February 15, 2000

Mr. Brian Gutherman, Licensing Manager
Holtec International
Holtec Center
555 Lincoln Drive West
Marlton, NJ 08053

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION ON HIGH SEISMIC TOPICAL REPORT (TAC NO. L22966)

Dear Mr. Gutherman:

On December 10, 1998, Holtec International requested review and approval of Holtec Report Number HI-982004, Revision 0, "Topical Report on HI-STAR 100 and HI-STORM 100 System Deployment at High ZPA ISFSI Sites." To complete our review of the topical report and prepare a safety evaluation report, we need the information identified in the enclosed Request for Additional Information (RAI).

Please provide your response to this RAI by April 30, 2000. If you are unable to respond by this date, please notify us in writing, at least two weeks in advance, of your new submittal date and the reasons for the delay.

If you have any comments or questions concerning this request, you may contact me at (301) 415-8531. Please refer to Docket Nos. 72-1008 and 72-1014 and TAC No. L22966 in future correspondence related to this request.

Sincerely,

ORIGINAL SIGNED BY /s/

Marissa G. Bailey, Project Manager
Spent Fuel Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket Nos. 72-1008, 72-1014

Enclosure: Request for Additional Information - 2

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REQUEST FOR ADDITIONAL INFORMATION - 2

Topical Report on HI-STAR 100 and HI-STORM 100 System Deployment at High ZPA ISFSI Sites Holtec Report No. HI-982004

Chapter 1 Introduction and Scope

1-1 Explicitly state the scope of this Topical Report. Specify the conditions that the users (the certificate holder, general licensee or site-specific licensee) must satisfy or address to reference or implement the methodology discussed in this Topical Report.

The Topical Report should have a clear description of its purpose and scope. The response to Round 1 request for additional information (RAI) 1-1 (Singh, 1999) states that the "topical report has been submitted to obtain NRC approval of an analysis methodology and anchorage designs for deployment of the HI-STAR 100 and HI-STORM 100 spent fuel storage systems at ISFSI's with site design basis seismic accelerations higher than those currently included in the Topical Safety Analysis Reports (TSARs) and Certificates of Compliance (CoC) for these storage systems." A similar statement should be included in the Topical Report.

1-2 Clarify that the "60g" and "40g" limits, stated with reference to spent nuclear fuel fragility issues (page 1-7 of the Topical Report), are not the upper bound limits for the seismic loads, but are limits for a one time drop event only.

Although the Topical Report "... does not deal with spent nuclear fuel fragility issues," the upper bound load limits specified imply that they are acceptable design basis earthquake loads, which may subject the fuel to repeated impact loading. The upper bound limits stated in the TR for the HI-STAR and HI-STORM casks may occur during a drop event only, and are not the design basis upper bound earthquake loads.

RAI-2

Chapter 2 Structural Definition of HI-STAR 100 and HI-STORM 100

2-1 In Table 2.2 of the Topical Report, include data on the axial gaps between (i) the spent nuclear fuel and multi-purpose canister (MPC) and (ii) the overpack and MPC, for the latest revisions of the HI-STAR 100 and HI-STORM 100 cask TSARs.

This information is required to verify that proper values of axial gaps have been used in the respective HI-STAR 100 and HI-STORM 100 anchor system dynamic analyses and to evaluate compliance with 10 CFR 72.122(b).

2-2 Update Table 2.2 of the Topical Report to reflect the dimensions and other relevant data associated with the latest revisions of the HI-STAR 100 and HI-STORM 100 cask TSARs.

The staff needs the latest information to verify that the models used in the dynamic analyses of the HI-STAR 100 and HI-STORM 100 anchor systems are consistent with the design specifications contained within the TSARs of the respective casks and to evaluate compliance with 10 CFR 72.122(a) and (b).

RAI-2

Chapter 3 General Design and Construction Requirements for the Pad

3-1 **Include a reference to 10 CFR 72.102 wherever a reference to 10 CFR 72.212 is made in the Topical Report.**

Because the proposed anchor systems may be used under either a general license or a site-specific license, a reference to 10 CFR 72.102 should be added wherever there is a reference to 10 CFR 72.212 in the Topical Report.

