Holtec Response to Request for Additional Information (Part 5)

Docket No. 72-1032
Holtec International
HI-STORM FW
Multipurpose Canister Storage System
Certificate of Compliance No. 1032
Amendment No. 7

RAI 3-4

Clarify throughout the final safety analysis report (FSAR) which Multi-Purpose Cannister (MPC) and basket combinations are being referenced when discussing an MPC.

It does not appear that the designation "Continuous Basket Shim" (CBS) is always used when referring to CBS designs. With baskets that have a standard, loose shim version and a CBS version, it is unclear at times which model or both is being discussed.

For example, there are mentions of the "MPC-44" in SAR section 3.4.4.1.4a, "Load Case 4: Non-Mechanistic Tipover of Standard Basket Design." However, the staff's understanding is that MPC-44 does not have a standard basket design version, and it appears these statements should refer to the MPC-44CBS and be moved to safety analysis report (SAR) section 3.4.4.1.4b or 3.4.4.1.4c.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.230(a).

Holtec RAI Response:

As clarified in response to RAI 4-2 (ADAMS Accession Number ML22192A217), in licensing documentation (FSAR, CoC, etc.) the MPC is identified by the maximum number of fuel assemblies it can contain in the fuel basket (MPC-37, MPC-89, etc.). This identification does not specify what basket version is used in the MPC. Therefore, unless the basket version is specifically called out in a particular statement or discussion of an MPC, it should be assumed that the statement or discussion applies to any basket version designed for use with the identified MPC number. For instance, if a statement refers to MPC-89, that statement may apply to MPC-89 with standard basket or MPC-89CBS (MPC-89 with CBS basket). However, if MPC-89CBS or MPC-89 with CBS basket is called out specifically in a statement, that statement only applies to an MPC-89 with CBS basket. A statement has been added to FSAR Section 1.1 clarifying this point (ADAMS Accession Number ML22192A221). Minor revisions are made to the text in subparagraphs 3.4.4.1.4a, 3.4.4.1.4b, and 3.4.4.1.4c to clearly differentiate between standard and CBS baskets where appropriate.

RAI 3-5

Clarify, in the SAR, which combinations of MPC vessels, basket designs, and overpacks are acceptable for the HI-STORM FW.

The SAR does not clearly state which MPCs, baskets, and overpacks are permitted to be used with one another. For example, SAR table 1.0.1 contains a note that "MPC-37P," referring to MPC-37P-CBS, is qualified for storage in the HI-STORM FW Version E overpack. This table does not include the UVH among the list of overpacks for the HI-STORM FW. SAR section 3.4.4.1.4a states that the tipover of "MPC-44," referring to the MPC-44CBS, is only postulated in the Version E overpack; while table 1.I.1.2 lists "MPC-44" as a principal component of the HI-STORM FW UVH system with a tipover analysis in HI-2210313, "Analysis of the Non-Mechanistic Tipover Event of the Loaded HI-STORM FW Version UVH Storage Cask."

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.230(a).

Holtec RAI Response:

In response to RAI 4-1 (ADAMS Accession Number ML22192A217), FSAR Table 1.0.1 was updated to clarify which MPCs, baskets, and overpacks can be used together (ADAMS Accession Number ML22192A221). It also directs the reader to Supplement I for information on the UVH overpack. Specifically, Table 1.I.1.2 has been updated to clarify that only the MPC-89 with the Standard basket, not the MPC-89CBS, may be used with the HI-STORM FW UVH Storage Cask. FSAR Table 1.0.1 has been updated further in response to this RAI to give the reader a clear understanding of which MPCs can be paired with which overpacks.

RAI 3-6

Provide a description and the results of the finite element analyses of the MPCs with CBS basket designs in the SAR.

