 and the applicant's clarification regarding the thermal, "72.48 model," being based on the TR thermal, "invariant model," as well as including all applicable 72.48 modifications along with the candidate heat load pattern that must meet the TR (ML24018A198) acceptance criteria, the staff finds Holtec's or the general licensee's use, and TR evaluation, of the thermal, "72.48 model," to be acceptable.

The staff verified that the calculation of the helium backfill limits is discussed in section 2.3.6 of the TR for the HI-STORM 100 Cask System and the time to boil calculation is adequately described in section 2.3.8 of the TR. The staff also verified that the duct blockage allowable clearance time calculation is described in section 2.3.12 of the TR and the duct blockage temperature monitoring limit calculation is described in the HI-STORM 100 Cask System TS, appendix A, section 3.1.2, SR 3.1.2 and on page B 3.1.2-9 of the UFSAR. The staff also verified that section 4.4.4.3 of the UFSAR described that the effect of site elevation shall also be

evaluated by Holtec or the general licensee for new heat load patterns and compliance demonstrated with the acceptance criteria specified in the TR.

Based on the staff's review of the Holtec Report No. HI-2200343-A TR implementation in section 1.0.3.1 of the UFSAR and change control through use of 10 CFR 72.48 implementation also in section 1.0.3.1 of the UFSAR, as described above, the staff finds the implementation to be acceptable for the applicant to add and evaluate the new applicant-developed heat load patterns for use in the HI-STORM 100 Cask System, within the limitations described in the Holtec Report No. HI-2200343-A TR SE (ML24018A198), while also taking into account the revised TR SE limitation L4.2 described above.

5.4 Thermal Model Audit

As part of the staff's thermal model audit of the applicant's computational fluid dynamics models associated with section 5.2 of this SER and the response to RSI 4-3 (ML22122A200), the staff reviewed the applicant's thermal models used in the analyses and confirmed that the proper material properties and boundary conditions were used. The staff verified that the applicant's selected code models and assumptions were adequate for the flow and heat transfer characteristics prevailing in the HI-STORM 100 Cask System geometry and analyzed conditions.

5.5 Proposed Technical Specification Changes

The decay heat changes to the TS appendices A and B are evaluated in section 5.2 of this SER.

The applicant proposed to change the air temperature rise value in SR 3.1.2 of appendix A of the TS based on the TR methodology and further described on pages B 3.1.2-9 and II.B 3.1.2-7 of the UFSAR. The average air outlet temperature is calculated for each candidate heat load pattern, as shown in an example in table 3.1 of the TR. The acceptance criteria in the example in table 3.1 of the TR is the difference between the average air outlet temperature and the independent spent fuel storage installation (ISFSI) ambient temperature (80 degrees Fahrenheit [°F]). This is described in note 3 of table 3.1 of the TR, which supports SR 3.1.2 of appendix A of the TS, where this is described as delta T (ΔT). This ΔT would then be recalculated for every fuel loading pattern and the appropriate numerical value in TS appendix A, SR 3.1.2 would be replaced based on the type of canister. The staff verified that the calculation of the 100 percent duct blockage of HI-STORM 100 Cask System inlet vents temperature monitoring limit was described in the HI-STORM 100 Cask System TS, appendix A, section 3.1.2, SR 3.1.2 and further clarified on page B 3.1.2-9 of the UFSAR.

The applicant proposed to change the helium backfill limits in table 32a of appendix A of the TS and in table 1.2.2 of the UFSAR, stating that the helium backfill limits shall be calculated in accordance with TR HI-2200343-A, section 2.3.6. The staff verified that this is in step 5 of section 1.0.3.1 of the UFSAR, and the staff has described this step within section 5.3, step 5a of this SER. The staff verified that the calculation of the helium backfill limits was discussed in section 2.3.6 of the TR for the HI-STORM 100 Cask System.

The applicant proposed to calculate alternative completion times for actions to restore the spent fuel storage cask (SFSC) heat removal system to operable conditions in table 3-5 of appendix A of the TS, and on pages B 3.1.2-4 and II.B 3.1.2-3 of the UFSAR. The staff verified that this is in step 5 of section 1.0.3.1 of the UFSAR, and it is described in section 5.3, step 5c of this SER.

The staff verified that the calculation of the alternative completion times for actions to restore the SFSC heat removal systems to operable conditions was discussed in section 2.3.12 of the TR for the HI-STORM 100 Cask System.