RAI-2

Chapter 4 Structural Design Requirements for the Concrete Slab

4-1 Provide clarification as to how the characteristic shear modulus of subbase below subgrade parameter listed in Table 4.1 of the Topical Report is used in the design of the independent spent fuel storage installation (ISFSI) pad.

The staff needs this clarification to ensure that the design methodologies and procedures set forth in the Topical Report are comprehensive and complete and to evaluate compliance with 10 CFR 72.122(b).

4-2 Provide a complete and thorough summary of the (i) pad-anchor-cask interface design forces, (ii) anchor and cask component spring constants, (iii) cask component mass moments of inertia, (iv) acceptable cask carry heights, and (v) all other design data relevant to the analysis and design of the site-specific ISFSI pad.

This summary is needed to (i) ensure the information required to analyze and design the site-specific ISFSI slab is readily available, (ii) facilitate the staff review of the Topical Report, and (iii) evaluate compliance with 10 CFR 72.122(b).

4-3 Include the bounding maximum value for the Modulus of Elasticity of the subgrade in Table 4.1 instead of the maximum characteristics standard Subgrade Modulus value.

Because the maximum value of the Modulus of Elasticity of the subgrade is used in the analysis to verify the deceleration limits, it would be appropriate to use the Modulus of Elasticity limit in Table 4.1, instead of the Subgrade Modulus.

RAI-2

Chapter 5 Design Basis Loadings

5-1 Address an apparent contradiction between the design basis loading set forth in the Topical Report and the models used for dynamic analyses of the HI-STAR 100 and HI-STORM 100 anchor systems.

The following statement is made on page 5-1 of the Topical Report:

> "Because of potential soil-structure interaction effects, a site-specific design basis, also known as free-field or control motion, may be markedly different from the earthquake motions at the top of the storage pad. For the purpose of establishing controlling seismic loadings for subsequent dynamic analyses, the seismic inputs defined from the postulated response spectra set are considered to act at the top surface of the slab."

The assumption of a rigid pad would clearly place the seismic design-basis event (DBE) at the top surface of the pad. Treating the pad as a rigid body eliminates the need to consider the effective stiffness of the concrete, rebar, and subbase soils that are to be addressed in the site-specific license application, as is the apparent intent (page 5-1 of the Topical Report). The descriptions provided in the Topical Report of the HI-STAR 100 and HI-STORM 100 lumped mass models that were used for the dynamic analyses clearly show, however, that the stiffness of the concrete pad was taken into account, indicating that the pad has been treated as a deformable body (see pages B-7 and B-12 of the Topical Report). Because the spring constant of the concrete pad was assembled with the spring constants representing the HI-STAR 100 and HI-STORM 100 anchor systems, the seismic DBE motion can be construed to have been applied at a location other than the top surface of the pad.

The staff needs this clarification to verify that the models used for dynamic analyses of the HI-STAR 100 and HI-STORM 100 anchor systems are consistent with the design specification set forth in the Topical Report and to evaluate compliance with 10 CFR 72.92(a), 72.122(b), and 72.236(b).

5-2 Provide breakpoint tables for the three axes of the new design basis spectra provided by Pacific Gas and Electric Company that was identified in the response to Round 1 RAI 5-1 (Singh, 1999).

This information is necessary to assess the adequacy of the design basis earthquake event and to verify compliance with 10 CFR 72.92(a) and (c) and 72.102(b).

RAI-2

5-3 Provide digital files of the time histories for the three axes of the new design basis spectra provided by Pacific Gas and Electric Company that was identified in the response to Round 1 RAI 5-1.

This information is necessary to assess the adequacy of the design basis earthquake event and to make a determination of compliance with 10 CFR 72.92(a) and (c) and 72.102(b).

RAI-2

Chapter 6 Factored Loads

6-1 Clarify which codes and/or standards are being used to define the allowable stresses for the clevis components of the HI-STAR 100 anchor system.

