Thermal RSIs:

RSI 4-1: Describe in Section 1.0.3.1 of the safety analysis report (SAR) the meaning of each step in figure 1.0.1 of the SAR. In addition, explain how the process that is described in section 1.0.3.1 of the SAR will ensure the limitations in the safety evaluation (SE) Agencywide Documents Access and Management System (ADAMS) Accession No. ML21216A181 will be met or clarify and provide justification for any deviations.

Figure 1.0.1 of the SAR illustrates a flowchart of the thermal topical report (ML21302A147) implementation that includes at least 14 individual steps. However, Section 1.0.3.1 of the SAR does not describe each of the steps in figure 1.0.1 of the SAR. Examples of items that are not clear include:

- "Evaluate the candidate heat load pattern using the approved topical report methodology." It is not clear in the context of the flowchart if this includes the entire topical report with all the acceptance criteria and considers all limitations in the topical report (TR) safety evaluation (SE) (ML21216A181).

- "Will the candidate heat load pattern be used in a system identical to that in the TR invariant model?" It is clearly stated in L4.2 of the TR SE, "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." It is also clearly described in appendix 1 of the TR SE, the methodology in the SE is considered applicable to and limited to the following design variants for the HI-STORM 100 System:

  Multi-purpose canisters (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

Therefore, the HI-STORM 100 MPCs, HI-TRACs, and overpacks that the SE methodology is applicable to and limited to is clearly described in the TR SE. Clarification of the statement in section 1.0.3.1 of the SAR is necessary for the staff to have a clear understanding of how the thermal topical report is implemented. For a more efficient thermal review, the MPCs, HI- TRAC transfer casks, and HI-STORM 100 overpacks should be limited to those above for the HI-STORM 100. Similarly, all proposed changes to Technical Specifications (TS) Appendices C and D should be removed, because those TS appendices are for the HI-STORM 100S Version E overpack, and the HI-STORM 100S Version E overpack and the HI-TRAC MS, respectively, which are not included in the list above. Also, the proposed change to TS Appendix B on page 2-54, "These same limits apply for heat load patterns developed in accordance with the topical report HI-2200343-A, Revision 2.," should be removed because that TS is for the unventilated (UVH) overpack, which is not included in the list above. Similarly, the maximum cell decay heat load limit in TS Appendix B, Table 2.4-9 should not be removed, because that TS is for the UVH overpack and because the TR HI-2200343-A does not contain the information necessary to develop alternate decay heat limits that are higher than those currently in the TS.

- "Can the thermal model of the system be utilized under 72.48?" It is not clear in the context of the flowchart what this means, or how it considers the specific design variants of the HI-STORM 100 system specified above and in the TR SE.

- "Obtain NRC amendment or utilize a different canister model." This should be clarified to describe that the canister model is limited to those in the TR SE.

- "Are the temperature results bounded by those used in the FSAR structural analysis." The structural analysis within the final safety analysis report (FSAR) has not been specified. Also, while temperatures could be bounded by those used in the FSAR structural analysis, that does not necessarily mean stresses are bounded if, for example, there are large temperature gradients. Therefore, this step should be clarified to provide reasonable assurance that the structural analysis is adequately evaluated.

- "Document thermal heat load pattern in technical report." This technical report should be referenced in the TS or CoC.

The TR SE includes limitations L4.1 through L4.4 on the evaluation methodology; it is not clear in the application how the limitations on the evaluation methodology are met.

If the applicant considers removing the section on, "Change control," within Section 1.0.3.1 of the SAR, Figure 1.0.1 of the SAR, as well as any reference to that figure, then RSIs 4-1 through 4-3, and Observations Th-1 through Th-3, are not applicable. Alternatively, the applicant could revise the TR HI-2200343-A to address the applicant's statement in Section 1.0.3.1 of the SAR, "However, since this FSAR is subject to the provisions of 10CFR72.48, use of that topical report needs to address the change control process.," instead of amending the HI-STORM 100 SAR to address the change control process. This could allow for the added efficiency of incorporate the change control process for the HI-STORM FW system, see also the applicant's presentation entitled, "Use of Topical Reports to Risk Inform Spent Fuel Licensing," from Thursday, March 10, 2022, at the U.S. NRC Regulatory Information Conference (RIC), Technical Session TH29, "The Benefits of Risk-Informed Decision-making for Dry Cask Spent Nuclear Fuel Storage Systems."

This information is necessary to determine compliance with 10 CFR 72.236(f).

Holtec Response

Holtec has updated Figure 1.01 and Section 1.0.3.1 of the SAR to address the NRC's concerns. This revision ensures that the final qualification of the candidate heat load pattern is based on the invariant model described in the topical report. This modified figure and explanation does still include a description of how the flexibility granted to the CoC holder under 10CFR72.48 is still applicable when utilizing the approved topical report.

Additionally, Holtec has updated the CoC to make it clear that the use of the topical report only applies to the systems listed in the Topical Report SE. This update includes removing technical specifications appendices C and D and clarifying that the UVH overpack is not included.

RSI 4-2: Based on the invariant thermal model limitation in L4.2 of the TR SE, clarify in section 1.0.3.1 and in figure 1.0.1 of the SAR, if the invariant model is changed to incorporate 10 CFR 72.48 changes and the thermal heat load is documented, how subsequent changes are made to the invariant model if a subsequent candidate heat load pattern is considered in this process.

It appears that section 1.0.3.1 and figure 1.0.1 of the SAR considers the implementation of the TR for a candidate heat load pattern that results in documentation or termination of the thermal heat load pattern. However, if the implementation results in a thermal heat load pattern(s) being documented, then any existing 10 CFR 72.48 changes for the documented thermal heat load pattern(s) might have to be incorporated in the invariant model again for a subsequent candidate heat load pattern. That concept is not clearly described in section 1.0.3.1 and figure 1.1.1 of the SAR. The concept of an invariant model is clearly stated to be a limitation in L4.2 of the TR SE.