The SAR merely refences other reports in lieu of describing the finite element models, input data, and results of these analyses. For example, sections 3.4.4.1.4b and 3.4.4.1.4c state that the details of the finite element models with CBS baskets, input data, and results are archived in HI-2094353, "Analysis of the Non-Mechanistic Tipover Event of the Loaded HI-STORM FW Storage Cask" and HI-2200503, "Analysis of the Non-Mechanistic Tipover Event of the Loaded HI-STORM FW Version E Storage Cask." The staff requests descriptions of these analyses be added to the SAR.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.230(a).

Holtec RAI Response:

Subparagraphs 3.4.4.1.4b and 3.4.4.1.4c of the FSAR have been updated to include descriptions of the finite element models, input data, and results of the tipover analyses for the MPCs with CBS basket designs.

RAI 3-7

Include the size of the bolt holes in the CBS and basket panel extensions in drawings for the CBS basket designs.

HI-2200503, appendices C and D, state that bolt holes in the CBS and basket panel extensions are sized to allow the shims to slide up against the basket panels without subjecting the bolts to shear loads. Neither the drawings nor SAR mention the size of the bolt holes which are necessary to achieve the behavior assumed in the tipover analyses.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.150.

Holtec RAI Response:

The drawings for the MPC-37CBS-P (Drawing 12283) and the MPC 44CBS (Drawing 12288) have been revised to include information relative to the bolt hole requirements to ensure that there is sufficient clearance around the bolt to allow the shims to slide up against the basket panels without subjecting the bolts to shear loads. The proposed revisions to the drawing are attached with this response.

RAI 3-8

Provide HI-2094353, "Analysis of Non-mechanistic Tipover and Drop Events of Loaded HI-STORM FW Storage Cask," Revision 18 or later.

SAR section 3.4.4.1.4b states that details of the tipover analyses for the CBS basket designs are archived in this calculation package. Revision 18 includes analyses of MPC-37CBS, which is needed for the staff's review of MPC-37P-CBS for this amendment.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(l).

Holtec RAI Response:

A copy of Holtec Report HI-2094353 Revision 19 is provided as an Enclosure to this RAI response submittal.

RAI 3-9

Provide the maximum total deflection of the fuel basket from the tipover analyses performed for the MPC-37CBS and MPC-44CBS basket designs and the HI-STORM FW UVH baskets. Include these results in the safety analysis report (SAR).

As described in chapter 2 of the SAR, the structural design criterion for the fuel basket is to limit the deflection of the basket panels to 0.5% of the cell width. However, the results reported in the SAR and calculation packages for the tipover analyses do not include the maximum total deflection of the fuel baskets. SAR sections 3.4.4.1.4b, 3.4.4.1.4c, and 3.I.3.8 and calculation packages HI-2200503, HI-2210313, and HI-2094353 all make the conclusion that the deflections in basket panels are less than the deflection limit, but results are not provided to support this conclusion. This information is necessary to support a finding that the storage system will satisfy the design criteria with an adequate margin for safety.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(c).

Holtec RAI Response:

Subparagraphs 3.4.4.1.4b, 3.4.4.1.4c, and 3.4.4.1.4d of the FSAR have been updated to include the maximum panel deflections and corresponding safety factors for the MPC-89 CBS, MPC-44 CBS, and MPC-37PCBS fuel baskets, respectively. The tipover analysis results for the MPC-37 CBS basket inside the HI-STORM FW Version E (which was added in Revision 9 of the HI-STORM FW FSAR) bound the results for the MPC-37P fuel basket for the reasons given in subparagraph 3.4.4.1.4d. Therefore, a separate tipover analysis is not performed for the MPC-37P fuel basket. Instead, the bounding results for the MPC-37 CBS basket are summarized in Table 3.4.19, along with those for the MPC-89 CBS and MPC-44 fuel baskets. The calculated safety factors for the maximum permanent deflection for all three CBS fuel baskets are well above 1.0. Lastly, Figures 3.4.9D, 3.4.12D, 3.4.12E, 3.4.15D, and 3.4.15E are also added to the FSAR as a result of this RAI.