Section 9.3 of the Topical Report indicates that the AISC Manual of Steel Construction (American Institute of Steel Construction, 1991) will be used to define the allowable stresses for the clevis components of the HI-STAR 100 anchor system. In Section 6.4 of the Topical Report, however, it is asserted that:

> "The attachment bolts connecting HI-STAR [100] to the steel interface structure and the clevis pins...are not explicitly covered by the AISC manual or by NUREG–1567 [Nuclear Regulatory Commission, 1996]. We consider these components to be governed by the ASME [Boiler and Pressure Vessel (B&PV)] Code, Section III, [Sub]Section NF and Appendix F [American Society of Mechanical Engineers, 1998]."

This clarification is required for the staff to assess whether the design analysis procedures presented in the Topical Report are based on the appropriate design code and to verify compliance with 10 CFR 72.122(a) and (b).

6-2 Clarify the type and class support designation used for the HI-STAR 100 anchor system in the context of ASME B&PV Code, Section III, Division 1, Subsection NF, Table NF-3131(a)-1. Also clarify which analysis procedure was adopted.

Because the HI-STAR 100 anchor support is designed to meet Level D Service Limits, as defined in ASME B&PV Code, Section III, Subsection NCA, Subparagraph NCA-2142.4(b)(4), this clarification is required for the staff to assess whether the design analysis procedures presented in the Topical Report are consistent with the adopted design code and to verify compliance with 10 CFR 72.122(a) and (b).

6-3 Justify using ASME B&PV Code, Section III, Appendix F as the HI-STAR 100 anchor attachment bolt design basis under accident conditions.

ASME B&PV Code, Section III, Appendix F establishes the rules for evaluation of service loadings with Level D service limits. According to ASME B&PV Code, Section III, Subsection NCA, Subparagraph NCA-2142.4(b)(4):

> "Level D Service Limits are those sets of limits which must be satisfied for all Level D Service loadings identified in the Design Specifications for which these Service Limits are designated. These sets of limits permit gross general deformation with some consequent loss of dimensional stability and damage requiring repair, which may require removal of the component or support from service. Therefore the selection of this limit shall be reviewed by the Owner for compatibility with established system safety criteria."

This level of service limits implies that plastic deformation can be expected for those components designed according to the criteria contained in ASME B&PV Code, Section III, Appendix F. As a result, low-cycle fatigue may be an area of concern (see ASME B&PV Code, Section III, Division 1, Subsection NF, Mandatory Appendix NF-III and Article NF-III-3000).

This justification is required for the staff to assess whether the design analysis procedures presented in the Topical Report are consistent with the adopted design code and to verify compliance with 10 CFR 72.122(a) and (b).

6-4 In light of the observations made by the staff pertaining to the use of ASME Level D Service loadings as the design criteria for the HI-STAR 100 anchor system (see RAI 6-3), provide the technical basis for not taking into account the mandatory requirements of ASME B&PV Code, Section III, Division 1, Subsection NF, Mandatory Appendix NF-III.

Because ASME Level D Service loadings imply that plastic deformation can be expected for those components designed according to the criteria contained in ASME B&PV Code, Section III, Appendix F; the mandatory requirements of ASME B&PV Code, Section III, Division 1, Subsection NF, Appendix NF-III would appear to apply based on the following (Article NF-III-1000):

> "Energy absorbing material of linear-type pipe supports designed to Subsection NF which is designed to dissipate energy associated with dynamic piping movements by yielding, shall be constructed for services in accordance with Section III, Division 1, Subsection NF, as modified by this Appendix."

Because "welding shall not be permitted for fabrication and installation of energy absorbing support material," (Article NF-III-4000), using welds as primary load-carrying structural components under Level D Service loadings would appear to be prohibited. This is significant because both HI-STAR 100 and HI-STORM 100 high-seismic anchor systems rely on welds that are structurally in series with important-to-safety load-carrying components.

The staff needs to resolve this issue to ensure that the design analysis procedures presented in the Topical Report are based on the appropriate design codes and to verify compliance with 10 CFR 72.122(a) and (b).