This information is necessary to determine compliance with 10 CFR 72.236(f).

Holtec Response

The revisions to Section 1.0.3.1 and Figure 1.0.1 of the SAR described in the response to RSI 4-1 ensure that all changes under 72.48 are done first, then the candidate heat load pattern is evaluated in the 72.48 model, then only after all those are determined to be acceptable, the candidate heat load pattern is used in the invariant model for final qualification in accordance with the topical report SE.

RSI 4-3: Provide justification for the maximum decay heat exceeding the total decay heat, and the maximum per assembly decay heat exceeding the per assembly decay heat for each configuration in the TS using the methodology described in the TR.

Title 10 of the *Code of Federal Regulations* (CFR) 72.236(a) states, "Specifications must be provided for the spent fuel to be stored in the spent fuel storage cask, such as, but not limited to, type of spent fuel (i.e., BWR, PWR, both), maximum allowable enrichment of the fuel prior to any irradiation, burn-up (i.e., megawatt-days/MTU), minimum acceptable cooling time of the spent fuel prior to storage in the spent fuel storage cask, maximum heat designed to be dissipated, maximum spent fuel loading limit, condition of the spent fuel (i.e., intact assembly or consolidated fuel rods), the inerting atmosphere requirements."

In table 3-1a of Appendix A of the TS, note 9 states, "…Alternative heat load limits may be developed following the methodology in Topical Report HI-2200343-A, Revision 2. 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; however, the methodology in the TR and the application SAR do not include justification for expanding the use of the thermal models to higher total or per assembly decay heats, or in other words, to develop alternate total or per assembly decay heat limits that are higher than those currently in the TS.

Similar statements include, but are not limited to:

- "Total MPC heat load and individual cell limits may also be determined using the methodology outlined in Topical Report HI-2200343," in SAR section 2.1.9.1,
- "For heat load patterns developed in accordance with Table 3-1, Note 9, these limits do not apply.," in tables 3-3 and 3-4 of Appendix A of the TS,
- removing the maximum cell decay heat limit in table 2.II.1.6 of the SAR, and Appendix B of the TS, table 2.4-9.,
- "Alternatively, decay heat limits can be calculated in accordance with the methodology in Topical Report HI-2200343-A.," in section 12.II.2.10 of the SAR., and
- "Alternatively to the heat load patterns in Sections 2.4.1 and 2.4.2, per cell allowable heat loads may be determined per Topical Report HI-2200343-A Revision 2.," in section 2.4.2 of Appendix B of the TS.

Alternatively, these statements and similar ones throughout the TS and SAR should be removed.

This information is necessary to determine compliance with 10 CFR 72.236(a).

Holtec Response

The Topical Report (TR) establishes the principal methodology, which is the same as that in Chapter 4 of the FSAR, to qualify candidate loading patterns that satisfy temperature limits established in Section 2.2 of the TR. Irrespective of the distribution of decay heat in the MPC and total decay heat, the PCT and component temperatures are limited to those prescribed in Section 2.2 of the TR. The acceptance criteria can be considered self-limiting given that conservative (lower than existing FSAR acceptance criteria) values are adopted. Additionally, the following justifications ensure the thermal model developed following the methodology presented in Section 2.3 of the TR, which is essentially the same as that in Chapter 4 of the HI-STORM 100 FSAR, is robust to capture the physical phenomenon irrespective of the total MPC decay heat and distribution of decay heat in the MPC.

1. Reynolds number (Re) of flow inside the MPC is less than 100. Therefore, flow inside the MPC is laminar irrespective of the decay heats due to extremely low velocities through fuel assemblies.
2. Heat transfer from a fuel assembly to the basket wall is via conduction and radiation.
3. All modes of heat transfer within the MPC remain valid irrespective of the decay heats.
4. Flow in the annulus region between the MPC and HI-STORM remains in the transition turbulent regime irrespective of the total decay heat. Reynolds number of this flow, which is a function of density, velocity and viscosity, remains in the range of 2000–4000[1]. As the decay heat increases, air velocity and temperature in the annulus increase. This also results in a reduced air density and viscosity. As a result, the Reynolds number remains within the range of 2000–4000 i.e., in the transition turbulent regime. Similarly, flow in the annulus region between the MPC and unventilated HI-TRAC remains laminar irrespective of the total decay heat. This is due to an extremely small gap between the MPC and HI-TRAC that result in low air velocities.
5. Heat rejection from cask external surfaces via natural convection and radiation remains unchanged irrespective of the cask decay heat. Natural convection is modeled using correlations described in Sections 4.2 and 4.4 of the FSAR. Radiation heat transfer is modeled using Discrete Ordinates (DO) model in ANSYS FLUENT

To illustrate the above and provide further assurance to the staff, three example heat load patterns (HLP) as shown in Figures 4-3.1, 4.3-2 and 4-3.3 are evaluated for an MPC-68M under long-term storage condition. The thermal model adopted for these evaluations is the same as that used in HI-STORM 100 LAR 1014-14. The following can be noted from these heat load patterns:

a. Figure 4.3-1: The total heat load is 50kW, which is the maximum total heat load requested in this amendment. This is also higher than that previously approved for MPC-68M in HI-STORM 100 FSAR (= 42.8 kW in Table 2.0.1 of the HI-STORM 100 FSAR Revision 23).
b. Figure 4.3-2: The per storage cell allowable decay heat is higher than that previously approved for MPC-68M (= 1.66kW in Figure 2.III.2 of the HI-STORM 100 FSAR Revision 23).
c. Figure 4.3-3: The total heat load is 50kW, which is the maximum total heat load requested in this amendment. This is also higher than that previously approved for MPC-68M in HI-STORM 100 FSAR (= 42.8 kW in Table 2.0.1 of the HI-STORM 100 FSAR Revision 23). Similarly,

[1] This observation is also supported by thermal evaluations of MPC-68M at 36.9kW and 42.8kW in HI-STORM 100 FSAR.

the per storage cell allowable decay heat is similar to that previously approved for MPC-68M (= 1.66kW in Figure 2.III.2 of the HI-STORM 100 FSAR).