To facilitate the staff's review of the MPC-37P CBS basket, the latest revision of Holtec calculation package HI-2200503, which contains the bounding results of the MPC-37 CBS tipover analysis in Appendix C, is provided as Attachment 7 to this updated RAI response submittal.

With regard to the HI-STORM UVH, the MPC-44 is the only CBS basket design that is permitted to be stored inside the overpack. Aside from the MPC-44, only the standard (non-CBS) versions of the MPC-37 and MPC-89 can be used with the HI-STORM FW UVH (see FSAR Table 1.I.1.2). Based on the plastic strain contours plotted in FSAR Figures 3.I.3.4 through 3.I.3.6 (added as part of Holtec's response to RAI 3-1, ADAMS Accession Number ML22210A149), the MPC-44 is the limiting basket design from a tipover perspective. This is because the visible plastic strain regions are more widespread, and the strain values are also higher for the MPC-44. Therefore, the MPC-44 has been chosen for additional post-processing to determine the maximum permanent deflection for direct comparison with the allowable limit in Table 2.2.11. The deflection results for the MPC-44, which are considered bounding for the MPC-37 and MPC-89 inside the HI-STORM FW UVH, have been incorporated in Section 3.I.3.8 of Supplement 3.I. Table 3.I.3.12 is also added.

RAI 3-10

Clarify what parameter is measured to demonstrate that the maximum total deflection design criterion for the fuel basket is met and describe how it is measured in the finite element models for the tipover event. Update the SAR as necessary.

A variety of different terms for the parameter are used in different calculations and SAR sections. HI-220503 and HI-2210313 refer to "permanent deformation" adversely affecting fuel assemblies spacing. SAR section 2.2.3b refers to the "maximum plastic deformation" sustained by the fuel basket panels. SAR section 2.2.8 and SAR table 2.2.11 refer to "maximum total deflection." The term total deflection would seem to refer to elastic and plastic deformation, whereas permanent and plastic deformation would seem to discount the elastic deflection.

Holtec's position paper, DS-331, "Structural Acceptance Criteria for the Metamic-HT Fuel Basket," which is cited in SAR section 2.2.4 as the basis for the lateral deflection limit, states, "To prevent excessive plastic deformation, the maximum total deflection of the Metamic-HT panel under the most limiting condition of lateral loading expressed as the dimensionless factor theta is set equal to 0.005." DS-331 suggests that the design criteria of 0.005 in SAR table 2.2.11 should be for the maximum total deflection, not just plastic deformation.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(c).

Holtec RAI Response:

The structural performance of the Metamic-HT fuel baskets following a non-mechanistic tipover event is judged based on the plastic (or permanent) deflection of the fuel basket panels. To avoid confusion, the text in FSAR Section 2.2.8 and Table 2.2.11 have been revised to change the term "maximum total deflection" to "maximum permanent deflection". The method of computing the maximum permanent deflection from the finite element results is described in the notes that accompany Table 3.4.19 of the FSAR. The following paragraphs further discuss the origin of Holtec position paper DS-331 and the reason why the design criterion for the fuel basket is measured in terms of its permanent deflection.

The position paper DS-331, which is included as a reference in the HI-STORM FW FSAR, was originally created in support of the initial qualification of Metamic-HT as a basket material. Since the material is not an ASME material, the previous stress-based acceptance criteria used for stainless steel baskets were no longer appropriate. One of the early uses of the position paper was in the HI-STAR 180D transportation application. The position paper is a reference in that cask SAR (ML14203A275), which uses the "maximum total deflection," criteria of 1mm. It was clear in this review that maximum total deflection referred to the permanent deformation only, as the HI-STAR 180D SER (ML14211A027) states:

> "For the fuel basket, the acceptance criteria include: (1) Permanent deformation is limited to 1 mm between adjacent plates after a package free drop."