The staff verified that there were no changes to TS appendices C and D because the HI-STORM 100S Version E overpack (TS appendices C and D), and the HI-TRAC MS (TS appendix D) are not in the TR SE. The staff also verified that there were no changes to TS appendix B because the HI-STORM 100 UVH overpack is not included in the TR SE appendix 1 list of approved design variants for HI-STORM 100 Cask System overpacks.

The staff finds the proposed TS changes described above to be acceptable based on the staff's review and discussion in section 5.5 of this SER.

5.6 Evaluation Findings

Given the implementation of the TR described in this amendment and the limitations in the TR SE, and the revised TR SE limitation L4.2 in this SER, the staff finds:

F5.1 The NRC has reasonable assurance that the HI-STORM 100 Cask System continues to be designed with a heat-removal capability having verifiability and reliability consistent with its importance to safety with the use of the method of evaluation (MOE) described in TR HI-2200343-A.

F5.2 The HI-STORM 100 Cask System storage container structures, systems, and components (SSCs) important to safety will continue to meet their thermal effectiveness in accordance with 10 CFR 72.236(f) and 10 CFR 72.236(h) provided that the MOE presented in TR HI-2200343-A is explicitly followed. Storage container SSCs important to safety remain within their operating temperature ranges in accordance with 10 CFR 72.236(a) and 10 CFR 72.236(b).

F5.3 The spent nuclear fuel (SNF) cladding is protected against degradation leading to gross ruptures under normal conditions by maintaining the cladding temperature in the license period below 400 degrees Celsius (°C) (752 °F) in a helium environment, and with margin as the cladding temperature limit described in the TR is 390 °C (734 °F). Protection of the cladding against degradation is expected to allow ready retrieval of the SNF for further processing or disposal in accordance with 10 CFR 72.236(g), 10 CFR 72.236(l), and 10 CFR 72.236(m).

F5.4 The SNF cladding is protected against degradation leading to gross ruptures under off-normal and accident conditions by maintaining the cladding temperature below 570 °C (1058 °F) in a helium environment, and with margin as the cladding temperature limit described in the TR is 560 °C (1040 °F). Protection of the cladding against degradation is expected to allow ready retrieval of spent fuel for further processing or disposal in accordance with 10 CFR 72.236(g), 10 CFR 72.236(l), and 10 CFR 72.236(m).

The staff concludes that the thermal design of the HI-STORM 100 Cask System is in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the HI-STORM 100 Cask System will allow safe storage of SNF for a licensed (certified) life of 20 years. This conclusion is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

6.0 SHIELDING EVALUATION

This section of the SER documents the staff's review and conclusions with respect to shielding protection.

6.1 Review Objective

The objective of this shielding review is to evaluate whether the shielding features of the HI-STORM 100 Cask System design, as amended, will continue to provide reasonable assurance of adequate protection to workers and the public from radiation from the proposed contents. The staff reviewed the applicant's safety analyses for the requested change to incorporate the TR to this CoC following the guidance provided in NUREG-2215.

6.2 Shielding Evaluation

The applicant has requested only one change for Renewed Amendment No.18 of the HI-STORM 100 Cask System. This change is to incorporate the TR HI-2200343-A. This report outlines a methodology for developing heat load patterns for each canister, and a methodology for calculating heat load patterns.

Based on NUREG/CR-6700, "Nuclide Importance to Criticality Safety, Decay Heating, and Source Terms Related to Transport and Interim Storage of High-Burnup LWR Fuel," (ML010330186) and another study published by Oak Ridge National Laboratory [R. Cumberland et. al., "A Study on the Relationship between Dose Rate and Decay Heat for Spent Nuclear Fuel Casks," Oak Ridge National Laboratory, June 17, 2020. https://doi.org/10.2172/1649326], there is essentially no correlation between decay heat and radiation source terms (neutron and gamma). Therefore, using higher decay heat load will not necessarily result in higher source terms for shielding calculation.

The FSAR defines a set of qualified fuel parameters. Regardless of the heat load patterns calculated per the TR, the fuel must also meet the required fuel qualification table (FQT) combinations of burnup, cooling time, and enrichment outlined in this FSAR. Therefore, the applicant has incorporated the shielding analysis from HI-STORM 100 Cask System Renewed Amendment No. 16 to support Renewed Amendment No. 18 of the HI-STORM 100 Cask System.