The above calculations are documented in Holtec report HI-2043317 Revision 55 and supporting computer input/output files are provided with this response. The results from these calculations are presented in Table 4-3.1. The results indicate HLP 1 and 2 are potential candidate heat load patterns that will be further evaluated to confirm whether they meet the acceptance criteria in the TR under all conditions of storage and onsite transfer. Clearly, HLP3 does not meet the acceptance criteria in the TR under normal conditions of storage although the total heat is the same as HLP1 and per assembly heat loads are similar to HLP2. Therefore, HLP3 is not a candidate heat load pattern. These examples provide confidence that the thermal model and methodology has the capability to solve an array of heat load patterns for an MPC within the boundaries established in the proposed CoC.

Table 4.3-1: Computed Temperatures for MPC-68M Under Example Heat Load Patterns during Normal Long-Term Storage

Component	Temperature (°F)			Temperature Limits from the TR (°F)[Note 1]
	HLP1 in Figure 4.3-1	HLP2 in Figure 4.3-2	HLP3 in Figure 4.3-3	
Fuel Cladding	711	696	776	734
Basket	687	623	713	752
Basket Shims	547	482	550	752
MPC Shell	516	452	526	800
MPC Baseplate[1]	289	246	288	800
MPC Lid[1]	502	453	514	800
Overpack Inner Shell	384	320	388	800
Overpack Body Concrete[1]	266	232	268	300
Overpack Lid Concrete[1]	282	259	277	300
Overpack Outer Shell	173	173	190	800
Area Averaged Air Outlet[2]	275	244	277	-
Note 1: The temperature limits under normal long-term are obtained from Table 2.1 of the Topical Report HI-2200343-A Revision 2.				

[1] Maximum thru thickness section average temperature reported.
[2] Reported herein for the option of outlet ducts air temperature surveillance set forth in the Technical Specifications.

			1400	1400				
		1575	1000	500	500	1000	1575	
	1575	600	400	500	500	400	600	1575
	1000	400	400	200	200	400	400	1000
1400	500	500	200	350	350	200	500	500	1400
1400	500	500	200	350	350	200	500	500	1400
	1000	400	400	200	200	400	400	1000	
	1575	600	400	500	500	400	600	1575	
		1575	1000	500	500	1000	1575	
			1400	1400				

Figure 4-3.1: Example Heat Load Pattern 1 (all numbers are in Watts)

			500	500				
		100	500	400	400	500	100	
	100	1800	1800	400	400	1800	1800	100
	500	1800	100	100	100	100	1800	500
500	400	400	100	100	100	100	400	400	500
500	400	400	100	100	100	100	400	400	500
	500	1800	100	100	100	100	1800	500	
	100	1800	1800	400	400	1800	1800	100	
		100	500	400	400	500	100		
				500	500				

Figure 4-3.2: Example Heat Load Pattern 2 (all numbers are in Watts)

			1450	1450				
		400	1000	500	500	1000	400	
	400	500	1650	500	500	1650	500	400
	1000	1650	400	200	200	400	1650	1000
1450	500	500	200	200	200	200	500	500	1450
1450	500	500	200	200	200	200	500	500	1450
	1000	1650	400	200	200	400	1650	1000	
	400	500	1650	500	500	1650	500	400	
		400	1000	500	500	1000	400	
				1450	1450			

Figure 4-3.3: Example Heat Load Pattern 3 (all numbers are in Watts)

RSI 4-4: Provide the following information with respect to how the TR HI-2200343-A, which is proposed to be incorporated by reference in the TS and application SAR, allows for:

1. recalculation of the air temperature rise,
2. justification for removal of helium backfill limits,
3. recalculation of the quantity of helium gas, and
4. recalculation of completion times to restore the spent fuel storage cask (SFSC) heat removal system to operable conditions.

1. In surveillance requirement (SR) 3.1.2 of Appendix A of the TS, the applicant stated, "For sites that have loaded in accordance with the Topical Report HI-2200343-A, Revision 2, verify that the difference between the average OVERPACK air outlet temperature and ISFSI ambient temperature is less than or equal to the value computed using the topical report methodology." It is not clear to the staff how this value is computed within the topical report methodology.

   An example is provided in section 3.1.2, "Screening Evaluation," of the Topical Report HI-2200343-A. It is not clear in this example how the temperature value was calculated for an MPC, as it is different from what is in the TS for SR 3.1.2. In addition, page B 3.1.2-9 of the SAR states, "(or calculated using the topical report)," which should be more specific to the Topical Report HI-2200343-A.

2. In table 3-2a of Appendix A of the TS the backfill limits for the MPC-68M were removed, no justification was provided for removing those limits.

3. SAR table 1.II.2.3 (and pages B 3.1.1-9 and II.B 3.1.1-8 of the SAR) states that the quantity of helium gas installed may be evaluated according to topical report HI-2200343- (or topical report HI-2200343-A, respectively). It is not clear to the staff how this value is computed within the topical report HI-2200343-A methodology. The staff notes that the HI-STORM 100 MPC-32 Version 1, MPC-32M, and MPC-68 Version 1 canisters (each from the HI-STORM 100 Amd. No. 15) are not included on the list of MPCs in Appendix 1 of the TR HI-2200343-A SE.

4. Table 3-5 of Appendix A of the TS (and in Table 3-3 of Appendix C of the TS), and pages B 3.1.2-4 and II.B 3.1.2-3 of the SAR describes that alternative completion times for actions to restore the SFSC heat removal system to operable conditions may be calculated according to topical report HI-2200343-A, Revision 2. It is not clear to the staff how the completion time values are computed within the topical report HI-2200343-A methodology.