6-5 Justify the use of the load combinations presented in Section 6.3 of the Topical Report for the design of the HI-STORM 100 sector lugs (Table 7-1 of NUREG–1567, page 7-55, states that "The load combinations for steel SSC [structures, systems, and components] apply to steel SSC important to safety that are not within the scope of the ASME B&PV Code, Section III, Division 1.")

Subarticle NF-1130 contained within ASME B&PV Code, Section III, Division 1, Subsection NF clearly indicates that the sector lugs of the HI-STORM 100 anchor system are within the scope of ASME B&PV Code, Section III, Division 1 jurisdiction. As a result, the load limits from NUREG–1567 employed as the design criteria for the HI-STORM 100 anchor system are inappropriate.

The staff needs to resolve this issue to ensure that the design analysis procedures presented in the Topical Report are based on the appropriate design codes and to evaluate compliance with 10 CFR 72.122(a) and (b).

RAI-2

Chapter 7 HI-STAR 100 Anchor System

7-1 Provide justification for not satisfying the design requirements of ACI 349-97 (American Concrete Institute, 1997), Appendix B.5.1 for the HI-STAR 100 anchorage system.

Appendix B.5.1 of ACI 349-97 states that "anchorage design shall be controlled by the strength of embedment steel unless otherwise specified in this appendix." Based on a simplified analysis, the allowable tensile load for the anchor bolts is greater than the pullout strength of the concrete. Consequently, the concrete will fail in a brittle manner prior to ductile failure of the anchor bolts, which is contrary to the requirements of ACI 349-97, Appendix B.5.1. Note that the pullout strength of the concrete was based on the projected area of the concrete shear stress cone.

The staff needs to resolve this issue to ensure that the design analysis procedures presented in the Topical Report are in conformance with the applicable design codes and to evaluate compliance with 10 CFR 72.122(a) and (b).

7-2 Identify all springs (in one quadrant only) used to model the connectivity of HI-STAR 100 cask overpack to the ISFSI storage pad according to Figure 7.2 in Chapter 7 of the Topical Report (Holtec International, 1998). Provide coordinates used in the evaluation of the coupling coefficients associating a given degree of freedom to a particular spring for all springs in the model.

The input data file for Run 251, submitted in response to Round 1 RAI 10-1 (Singh, 1999), shows eight sets of five compression-only springs, one tension-only spring, and two shear (tension and compression) springs connecting the cask overpack to the ISFSI storage pad. The connectivity diagram (Figure 10.3.2), provided in response to Round 1 RAI 10-3, shows only three compression springs instead of five.

Detailed information on the dynamic model is required to determine the adequacy of the model for design of the anchor systems and to verify compliance with 10 CFR 72.122(b).

7-3 Provide a complete bill of materials and associated specifications for the proposed anchor bolts connecting the HI-STAR 100 cask to the ISFSI pad.

The bill of materials in Figure 7.5 of the Topical Report does not contain the specifications for the anchor bolts. The bill of materials should provide (i) the anchor bolt material and (ii) the dimensions of the anchor bolts.

This information is required to evaluate compliance with 10 CFR 72.122(a) and (b).

RAI-2

Chapter 8 HI-STORM 100 Anchor System

8-1 **Provide a bill of materials and associated specifications for the proposed HI-STORM 100 anchor system.**

The bill of materials should provide the material types and dimensions of the components shown in Figures 8.3 and 8.4 of the Topical Report. This information is required to evaluate compliance with 10 CFR 72.122(a) and (b).

Chapter 9 Structural Materials And Stress Limits

9-1 Provide the relevant properties for the materials identified in Section 9.1 of the Topical Report (Holtec International, 1998) and the specific references used to obtain these properties.

Material properties are used to calculate the factors of safety under the various load conditions prescribed by the applicable codes and standards. This information is necessary to verify that the SSCs important to safety can withstand the effects of environmental conditions and natural phenomena as required in 10 CFR 72.122(b).

9-2 Provide the specific references used to obtain the material properties identified in Table 9.1 of the Topical Report.

Material properties are used to calculate the factors of safety under the various load conditions prescribed by the applicable codes and standards. This information is necessary to verify that the SSCs important-to-safety can withstand the effects of environmental conditions and natural phenomena as required in 10 CFR 72.122(b).