In Renewed Amendment No. 16, the staff independently evaluated several of the applicant's allowable burnup and cooling time combinations from the UFSAR and using enrichment from HI-2012702 Report, Revision 19. The staff used the STANDARDS Spent Nuclear Fuel Data and Analysis Tool (formerly known as UNF-ST&DARDS) code to perform the dose rates calculations. The STANDARDS code employs the SCALE/MAVRIC code to calculate dose rates and SCALE/ORIGAMI code to calculate the neutron and gamma source term from fuel and activated hardware (Radulescu, 2017). Based on the staff's independent calculations, the staff finds the burnup, enrichment, and cooling time combinations for Renewed Amendment No. 18 acceptable since these combinations are applicable for this amendment.

Based on the assumption described in the above paragraph, the staff found the shielding evaluation acceptable in the preliminary SER (ML23123A112) for HI-STORM 100 Cask System Amendment No. 16, and this same shielding evaluation was submitted in Renewed Amendment

No. 18. Since there is no change in the shielding evaluation as result of TR HI-2200343, no further shielding evaluation is required.

6.3 Evaluation Findings

Based upon its review, the staff has reasonable assurance that the design of the shielding system of the HI-STORM 100 Cask System, Renewed Amendment No. 18 with the incorporation of the shielding evaluation in Renewed Amendment No. 16, complies with 10 CFR Part 72 and that the applicable design and acceptance criteria have been satisfied. The evaluation of the shielding system design provides reasonable assurance that the HI-STORM 100 Cask System, Renewed Amendment No. 18 will allow safe storage of spent fuel in accordance with 10 CFR 72.236(d). This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes, and standards, accepted engineering practices, and the statements and representations in the application. Accordingly, the staff finds:

F6.1 The UFSAR provides specifications of the spent fuel contents to be stored in the HI-STORM 100 Cask System in sufficient detail to adequately define the allowed contents and allow evaluation of the DSS shielding design for the proposed contents. The UFSAR includes analyses that are adequately bounding for the radiation source terms associated with the proposed contents' specifications. Thus, the applicant has satisfied the requirements in 10 CFR 72.236(a).

F6.2 The UFSAR describes the SSCs ITS that are relied on for shielding in sufficient detail to allow evaluation of their effectiveness for the proposed term of storage. Thus, the applicant satisfies the requirements in 10 CFR 72.236(b) and 10 CFR 72.236(g).

7.0 CRITICALITY EVALUATION

There were no changes to the applicant's criticality section of the UFSAR requested in the amendment application.

8.0 MATERIALS EVALUATION

The staff reviewed the information provided by the applicant and evaluated the changes requested in the application. The application consisted of changes to the methodology for developing heat load patterns for the HI-STORM 100 Cask System MPCs as described in TR HI-2200343-A.

The applicant provided the updated technical specifications and an UFSAR to support the proposed Renewed Amendment No. 18 changes. In response to an NRC observation on the application, the applicant stated that the application did not include the addition of new structures systems or components (SSCs) or changes to the materials specifications for the existing SSCs. As such, the applicable aging mechanisms and effects for the structures, systems, and components included in the HI-STORM 100 Cask System were evaluated in the CoC No. 1014 renewal.

The staff reviewed and evaluated the application using the guidance in chapter 8 of NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities," to determine adequate materials performance under normal, off-normal, accident-level conditions. In addition, the staff used the guidance in NUREG-1927, Revision 1, "Standard Review Plan for

Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," and the information on materials and aging mechanisms and effects included in NUREG-2214, "Managing Aging Processes in Storage (MAPS) Report," to evaluate the applicant's aging management activities and consideration of aging mechanisms and effects for the in scope SSCs relevant to the application.

The staff determined that because the application did not include the addition of new SSCs or changes to the materials specifications for the existing SSCs, the materials review of the application would focus on the effects of the methodology for the determination of acceptable heat load patterns on (1) the fuel and SSCs materials and (2) the management of aging mechanisms and effects. The materials review is provided in the following sections.