This information is necessary to determine compliance with 10 CFR 72.236(a).

Holtec Response

1. The temperature results of an example heat load pattern under long-term storage in HI-STORM 100 are presented in Table 3.1 of the TR. Such table will also be prepared for candidate heat load pattern. The component "average air outlet" presented in this table is the average temperature of air exiting the HI-STORM outlet vents. As rightly noted by the staff, surveillance requirement (SR) 3.1.2 of Appendix A of the TS requires the user to verify that the difference between the average OVERPACK air outlet temperature and ISFSI ambient temperature is less than or equal to the value computed using the topical report methodology. This value can therefore be calculated based on the "average air outlet" component temperature in Table 3.1 and ambient air temperature.

   Page B 3.1.2-9 of the SAR has been revised to be more specific by referencing the Topical report HI-2200343-A.

2. Initial helium backfill limits for approved QSHL loading patterns in MPC-68M were deleted accidentally. This typo has been fixed.

3. Section 2.3.6 of the TR provides the methodology to compute the initial helium backfill range. It provides the necessary equations to establish an upperbound and lowerbound limits for the initial helium backfill pressure.

   The staff rightly notes that the HI-STORM 100 MPC-32 Version 1, MPC-32M, and MPC-68 Version 1 canisters (each from the HI-STORM 100 Amd. No. 15) are not included on the list of MPCs in Appendix 1 of the TR HI-2200343-A SE. Based on this, Table 1.II.2.3 and page II.B 3.1.1-8 of the SAR have been revised to disallow the option to compute helium backfill pressure for HI-STORM 100 MPC-32 Version 1, MPC-32M, and MPC-68 Version 1 canisters. However, the callout for calculating initial helium gas quantity on Page B 3.1.1-9 of the SAR is correct as this TS basis is not applicable to MPC-32M, MPC-32 Version 1 or MPC-68 Version 1.

4. Section 2.3.12 of the TR provides discussions related to 100% duct blockage event. To evaluate this event, a transient thermal solution of the HI-STORM 100 System starting from normal storage conditions is obtained. The duration from the blocked duct transient in combination

with the required times for cleaning the vents provides the alternative completion times for actions to restore the SFSC heat removal system to operable conditions.

Thermal Observations:

Observation Th-1 Clarify the following statement in section 1.0.3.1 of the SAR to demonstrate that the methodology in the TR and limitations in the TR SE are met.

"Once it has been demonstrated that the heat load pattern meets the peak cladding temperature requirements in the topical report model, then the heat load pattern can be considered acceptable, similar to any of the explicit patterns listed in the CoC."

The staff notes that there is more to an acceptable heat load pattern than only meeting the PCT requirements, as described in the TR HI-2200343-A and TR SE; therefore, meeting only the PCT requirement does not provide justification to conclude that the heat load pattern is acceptable. This is necessary for the staff to have a clear understanding of how the thermal topical report is implemented.

This information is necessary to determine compliance with 10 CFR 72.236(f).

Holtec Response
This statement has been removed in response to RSI 4-1. The candidate heat load pattern must be run in the invariant model and demonstrated to meet all the acceptance criteria in the topical report.

Observation Th-2 Clarify the following statement in section 1.0.3.1 of the SAR.

"Then the heat load pattern should be run in the revised model, following the methodology in the Topical Report, to ensure that all the acceptance criteria are still met." In that statement, the word, "Should," should be changed to, "shall."

This is necessary because the first sentence of the fourth paragraph in section 1.0.3.1 of the SAR states, "After the heat load pattern is shown to meet the peak cladding temperature in the invariant topical report model, then any required changes to the model can be considered under the 10CFR72.48 process." However, for any 10 CFR 72.48 changes to the invariant model to be considered acceptable with the candidate heat load pattern, the methodology in the Topical Report, including ensuring that all acceptance criteria are still met, shall be run after any 10 CFR 72.48 changes have been incorporated in the thermal model that includes the candidate heat load pattern.

This information is necessary to determine compliance with 10 CFR 72.236(f).

Holtec Response
This statement has been removed in response to RSI 4-1. The changes are evaluated under 72.48 first, and only if they can be implemented without prior NRC approval, then the topical report invariant model can be used.

Observation Th-3: Clarify the following portions of figure 1.0.1 of the SAR:

1. what happens if the candidate heat load pattern does not meet the peak cladding temperature (PCT) acceptance criterion using the invariant model, and/or

2. what happens if any of the TR criteria are not met, and/or
3. if there is a need to obtain an NRC amendment, or utilize a different canister model, or utilize a different heat load pattern, that terminates the use of that candidate heat load pattern.

Also clarify that the candidate heat load pattern is the starting point.

Figure 1.0.1 of the SAR includes directional arrows going from the decision shape with the yes/no questions, "Does the candidate heat load pattern meet the PCT acceptance criterion using the invariant model?" and, "Are all TR acceptance criteria met?" with the answers, "No," that go back to the terminal shape, "Candidate heat load pattern," which is the start of the thermal topical report implementation process. However, if the candidate heat load pattern does not meet the PCT acceptance criterion using the invariant model, and/or if any of the TR acceptance criteria are not met, that candidate heat load pattern should be terminated.

Also, in figure 1.0.1 of the SAR and described in section 1.0.3.1 of the SAR, it should be clarified that if there is a need to obtain an NRC amendment or utilize a different canister model (see RSI 4-1) or utilize a different heat load pattern, that terminates the use of that heat load pattern, and another heat load pattern cannot be substituted at that point in the process.

Often a terminal shape that is the beginning or ending of a program includes the word, "Start," or, "End," respectively. These clarifications are necessary for the staff to have a clear understanding of how the TR HI-2200343-A is proposed to be implemented in the TS.

This information is necessary to determine compliance with 10 CFR 72.236(f).