Metamic-HT was then added to the HI-STORM 100 storage Certificate of Compliance for the MPC-68M (in Amendment 8). That system FSAR (ML13246A040) refers to the same position paper and uses a non-dimensional "maximum total deflection" limit of 0.005, and notes it is applicable to the active fuel region. Any minor locations of plastic strains are not quantified as permanent deformations to be compared to the limit, as the SER (ML12132A081) clearly states:

> "In order to ensure compliance with the dimensionless deformation limit (defined as the maximum total deflection sustained by the basket panels under the loading event over the nominal inside (width) dimension of the storage cell) of 0.005 set forth in the FSAR (Table 2.III.4) the applicant performed a finite element analysis applying a 70 g deceleration on the basket. The calculated results show only small plastic strains that do not significantly alter the basket structure. This demonstrates a significant margin between available basket strength and the design basis loads."

The HI-STORM FW FSAR clearly states that it is built on previous experience with licensing Metamic-HT fuel baskets, including the HI-STAR 180D and the HI-STORM 100 (i.e., MPC-68M). Therefore, Holtec has treated the deflection limit for MPC fuel baskets in Section 2.2.8 as consistent with those earlier applications, and only applied it to permanent deflections.

Based on the overall Metamic-HT licensing history across dockets, as well as the HI-STORM FW FSAR itself, it is clear that the limit on basket deflection applies to plastic deformation, and that as long as the plastic deformation is outside the active fuel region or confined to localized areas inside the active fuel region, no further quantification of the deflection has been needed in the past to demonstrate compliance with the limit.

With that said, Holtec has taken this opportunity to amend Holtec position paper DS-331 to include further discussion and a more complete technical basis for the non-dimensional "permanent" deflection limit of 0.005. The enhanced version of Holtec position paper DS-331 is provided as Attachment 6 to this updated RAI response submittal. In addition, Section 2.2.8 of the HI-STORM FW FSAR has been updated to refer to the latest revision (Rev. 2) of the position paper.

<u>RAI 3-11</u>

Provide results from the tipover analyses to justify the conclusion that the basket shims remain attached to the baskets and maintain their physical integrity for the MPC-37CBS and MPC-44CBS basket designs and the HI-STORM FW UVH.

SAR sections 3.4.4.1.4b, 3.4.4.1.4c, and 3.I.3.8 state this conclusion. However, the SAR sections and the calculation packages describing the finite element analyses of the tipover event do not include results for the basket shims and the bolts or welds connecting the baskets to the shims.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(c).

Holtec RAI Response:

The non-mechanistic tipover event causes only localized plasticity in CBS with no material failure and no gross deformation. Local yielding of the CBS shims is permissible provided that the fuel basket satisfies the maximum deflection limit in FSAR Table 2.2.11 (which is further addressed in the responses to RAI 3-9 and RAI 3-10). The Von Mises stresses in the CBS (within the active fuel region) are plotted in Figure N.9-1A of Holtec report HI-2094353 (rev. 19), Appendix N for the MPC-89 CBS, and in Figure D.11 of Holtec report HI-2200503 (rev. 5), Appendix D for the MPC-44 CBS inside HI-STORM FW Version E. A similar stress plot for the MPC-44 CBS when stored inside HI-STORM FW UVH is shown in Figure 12-38 of Holtec report HI-2210313 (rev. 1).

Except for a handful of localized areas, the maximum stress in the basket shims for the MPC-89 CBS and the MPC-44 CBS inside the HI-STORM FW Version E is less than 21 ksi. By comparison, the yield strength and ultimate strength of the CBS material (aluminum alloy 2219-T8511) at 500°F are 22 ksi and 26 ksi, respectively, per FSAR Table 3.3.7. For the MPC-44 CBS inside the HI-STORM FW UVH, the stresses in the basket shims are generally below 14 ksi, but the metal temperature is slightly higher at 550°F, lowering the yield strength and ultimate strength to 14 ksi and 17 ksi, respectively.