8.1 Fuel and SSC Materials

The NRC reviewed TR HI-2200343-A and concluded in its safety evaluation (ML24018A198) that the applicant's general methodology to evaluate alternate candidate heat load patterns is acceptable as a means to calculate component temperatures and pressures and to evaluate those results against the appropriate acceptance criteria. As noted in section 3.4.1 of the NRC SER for TR HI-2200343-A, the thermal evaluation specifies that all component temperatures and the cavity pressure shall remain below the limits specified in the TR HI-2200343-A tables 2.1 and 2.2 for the HI-STORM 100 Cask System and tables 4.1 and 4.2 for the HI-STORM FW system for the pattern to be considered acceptable. Further, section 4.0 the NRC SER for TR HI-2200343-A included Limitations on the Evaluation Methodology. Specifically, L4.4 states that the acceptability of cask and fuel assembly heat loads are solely determined by safety evaluations performed by the user of this TR and the established temperature and pressure acceptance criteria. Any heat load pattern that does not comply with all applicable safety limits under any design basis condition (normal, off-normal, accident or short-term operations) is not a qualified heat load pattern.

The staff reviewed TR HI-2200343-A table 2.1 and determined that the temperature limits for the HI-STORM 100 Cask System components under normal, short-term operations, off-normal and accident conditions were either consistent with or conservative with respect to the component temperature limits listed in the HI-STORM 100 Cask System UFSAR tables 2.2.3 and 2.II.2.9 which were previously reviewed by the NRC. Likewise, the staff reviewed TR HI-2200343-A table 2.2 and determined that the MPC pressure limits for long term normal, short-term operations, off-normal and accident conditions are consistent with those listed in HI-STORM 100 Cask System UFSAR tables 2.2.1 and 1.II.2.3, which were also previously reviewed by the NRC. The applicant did not alter the allowable component or material temperatures and did not alter the MPC pressure limits. As such, the staff determined that the conclusion of the TR HI-2200343-A safety evaluation (ML24018A198) and the findings documented in the SER for HI-STORM 100 Cask System Amendment No. 15 (ML21118A871) are still applicable. In addition, the applicant did not propose any changes that affect the staff's materials evaluation provided in previous safety evaluations for CoC No. 1014, Renewed Amendments Nos. 1 through 15. Therefore, the staff determined that a new evaluation was not required.

8.2 Management of Aging Mechanisms and Effects

The applicant applied for a renewal of the HI-STORM 100 Cask System CoC in Holtec Letter 5014890, dated January 31, 2020, and provided an aging management evaluation in the renewal application. The NRC has reviewed the renewal application and has concluded that the

HI-STORM 100 Cask System has met the requirements of 10 CFR 72.240. The staff determined (ML23068A455) that the HI-STORM 100 Cask System safety analysis report accompanying the CoC renewal application contain Time Limited Aging Analyses (TLAAs) and Aging Management Programs (AMPs) that ensure that the dry storage system SSCs will continue to perform their intended functions for the requested period of extended operation.

The application consisted of changes to the methodology for developing heat load patterns for the HI-STORM 100 Cask System MPCs as described in TR HI-2200343-A. In accordance with the guidance in NUREG-2215 section 8.5.14.2, the staff reviewed the amendment application and CoC renewal documentation to ensure that the application evaluated the need to revise (1) the scope of SSCs subject to aging management, (2) the aging management review (AMR) for applicable aging mechanisms and effects, and (3) the TLAAs and AMPs to ensure that they remain effective to manage the aging of all SSCs. The staff's review of the applicant's proposed aging management approach used the guidance in NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," and NUREG-2214, "Managing Aging Processes in Storage (MAPS) Report."

8.2.1 Scope of SSCs requiring aging management

As described in NUREG-1927, a scoping evaluation is necessary to identify the structures, systems, and components (SSCs) requiring an AMR. The objective of this scoping evaluation is to identify (1) SSCs that are classified as important to safety and (2) SSCs that are classified as not important to safety but, according to the design bases, their failure could prevent fulfillment of a function that is important to safety. After the determination of in-scope SSCs, the SSCs are screened to identify and describe the subcomponents that support the SSC intended functions.

The staff reviewed the application which included changes to the methodology for developing heat load patterns for the HI-STORM 100 Cask System MPCs as described in TR HI-2200343-A. The application did not include the addition of new SSCs or changes to the materials specifications for the existing SSCs. In addition, the application did not include changes to the material and environment combinations or changes to the maximum temperatures for the fuel or SSCs.

Based on its review, the staff finds that there are no changes to the in-scope SSCs identified in renewal of the HI-STORM 100 Cask System CoC in Holtec Letter 5014890. The staff's review of the renewal application documented in the NRC's SER (ML23068A455) concluded that the scoping evaluation was conducted in a manner consistent with NUREG-1927, and therefore, the staff found the scoping results to be acceptable. The staff reviewed the application and determined that the applicant did not propose any changes that affect the staff's materials evaluation provided in previous safety evaluations for CoC No. 1014, Renewed Amendments Nos. 1 through 15. Therefore, the staff determined that a new evaluation was not required.