Holtec Response

The figure has been revised in response to RSI 4-1, and the steps in Section 1.0.3.1 more clearly describe that if an amendment is needed the process does not continue until after that occurs.

Observation Th-4: Provide in Section 1.0.3.1 of the SAR, the details of how any required changes to the thermal models will be considered under the 10 CFR 72.48 process and how they will be evaluated and incorporated (individually and as an aggregate) following Holtec's 72.48 process. In addition, describe how these changes will continue to meet the limitations in NRC's TR SE.

Section 1.0.3.1 of the SAR states, "If the changes do not require prior NRC approval, they can be incorporated following Holtec's 10 CFR72.48 process." However, the application does not describe the details of how any required changes to the thermal models will be considered under the 10 CFR 72.48 process and how they will be evaluated and incorporated following Holtec's 72.48 process, if those changes do not require prior NRC approval. Examples of details could include how a design change will be evaluated on an individual basis within the thermal models and then together within the thermal models.

In the letter dated December 15, 2021, Holtec International submitted an application to the NRC for CoC No. 1014, Amendment No. 18 to the HI-STORM 100 system that requested a change purported to be of extremely limited scope and only incorporates a TR already reviewed and approved by the NRC technical staff. However, it has not been described how these changes will continue to meet the limitations approved in NRC's TR SE.

This information is necessary to determine compliance with 10 CFR 72.236(f).

Holtec Response

The process described in Figure 1.0.1 and Section 1.0.1.3 has been revised in the response to RSI 4-1. Any changes will be evaluated under the existing 72.48 program prior to the qualification of a candidate heat load pattern.

Shielding RSIs:

RSI 6-1: Provide the following information pertinent to the proposed changes to the TS for the HI-STORM 100 dry storage system and the use of the method defined in the thermal Topical Report HI-2200343-A (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21302A147):

1. Revise application to specify which canisters, overpacks, and transfer casks the thermal TR HI-2200343-A applies to and update the proposed TS (CoC Appendix A, B, C, D) as necessary and its impact on shielding analyses,
2. Provide shielding analyses as necessary for the combinations of burnup, enrichment, and cooling time (BECT) that are produced by the method defined in the thermal TR; or demonstrate that the BECT derived using the method defined in the thermal TR has no impact on the source terms of the spent fuel to be stored in the casks; or confirm that the burnup, cooling times derived from the TR are not used in the source terms calculations for shielding analyses,
3. Define the term "essentially identical" from shielding perspective and demonstrate, with supporting shielding analyses, that the MPC-24E and MPC-24EF are "essentially identical" to the MPC-24, the MPC-68 and MPC-68F are identical to MPC-68FF, and the MPC-32 and MPC-32F are identical from the shielding perspective.

The proposed changes to Section 2.4.6 of Appendix B to the HI-STORM 100 CoC indicate that the methodology defined in the thermal TR HI-2200343-A will be applied to the MPC-68M within the unventilated overpack. Page 5-1 of the FSAR states: "-- The MPCs are designated as MPC- 24, MPC-24E and MPC-24EF (24 PWR fuel assemblies), MPC-32 and MPC-32F (32 PWR fuel assemblies), and MPC-68, MPC-68F, and MPC-68FF (68 BWR fuel assemblies). The MPC-24E and MPC-24EF are essentially identical to the MPC-24 from a shielding perspective. Therefore, only the MPC-24 is analyzed in this chapter. Likewise, the MPC-68, MPC-68F and MPC-68FF are identical from a shielding perspective as are the MPC-32 and MPC-32F and therefore only the MPC-68 and MPC-32 are analyzed. Throughout this chapter, unless stated otherwise, MPC- 24 refers to either the MPC-24, MPC-24E, or MPC-24EF and MPC-32 refers to either the MPC- 32 or MPC-32F and MPC-68 refers to the MPC-68, MPC-68F, and MPC-68FF." However, there is no information to support the conclusion that the MPC-24E and MPC-24EF are essentially identical to the MPC-24, MPC-68, MPC-68F and MPC-68FF are identical, and the MPC-32 is identical to MPC-32F. It is also not clear what the term "essentially identical" means, i.e., the cask design configuration, geometry, shielding design, allowable contents, dose rate, or something beyond these items. It is not clear either if the MPC-24 bounds MPC-24E and MPC- 24EF so that shielding analyses are necessary for MPC-24E and MPC-24EF. The same concern applies to the shielding analyses for the MPC-32 and MPC-68.
In addition, Section B2.2.1 of HI-2201113, "HI-STORM 100 Version UVH Shielding Analysis," (ADAMS Accession No. ML21068A380) further states that the correlations corresponding to the decay heats in Table 2.409 of Appendix B to the CoC were analyzed in the loading pattern described in Figure A-5 of HI-2201113. Page ii of the report also states: "The loading configurations selected for shielding analyses of the HI-STORM 100 Version UVH System encompass all thermal configurations permitted for the MPC-32M and MPC-68M canisters, i.e., uniform loading, where all cells have the same heat load limit, and regionalized loading, where the heat load limits vary between cells." These statements appear to indicate that the BECTs, derived using the method specified in the thermal TR, are used to determine the source terms for each of the loading configurations.
However, Appendix 1 of the thermal Topical Report HI-2200343-A indicates that the previously