For the MPC-37/37P CBS, the Von Mises stresses in the CBS are plotted in Figure C.11-1 of Holtec report HI-2200503 (rev. 5), Appendix C. The localized peak stress in the basket shims is 15.7 ksi, but the primary stress throughout the shims is below 14 ksi, which is less than the yield strength of the CBS material at 550°F. To facilitate the staff's review of the MPC-37P CBS basket, the latest revision of Holtec calculation package HI-2200503, which contains the bounding results of the MPC-37 CBS tipover analysis in Appendix C, is provided as Attachment 7 to this updated RAI response submittal.

In summary, the CBS maintain their physical integrity during a tipover event as the stresses in the basket shims are mainly below the yield strength with only limited permanent deformation. To substantiate this conclusion, the above referenced stress contour plots for the CBS shims have been added to Chapter 3 of the HI-STORM FSAR as Figures 3.4.46A, 3.4.46B, 3.4.46C, and Figure 3.I.3.13 of Supplement 3.I.

See the response to RAI 3-12 for more information on the bolts connecting the baskets to the shims. None of the CBS basket designs utilize welds to connect the baskets to the shims.

RAI 3-12

Justify the assumption that the basket panels transfer shear load to the shims without inducing shear in the bolts and justify the lack of a bolt analysis for the bolts connecting the shims to the basket panel extensions for the continuous basket shim (CBS) basket designs.

The calculation packages for the tipover analyses of the CBS basket designs state that the CBS bolt holes allow basket panels to slide up against shims without subjecting bolts to shear loads. This assumed behavior should be described and justified in the SAR. It is unclear if the size of the bolt holes, the displacement of the basket panel extension relative to the shims needed to transfer load without engaging the bolts, or the bolt torque and friction resisting sliding of the components will allow the assumed behavior; particularly in locations where the basket panels are not continuously supported by hollow CBS basket shims. Additionally, discuss if there are any other loads observed in the bolts from the tipover or other normal, offnormal, or accident conditions requiring a bolt analysis.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(c).

Holtec RAI Response:

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PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390

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With respect to the full scope of normal, off-normal, and accident loadings, as defined in Section 2.2 of the HI-STORM FW FSAR, the only loading conditions that cause some level of stress in the CBS attachment bolts are dead weight and normal handling. When the MPC is being lifted vertically or when the MPC is at rest inside a freestanding HI-STORM/HI-TRAC, the CBS attachment bolts must be capable of supporting the dead weight of the CBS. The weight of an individual CBS, however, is very small, and therefore the induced stress is the CBS attachment bolts is only a small fraction of the material yield strength. More precisely, for the MPC-37P and MPC-44, the heaviest CBS weighs less than 300 pounds. Assuming that the full weight is resisted by only one (1) 0.5" diameter bolt, the average shear stress in the bolt is only 1.53 ksi [= 300 lb / ((0.5 in)^2 × π/4)]. By comparison, the CBS attachment bolts are made from Alloy X (see FSAR Table 3.3.1), which has a material yield strength of 18.3 ksi at 600°F. Therefore, the CBS attachment bolts have ample strength to resist the suspended weight of the CBS.

Finally, to insure that the CBS attachment bolts are installed properly during basket assembly, the licensing drawings for the MPC-37P (Dwg. 12283) and MPC-44 (Dwg. 12288) have been revised to add the following note:

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PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390

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RAI 3-13

Justify the modeling assumption to use nodal constraints to tie the basket shims to the basket panel extensions at the bolt hole locations in tipover analysis of the CBS basket designs, instead of explicitly modeling the CBS basket bolts. Update the SAR as necessary.

The calculation packages for the tipover analyses of the CBS basket designs state the above assumption. Using a nodal constraint to tie the basket shims to the basket panel extensions would seem to conflict with previously mentioned assumptions that loads will not form in the bolts. Additionally, this assumption should be discussed in the SAR.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(c).