9-3 Justify the use of A-490 as the specified material for the 2-inch-diameter anchor bolts proposed to be used for the HI-STAR 100 and HI-STORM 100 anchor systems.

As identified in ASTM A-490 (American Society of Testing and Materials, 1997) and AISC Manual of Steel Construction (American Institute of Steel Construction, Inc., 1991), bolts using A-490 material are limited to ½ to 1½ in. in diameter. This justification is necessary to assess the adequacy of the materials used in the fabrication of SSCs important to safety and to determine compliance with 10 CFR 72.122(a) and (b).

9-4 Identify the year of the ACI 349 document (Reference 13 in Section 15), and verify that the allowable stress values for tension and shear for A-490 bolts, listed in Table 9.1 of the Topical Report, comply with the ACI 349-97, Appendix B requirements. Revise the footnote on page 9-2 as required.

The staff needs to resolve this discrepancy to ensure that the design analysis procedures presented in the Topical Report are based on the appropriate design criteria and to verify compliance with 10 CFR 72.122(a) and (b).

9-5 Identify which HI-STAR 100 and HI-STORM 100 anchor support components will have to be impact tested as required by the ASME B&PV Code, Section III, Division 1, Subsection NF, Subarticle NF-2300 (American Society of Mechanical Engineers, 1998).

This information is required (i) to ensure that the requirements of ASME B&PV Code, Section III, Division 1, Subsection NF will be met; (ii) to assess the adequacy of the materials proposed to be used in the fabrication of SSCs important to safety; and (iii) to determine compliance with 10 CFR 72.122(a) and (b).

RAI-2

9-6 Identify the welding material general requirements and required tests in the context of ASME B&PV Code, Section III, Division 1, Subsection NF, Subarticle NF-2400.

This information is required to ensure (i) that the requirements of ASME B&PV Code, Section III, Division 1, Subsection NF will be met; (ii) to assess the adequacy of the materials proposed to be used in the fabrication of SSCs important to safety; and (iii) to determine compliance with 10 CFR 72.122(a) and (b).

RAI-2

Chapter 10 Dynamic Analysis of the Cask

10-1 Justify why none of the HI-STAR 100 anchor system components were considered in the calculation of the compression spring constant.

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report (Holtec International, 1998) and to verify compliance with 10 CFR 72.122(b).

10-2 Justify the equations and load bearing areas used for estimating the HI-STAR 100 spring constants for the concrete and provide references.

The equation at the top of page B-7 of the Topical Report, which is employed to calculate the compressive spring constant of the concrete, uses only the area of the compression load carrying components of the HI-STAR 100 anchor system. Because the bearing stress will be distributed over the entire surface of the anchor base plate, it would be prudent to use the entire area of the base plate for estimating the compressive spring constant of the concrete.

The equation used to calculate the tensile spring constant of the concrete in Appendix B.7.2.6 on page B-12 of the Topical Report is not applicable to tensile loading of concrete. Moreover, given that the tensile load is transmitted to the concrete through the embedded plate, justification for not using the effective area of the concrete shear cone as defined in ACI 349-97 (American Concrete Institute, 1997) to calculate the tensile spring constant for the concrete is required. The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system.

This justification is necessary for the staff to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(a) and (b).

10-3 Provide the basis for using a solid cylindrical rod to calculate the spring constant for the HI-STAR 100 clevis bolt, which is a bolt with a cubic block head that has a cylindrical hole through its center, and is loaded transversely with respect to the longitudinal axis of the cylindrical hole (refer to Appendix B.7.2.1 of the Topical Report).

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-4 Provide the basis for assuming the HI-STAR 100 clevis pin is loaded by two concentrated forces, as opposed to a uniformly distributed load, when calculating its stiffness in Appendix B.7.2.2 of the Topical Report.

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-5 Demonstrate that the approximated anchor base plate spring constant calculated in Appendix B.7.2.3 of the Topical Report adequately represents the stiffness of this component.