8.2.2 Aging management review

The objective of the staff's evaluation of the applicant's AMR is to determine whether the applicant has adequately reviewed applicable materials, environments, and aging mechanisms and effects and proposed adequate aging management activities for in-scope SSCs. The AMR addresses aging mechanisms and effects that could adversely affect the ability of the SSCs and associated subcomponents to perform their intended functions during the period of extended operation.

As noted above, the application did not include changes to the in-scope SSCs identified in renewal of the HI-STORM 100 Cask System CoC and did not include the addition of new SSCs or changes to the materials specifications for the existing SSCs. In addition, the application did not include changes to the material and environment combinations or changes to the maximum temperatures for the fuel or SSCs.

The staff reviewed the application and determined that the applicant did not propose any changes that affect the staff's materials evaluation provided in previous safety evaluations for CoC No. 1014, Renewed Amendments Nos. 1 through 15. Based on its review, the staff finds that the applicant has considered the materials and specific environments to identify the aging mechanisms that could lead to loss of intended functions in a manner consistent with NUREG-1927, in its application for the renewal of the HI-STORM 100 Cask System and, therefore, the staff finds the existing aging management review to be acceptable. Consequently, the staff determined that amendments or revisions to the aging management review were not required.

8.2.3 Time-Limited Aging Analyses

As noted above, the application did not include changes to the in-scope SSCs identified in the renewal of the HI-STORM 100 Cask System CoC and did not include the addition of new SSCs or changes to the materials specifications for the existing SSCs. In addition, the application did not include changes to the material and environment combinations or changes to the maximum temperatures for the fuel or SSCs.

The staff reviewed the application and determined that the applicant did not propose any changes that affected the staff's materials evaluation provided in previous safety evaluations for CoC No. 1014, Renewed Amendments Nos. 1 through 15. Based on its review, the staff finds that the applicant has considered the materials and specific environments to identify the aging mechanisms that could lead to loss of intended functions in a manner consistent with NUREG-1927 in its application for the renewal of the HI-STORM 100 Cask System and therefore, the staff finds the existing TLAAs to be acceptable. Accordingly, no amendments or revisions to the TLAAs were required.

8.2.4 Aging Management Programs

As noted above, the application did not include changes to the in-scope SSCs identified in renewal of the HI-STORM 100 Cask System CoC and did not include the addition of new SSCs or changes to the materials specifications for the existing SSCs. In addition, the application did not include changes to the material and environment combinations or changes to the maximum temperatures for the fuel or SSCs.

The staff reviewed the application and determined that the applicant did not propose any changes that affected the staff's materials evaluation provided in previous safety evaluations for CoC No. 1014, Renewed Amendments Nos. 1 through 15. Based on its review, and because the applicant has considered the materials and specific environments to identify the aging mechanisms that could lead to loss of intended functions in a manner consistent with NUREG-1927 in its application for the renewal of the HI-STORM 100 Cask System, the staff finds the existing AMPs to be acceptable. Therefore, the staff determined that amendments or revisions to the AMPs were not required.

8.3 Evaluation Findings

The staff concludes that the application adequately considers material properties, environmental degradation and other reactions, and material quality controls such that the design complies with 10 CFR Part 72. This finding is based on a review that considered the regulation, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. In addition, the staff reviewed the application along with the scoping evaluation, aging management review and aging management activities included in the HI-STORM 100 Cask System CoC renewal application to verify the aging management activities are applicable to the materials, environments, and aging effects of the in-scope SSCs identified in the amendment application. The staff performed its review following the guidance provided in NUREG-2215, NUREG-1927, and NUREG-2214. Based on its review of the renewal application, the staff finds:

F8.1 The applicant has met the requirements in 10 CFR 72.236(b). The applicant described the materials design criteria for SSCs important to safety in sufficient detail to support a safety finding.

F8.2 The applicant has met the requirements in 10 CFR 72.236(g). The properties of the materials in the storage system design have been demonstrated to support the safe storage of SNF.

F8.3 The applicant has met the requirements in 10 CFR 72.236(h). The materials of the SNF storage container are compatible with their operating environment such that there are no adverse degradation or significant chemical or other reactions, and are compatible with wet or dry spent fuel loading and unloading facilities.