Holtec RAI Response:

As discussed above in Holtec's response to RAI 3-12, the CBS attachment bolts are not in the load path during a non-mechanistic tipover event. Rather, the design of the CBS baskets is such that the inertial load of the CBS basket and its stored contents, during a tipover event, is transmitted to the MPC enclosure vessel through direct bearing contact between the fuel basket, the CBS and the MPC shell. Therefore, as long as the CBS are positioned correctly and proper contacts are defined between the interfacing parts, there is no need to explicitly model the CBS attachment bolts for the tipover analyses of the CBS basket designs.

In the LS-DYNA finite element model, this is accomplished by placing the individual CBS components in direct contact with the adjacent basket panels, with zero initial gap between them, at the start of the tipover simulation. To prevent the CBS from moving relative to the fuel basket in the longitudinal direction (i.e., parallel to the MPC centerline axis), during the course of the impact event, the basket shims and the basket panel extensions are also tied together using nodal constraints at a select few locations. This modelling approach captures the design function of the CBS attachment bolts in a simple and effective way, with no adverse effect on the tipover results.

Subparagraph 3.4.4.1.4b of the HI-STORM FW FSAR has been updated to indicate the modelling approach for the CBS attachment bolts.

RAI 3-14

Demonstrate that the combined radial gap between the basket, shims, and enclosure vessel is sized to ensure that no significant thermal stresses develop that would cause distortion in basket panels. Include a description of this evaluation in the SAR.

The application sections 3.1.1(i) states, "a small, calibrated gap designed to prevent significant thermal stressing associated with the thermal expansion mismatches between the fuel basket, the basket support structure, and the MPC shell." However, it is not clear if this was assessed for the CBS basket designs.

Additionally, explain why drawings for the MPC-44CBS and MPC-37P-CBS do not include the language from Note 4 regarding the sizing of the basket panel extensions to allow for unrestrained differential thermal expansion that drawings for other CBS designs contain.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(l).

Holtec RAI Response:

The radial thermal growth between the basket, the shims, and the enclosure vessel for all MPC types, including CBS basket designs, is evaluated in Section 4.4.6 of Chapter 4. The results of the evaluation are summarized in Table 4.4.6. The results presented in the table are the limiting results for all licensed MPC types, and all permissible combinations of MPC and storage overpack per the FSAR. As stated in FSAR Subsection 3.1.1, the design objective for the MPC is to mitigate thermal stresses due to differential thermal expansion (DTE) between the fuel basket and the MPC shell by providing a prescribed nominal gap at their interface locations. If thermal stresses arise, then they are evaluated according to the stress criteria per ASME, Section III, Subsection NB.

For some basket designs, specifically the MPC-37 CBS and MPC-89 CBS, the differential expansion slightly exceeds the minimum combined radial gap at maximum design basis heat load. Per Table 4.4.6, the worst-case basket interference is 0.0195” (or 19.5 mils) in the radial direction (i.e., 0.0625” – 0.082” = –0.0195”). The potential small basket-to-shell interference in the radial direction due to differential thermal expansion is acceptable as discussed in Subsection 3.4.4 of Chapter 3.

On the other hand, for the MPC-37P CBS and MPC-44 CBS, the differential thermal expansion at maximum design basis heat load is less than the minimum combined radial gap. Therefore, there are no thermal stresses due to restraint of free thermal expansion.

There is no technical reason why the language in Note 4 of the licensing drawings for the MPC-37P CBS and MPC-44 CBS is different from other basket drawings since the basket panel extensions are in fact sized to allow for unrestrained differential thermal expansion. For the MPC-44 CBS, this is confirmed in Appendix Z of Holtec report HI-2094400, which shows that radial thermal growth for the MPC-44 CBS basket, at maximum design basis heat load, is less than the minimum cold gap specified in Holtec report HI-2200285, “Dimensional Report for MPC Version CBS Baskets for the HI-STORM System” (which was previously submitted to the NRC as Attachment 9 to Holtec Letter 5018083). For the MPC-37P CBS, differential thermal expansion is evaluated in Appendix C of Holtec report HI-2210379, which also concludes that minimum cold gap per HI-2200285 is greater than the radial thermal growth (i.e., no restraint of free thermal expansion).