approved unventilated overpack, MPC-32M canister, and the HI-STORM 100S Version E overpack, are not on the list of the approved canisters and transfer casks of the thermal TR. In addition, HI-2200343-A states: "Different decay heat loading patterns are associated with different loading patterns in terms of the burnup, enrichment and cooling times of the assemblies. The CoC where this TR is implemented may have specific limitations on burnup, enrichment and cooling times. These fuel qualification parameters need to be satisfied independent of the qualification of the heat load patterns through the methodology in this TR." However, page ii of the shielding calculation package, HI-2201113, "HI-STORM 100 Version UVH Shielding Analysis," (ADAMS Accession No. ML21068A380), states: "The loading configurations selected for shielding analyses of the HI-STORM 100 Version UVH System encompass all thermal configurations permitted for the MPC-32M and MPC-68M canisters, i.e., uniform loading, where all cells have the same heat load limit, and regionalized loading, where the heat load limits vary between cells." As such, it is not clear whether the BECTs derived for these loading patterns have been used to determine the source terms for shielding analyses. If the amendment requests the thermal TR HI-2200343-A to apply to the MPC-68M within the unventilated overpack and the MPC-32M in the HI-STORM 100S Version E overpack, the applicant needs to provide supplemental information to demonstrate that the burnup and cooling time correlations and the source terms calculated using the BECTs derived from the correlations are used in the shielding analyses.
Alternatively, if the shielding analyses are not related to the loading patterns derived from the correlations presented in Section 2.1.9, "Summary of Authorized Contentsmxd6" of the SAR, HI-2002444 "HI-STORM 100 FINAL SAFETY ANALYSIS REPORT" (ADAMS Accession No. ML21221A329), the applicant should clearly state that the thermal TR and the shielding analyses are independent, and TS should reflect this condition accordingly. The applicant also needs to explain how the BECTs derived from the thermal TR work together with the BECTs determined by shielding analyses.
The staff needs this information to determine the system shielding design compliance with 10 CFR 72.236(d).

Holtec Response

1. Respective sections of the TS (CoC Appendix A, B, C and D) have been revised to clarify which canisters, overpacks and transfer casks the thermal TR (HI-2200343-A) applies to. The list of these components, as taken from the TR, is as follows:

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

Note that this excludes the unventilated version (UVH) that is being introduced in Amendment 16. It also excludes all systems qualified through current Appendices C and D that were introduced and approved in Amendment 15, mainly the MPC-32M, Overpack Version E, and HI-TRAC MS. Hence no justification is provided for the application of the TR to those systems, and this is noted in further responses below.

2. We apologize for the confusion. We have expanded the discussion in Section 1.0.3.1 to clarify the relationship (or absence thereof) between thermal (decay heat) and shielding (BECT) requirements. In short, the decay heat limits and BECT limits are completely independent of each other, so no BECTs are derived from decay heat limits developed using the TR. And for now, no new BECTs are generated, and no existing BECTs are modified, hence no new or modified dose analyses are needed. However, note that the independence of decay heat and BECT limits is based on the changes to this FSAR made under Amendment 16, where the previous complicated polynomials to link decay heat

and BECTs were removed and replaced with simple tables. Hence the acceptance and approval of the changes in that Amendment 16 are a prerequisite here.

3. The principal difference between the MPC-24 and MPC-24E is in the thickness of the neutron absorber, with that for the MPC-24E being slightly thicker (See Drawing 3925, Sheet 2, Notes 1, 2, 7 and 8 for the MPC-24E, and Drawing 3926, Sheet 2, Notes 1, 2 4 and 5 for the MPC-24). This has a significant effect on the criticality performance, but is negligible from a shielding perspective. Hence no distinction is made between these two basket types for dose analyses.

The "F" and "FF" versions of MPCs are remnants of a by-now obsolete 10CFR71 requirement. The difference to the standard version is just a larger lid-to-shell weld. But that larger weld requires a thicker outer shell in the weld area. For that, the shell thickness of the MPC is increased for the top part of the shell next to the MPC lid, and the lid diameters is correspondingly reduced. The details are shown on Drawing 3923 in Section 1.5, Sheet 3, see the two versions of Detail D on the right of the drawing. The characteristics relevant for the shielding performance, namely the total amount of steel, and the spatial distribution therefore are practically unchanged, hence they are characterized as "Essentially identical".

RSI 6-2: Provide shielding analyses for the loading pattern that the peripheral zone has twice as much decay heat as in the inner zone. Table 2.1.30 of the "HI-STORM 100 FINAL SAFETY ANALYSIS REPORT" shows that the heat load for the fuel assemblies in the peripheral zone can have a per assembly decay heat twice as much as the ones in the inner zone. As such, it is not clear whether the shielding analyses provided in the HI-STORM 100 UVH shielding analysis package is still valid for the loading pattern that allows fuel assemblies in the peripheral zone to have twice as much decay heat as in the inner zone. Although there is not a direct correlation between decay heat and source terms, hotter fuel in general produces more neutron and gamma radiations and hence higher dose at the controlled area boundary and dose rate around the cask.

The staff needs this information to determine the system shielding design compliance with 10 CFR 72.236(d).

Holtec Response

As discussed in item 1 of the response to RSI 6-1, the TR is not applicable to the HI-STORM UVH.

RSI 6-3: Provide information on the differences between the dose rates of the MPC-24 and MPC-32 or the MPC-68.

Page 5-8 of the HI-STORM 100 FSAR, HI-2002444 (ADAMS Accession No. ML21221A329), states: "The HI-STORM 100S Version B overpack was analyzed for the dose rate at the controlled area boundary. Although the dose rates for the MPC-32 in HI-STORM 100S V e r s i o n B are greater than those for the MPC-24 in HI-STORM 100S Version B at the ventilation ducts, as shown in Tables 5.1.11 and 5.1.12, the MPC-24 was used in the calculations for the dose rates at the controlled area boundary for the HI-STORM 100S Version B overpack. This is acceptable because the vents are a small fraction of the radial surface area and the MPC-24 has higher dose rates at the radial midplane than the MPC-32 in the HI-STORM 100S Version B overpack. The MPC-24 was also chosen because, for a given cooling time, the MPC-24 has a higher allowable burnup than the MPC-32 or the MPC-68 (see Section 2.1.9). Consequently, for the allowable burnup and cooling times, the MPC-24 will have dose rates that are greater than or equivalent to those from the MPC-68 and MPC-32." However, there is no information to support this conclusion. The staff also

notes that fuel with higher burnup does not necessarily produce higher source terms, cooling time and enrichment also have significant impact on the source terms.