F8.4 The applicant has identified that the aging management programs in the renewed CoC provide reasonable assurance that aging effects that are applicable to the in scope SSCs will be managed effectively during the period of extended operation, in accordance with 10 CFR 72.240(c)(3).

8.4 References

Holtec, International, “Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems,” Holtec Report No. HI-2200343-A (ML24018A198).

Holtec, International, “Final Safety Analysis Report for the Holtec International Storage and Transfer Operation Reinforced Module Cask System (HI-STORM 100 Cask System),” USNRC Docket No. 72-1014, Holtec Report HI-2002444, Revision 22, August 9, 2021 (ML21221A329).

NRC, “Final Safety Evaluation by the Office of Nuclear Material Safety and Safeguards for the Holtec International Topical Report HI-2200343-A, Topical Report for Allowance of Heat Load Patterns in HI-Storm 100 And HI-Storm FW [Flood Wind] Systems,” Docket Nos. 72-1014 and 72-1032 (ML24018A198).

9.0 CONFINEMENT EVALUATION

There were no changes to the applicant’s confinement section of the UFSAR requested in the amendment application.

10.0 RADIATION PROTECTION EVALUATION

There were no changes to the applicant's radiation protection section of the UFSAR requested in the amendment application.

11.0 OPERATING PROCEDURES EVALUATION

The staff reviewed the example configuration-controlled qualification report, in Attachment 4 to Holtec Letter 5014978, "Example Template to Evaluate New Heat Load Patterns," (ML24046A254) to confirm that it was consistent with the example provided in the Holtec Report No. HI-2200343-A TR entitled, "Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems," (ML24018A198). The staff confirmed that the example configuration-controlled qualification report referenced the temperature and pressure results, an associated list of calculation results described in table 1.2, and options to indicate that the results are from the invariant thermal model or the 72.48 thermal model. The applicant-provided configuration-controlled qualification report for each qualified candidate heat load pattern developed using the TR will be referenced in the inspectable 72.212 report as required by 10 CFR 72.212(b)(7). The staff finds the approach to implementing the Holtec Report No. HI-2200343-A TR through the applicant's description in section 1.0.3.1 of the UFSAR and illustrated in figure 1.0.1 of the UFSAR, to determine if a candidate heat load pattern can be implemented through use of the TR with the use of the invariant thermal model or the use of the 72.48 thermal model to be acceptable.

12.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM EVALUATION

There were no changes to the applicant's acceptance test and maintenance program requested in the amendment application.

13.0 WASTE MANAGEMENT EVALUATION

This section is not applicable to CoC evaluations.

14.0 DECOMMISSIONING EVALUATION

This section is not applicable to CoC evaluations.

15.0 QUALITY ASSURANCE EVALUATION

There were no changes to the applicant's quality assurance program requested in the amendment application.

16.0 ACCIDENT ANALYSIS EVALUATION

There were no changes to the applicant's accident analysis section of the UFSAR requested in the amendment application.

17.0 CONDITIONS FOR CASK USE - TECHNICAL SPECIFICATIONS

The staff reviewed the proposed amendment to determine that applicable changes made to the conditions in the CoC and to the TS for CoC No. 1014, Renewed Amendment No. 18, would comply with the requirements of 10 CFR Part 72. The staff reviewed the proposed changes to

confirm that the changes were properly evaluated and supported in the applicant's revised UFSAR. These modifications were found acceptable based on the staff's findings for the Structural, Thermal, Shielding, Materials, Operating Procedures and Radiation Protection sections of this SER.

The staff finds that the proposed changes to the HI-STORM 100 Cask System conform to the changes requested in the amendment application and do not affect the ability of the cask system to meet the requirements of 10 CFR Part 72. The proposed changes provide reasonable assurance that the HI-STORM 100 Cask System will continue to allow safe storage of spent nuclear fuel.

18.0 CONCLUSIONS

The staff has performed a comprehensive review of the amendment application, during which the requested change to incorporate the subject TR was considered.

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 HI-STORM 100 Cask System do not affect the ability of the cask system to meet the requirements of 10 CFR Part 72. Therefore, Renewed Amendment No. 18 to CoC No. 1014 for the HI-STORM 100 Cask System should be approved.

Issued with Certificate of Compliance No. 1014, Renewed Amendment No. 18
on October 8, 2024.