The staff needs this information to determine the system shielding design compliance with 10 CFR 72.236(d).

Holtec Response

As discussed in the response to item 2 of RSI 6-1, the BECTs applicable to a loading configuration using the TR are those developed for Amendment 16. As part of the shielding qualification of those BECTs, bounding calculations were performed for all three principal basket types, MPC-24, MPC-32 and MPC-68, based on the newly defined BECTs, with results presented in Chapter 5 submitted with this Amendment, in Table 5.4.22. The calculations show that results are quite similar between the MPCs, for both the HI-TRAC and the HI-STORM. Additionally, to alleviate any concerns with any remaining differences in dose rates between those MPCs, and any differences to the design basis dose rates, a dose rate limit for the side of the HI-TRAC was introduced in that amendment. This supports the conclusion that the dose rates at the controlled area boundary would also be comparable between casks loaded with those baskets, hence the site boundary dose rate examples in Table 5.1.9 are still considered applicable.

Shielding Observations:

Observation Sh-1: Review the statements in Section B2.2.1 of HI-2201113, "HI-STORM 100 Version UVH Shielding Analysis," with respect to heat load configurations (ADAMS Accession No. ML21068A380) for the MPC-68M canister and provide a clarification and/or explanation as necessary.

The decay heat loading patterns presented in the CoC do not appear to match the analyzed loading patterns, e.g., Figures 2.4-1, 2.4-2, 2.4-3, 2.4-4 in the TS do not seem to match Figure A-5 of the shielding calculation (ADAMS Accession No. ML21068A380). For example, locations 4, 7 in Figure 2.4-1 of the TS are assigned the same heat load limit as locations 1 and 2.
Whereas, the loading pattern identified in Figure A-5 of the shielding calculation package identifies locations 4 and 7 as zone 2 with a different heat load from heat load Region 3.
The staff needs this information to determine the system shielding design compliance with 10 CFR 72.230(a) and 10 CFR 72.236(d).

Holtec Response

As discussed in item 1 of the response to RSI 6-1, the TR is not applicable to the HI-STORM UVH. Additionally, with respect to the suspected discrepancy stated in the observation, note that Figures 2.4-1 through 2.4-4 are for the ventilated overpack while figures for the unventilated (UVH) overpack are 2.4-6a and 2.4-6b, and those are consistent with the information in the UVH report HI-2201113.

Observation Sh-2: Demonstrate that the source from a burnable poison rod assembly (BPRA) is bounding to all allowable non-fuel hardware.

Page 5-8 of the HI-STORM 100 FSAR, HI-2002444 (ADAMS Accession No. ML21221A329), states: "The controlled area boundary dose rates with the BPRAs bound the controlled area boundary dose rates with the TPDs." However, there is no information to support this conclusion. In addition, the notes on page xxxvii of the FSAR indicates that the HI-STORM 100 system is designed

to store a variety of non-fuel hardware besides BPRAs and thimble plus devices (TPDs), including Control Rod Assemblies (CRAs), Axial Power Shaping Rods (APSRs), Wet Annular Burnable Absorbers (WABAs), Rod Cluster Control Assemblies (RCCAs), Control Element Assemblies (CEAs), Neutron Source Assemblies (NSAs), water displacement guide tube plugs, orifice rod assemblies, instrument tube tie-rods (ITTRs), vibration suppressor inserts, and components of these devices such as individual rods. Based on PNL-8425, "Physical Characteristics of Non-Fuel Assembly Reactor Components," BPRAs typically reside in the reactors for only one cycle whereas TPDs and the other non-fuel hardware (NFHW) listed on page xxxvii of the FSAR will be used in the reactors for many cycles and with much higher exposure. Also, most of these NFHWs, such as RCCAs, CEAs, are made from different materials as compared with the BPRAs. Ag-In-Cd alloy and hafnium are widely used as control rods in PWRs. Since silver, indium, and cadmium will generate many new radioactive isotopes when irradiated, the gamma emitters in these materials are much different from the Co-60 in the stainless steel components of BPRAs. The applicant needs to provide information to support the conclusion that it is conservative to use the source term of BPRAs to bound all other allowable NFHW.

The staff needs this information to determine the system shielding design compliance with 10 CFR 72.236(d).

Holtec Response

The conclusion that it is reasonable to use the BPRA to represent other NFHs is linked to Table 2.1.25 with detailed burnup and cooling limits for each of the NFH, and to the fact that certain NFH are restricted to certain basket locations. None of this is changed in this Amendment, or when utilizing decay heat patterns developed using the TR. Additionally note that the decay heat of any NFH present in a cell is to be considered when showing that the decay heat limit of a certain cell location. This is also independent of whether the TR is used for developing heat load patterns or not. Overall, the introduction of the TR does not change how NFHs are considered, from either shielding or thermal perspective.

Observation Sh-3: Provide information to demonstrate that the results of the shielding calculations are reliable to be used in this application.
The applicant provided procedures and results of shielding calculation. However, there is no supporting information to demonstrate that the shielding analyses continue to be adequate for the proposed application. The applicant could consider providing this information via output files for the shielding calculations or analysis. This will assist the staff to make its regulatory determination. The staff needs this information to determine the system shielding design compliance with 10 CFR 72.236(d).

Holtec Response

Similar questions have been provided on several sets of RSIs and RAIs. In order to address this in a more generic way, we intend to have a separate discussion on this subject.

Observation Sh-4: Clarify the minimum distance between the hypothetical independent spent fuel storage installation (ISFSI) and its controlled area required for meeting the regulatory requirements of 10 CFR 72.104 and 10 CFR 72.106 with respect to the dose and revise the conclusions as necessary.
Page 5-2 of the FSAR (ADAMS Accession No. ML21221A329) states: "For example, the most bounding configuration might be located at the minimum distance (100 meters) to the controlled area boundary, without any shielding from other structures or topography." However, the numbers

shown in Table B-10 of the shielding calculation package, HI-2201113, "HI-STORM 100 Version UVH Shielding Analysis," (ADAMS Accession No. ML21068A380) do not appear to support this conclusion. As such, it is not clear what is the minimum distance from the hypothetical ISFSI pad to the controlled area boundary.

The staff needs this information to determine the system shielding design compliance with 10 CFR 72.236(d).

Holtec Response

The statement in the Observation quotes the UVH shielding calc package. However, as discussed in item 1 of the response to RSI 6-1, the TR is not applicable to the HI-STORM UVH.
Additionally note that the quoted text is not a conclusion, but merely an example as part of the discussion of the acceptance criteria. In fact, this text was taken verbatim from NUREG-1536, Rev. 0, and is not specific to any details for the HI-STORM 100 system, which was the guidance in place at the time that information was added to the HI-STORM 100 FSAR.

Materials Observation:
Observation M-1: On January 31, 2020, the applicant submitted an application (ADAMS Accession No. ML20049A081) for the renewal of the HI-STORM 100 CoC. In the amendment application for the HI-STORM 100 system submitted on December 15, 2021 (ADAMS Accession No. ML21349B418), the applicant did not provide an evaluation of the impacts of the requested amendment on the aging management activities included in the HI-STORM 100 renewal application. If the renewal for CoC No. 1014 is approved, subsequent amendment applications to CoC No. 1014, including the amendment application submitted on December 15, 2021, would need to include an evaluation of the impacts of the requested amendment on the aging management activities to assure they remain adequate for any changes to, or impacts on, the structures, systems and components (SSCs) within the scope of renewal.

As described in NUREG-2215 Section 8.5.14.2, "Amendment Applications Submitted During a Renewal Review or after a Renewal is Issued," the evaluation of the impacts of the requested amendment on the aging management activities should include the following, as applicable:

- Changes and additions to the CoC No. 1014 renewal by the completion of a Scoping Evaluation, Aging Management Review, and Fuel Retrievability review for the SSCs determined to be within the scope of Amendment No. 18 for CoC No. 1014
- Impacts on CoC No. 1014 TS for the proposed amendment as a result of renewal.
- Revisions to the time limited aging analysis (TLAA) results provided in the CoC No. 1014 renewal application as a result of changes in the amendment, or verification that the TLAA results remain bounding and applicable to the SSC included in, or affected by, the amendment.
- Revisions to the aging management programs (AMPs) provided in the CoC No. 1014 renewal application as a result of changes in the amendment, or verification that the AMPs remain bounding and applicable to the SSC included in, or affected by, the amendment.

This information is needed to determine compliance with 10 CFR 236(g).

Holtec Response

The request to incorporate the Thermal Topical Report in this amendment does not add any new components to the system. Additionally, there are no changes to any materials or environments for the existing components. The acceptance criteria in the Topical Report for temperature and

pressure are the same as those in the existing FSAR used as the basis for license renewal. Since there is no change to any component, material, environment, temperature, or pressure there is no change to any aging management requirements due to this amendment.

Typos/Errors to proposed changes in SAR and TS:

- In figure 1.0.1 of the SAR, change, “choses,” to, “chooses.”
- In table 3-1a of Appendix A of the TS, note 3 is not included within the table.
- In table 3-1a of Appendix A of the TS, notes 1, 2, 3, and 4, were changed to note 9.
- In table 1.2.2, note 3; table 1.III.1, note 1, and pages 2.III-2, B 3.1.2-4, and II.B 3.1.2-3 of the SAR change, “HI-2200343” to, “HI-2200343-A.”
  - In table 1.II.2.3 of the SAR, change, “HI-2200343-” to, “HI-2200343-A.”
- There are numbering typos within section 2.4.3 of Appendix B of the TS.
- It is not clear how in table 3-3, note 2, and table 3-4 of Appendix A of the TS, the statement, “… For heat load patterns developed in accordance with Table 3-1, Note 9, these limits do not apply.,” referring to decay heat limits, is justified based on the proposed implementation of the TR.
- In table 3-3 of Appendix A of the TS, note 2 refers to table 3-1; however, table 3-1 refers to all MPCs with no reference to the TR HI-2200343-A, Revision 2 methodology; whereas table 3-1a of Appendix A of the TS refers to ventilated MPCs and includes a reference to the TR HI-2200343-A, Revision 2 methodology. This is similarly done in tables 3-2a, 3-4, and 3-5 of Appendix A of the TS.
- In table 3-5 of Appendix A of the TS, there is erroneously two, “note 2)” and no, “note 1)” at the bottom of the table.

The relatively small number of proposed page changes in this application has many errors and typos, requiring staff to ask RSIs and Observations, which could have been avoided with a higher quality application.

Holtec Response

The responses to the editorial bullets are addressed below:

- This figure has been significantly revised in accordance with RSI 4-1
- Note 3 has been added
- Numbering has been corrected
- All references to HI-2200343 updated with -A
- All references to HI-2200343 updated with -A
- Numbering in Section 2.4.3 fixed
- Tables 3-3 and 3-4 specify heat load patterns for the existing patterns in the HI-STORM 100 CoC. With the implementation of the topical report, these limits no longer apply, and the site can develop patterns in accordance with the methodology in the topical report. Patterns that meet the acceptance criteria in the topical report may differ from the previously approved per cell limits.
- Table 3-1a, Note 9 refers to the topical report methodology for the ventilated system, Table 3-1b does not allow use of the topical report methodology for the unventilated system, similar to the notes on Table 3-2a and not on Table 3.2b. However, for clarity the later tables (3-3, 3-4, and 3-5) are updated to refer only to the ventilated table 3.1a.
- The note numbering has been fixed on Table 3-5.