This particular spring constant calculation will exhibit a fair amount of variation depending on the assumptions and approximations employed to do the calculation. Use alternative methods, including numerical methods, to demonstrate that the approximating techniques used to calculate the anchor base plate spring constant are adequate. The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 and HI-STORM 100 anchor systems. This information is necessary for the staff to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(a) and (b).

10-6 Clarify the diameter and length of the anchor bolts for the HI-STAR 100 cask system.

In Appendix B.7.2.4 of the Topical Report, the cross sectional area of the anchor bolts is calculated using a diameter of 1.875 in. These same anchor bolts are shown to be 2 inches in diameter in Figure 7.1 of the Topical Report. Moreover, an anchor bolt length of 38 inches is assumed. This length dimension was not given in Chapter 7 of the Topical Report. This clarification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-7 Provide the details of the methodology employed within the MathCad program "basket.mcd" used to calculate the mass moment of inertia for the MPC-32 basket.

The approximated mass moment of inertia will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 and HI-STORM 100 anchor systems. This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-8 Provide the technical basis for using the mass moments of inertia about the centroids of the fuel basket and overpack instead of the top surface of the pad where they are anchored.

The approximated mass moments of inertia will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 and HI-STORM 100 anchor systems. This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-9 Justify the exclusion of the axial gap between the fuel basket of the HI-STAR 100 cask and MPC (degrees of freedom 9 and 23) in the input data file for Run 251 that was provided in response to Round 1 RAI 10-1 (Singh, 1999).

The sensitivity study results presented in Table 10-2 of the Topical Report indicate that the resultant loads determined from the dynamic analyses are sensitive to the presence and size of gaps in the model. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-10 Justify the exclusion of the gap clearance between the clevis pin and concomitant clevis block components in the HI-STAR 100 dynamic analysis.

The sensitivity study results presented in Table 10-2 of the Topical Report indicate that the resultant loads determined from the dynamic analyses are sensitive to the presence and size of gaps in the model. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-11 Clarify whether the axial spring constants between the (i) MPC and fuel basket (degrees of freedom 9 and 23) and (ii) MPC and fuel (degrees of freedom 9 and 22) of the HI-STAR 100 cask system were defined properly in the DYNAMO data file that was provided in response to Round 1 RAI 10-1. It appears that the calculated spring constants, based on information provided in Appendix E of the Topical Report, were transposed in the aforementioned data file.

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 and HI-STORM 100 anchor systems. This clarification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-12 Provide input and output data files as originally requested in Round 1 RAI 10-1 for the nonlinear dynamic analysis of the HI-STORM 100 anchor system.

This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-13 Clarify whether run identifiers Run 112 and Run 113 in Table 10-6 of the Topical Report correspond to Run 010 and Run 020 for the HI-STORM 100 dynamic analyses.

The discussion provided in the text of the Topical Report (see page 10-11) gives the impression that the results obtained from these analyses are the same, but traceability of the results is in question because of the different designations. This clarification is required to ensure that the results presented in the Topical Report are consistent and correct and assess compliance with 10 CFR 72.122(b).

10-14 Provide the basis for excluding the motion of the internal masses within the HI-STORM 100 MPC from the dynamic analyses for the HI-STORM 100 anchor system.

Even though the HI-STORM 100 overpack is 50 percent more massive than the HI-STAR 100 overpack, this observation alone does not provide the technical basis for discounting the effects that the rattling motion of the masses inside the MPC may have on the anchorage system. This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-15 Justify the use of the Boussinesq solution to determine the axial stiffness of the fuel basket honeycomb structure of the HI-STAR 100 casks in Appendix E.

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-16 Justify the assumption that the lateral contact spring constant between the MPC and overpack is the same as the contact spring constant between the fuel basket and SNF assembly for the HI-STAR 100 dynamic analyses. The geometries and materials involved in the fuel basket and SNF assembly contact are different from those of the MPC and overpack contact.

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-17 Provide the technical basis for assuming that the contact spring constant between the MPC and the top of the HI-STAR 100 overpack is 10 times greater than what was derived for the bottom contact spring for the same components (Appendix E of the Topical Report).

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This information is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-18 Provide justification for not using the 0.31-inch cell half-gap between the SNF and MPC-68 fuel basket as the bounding value in the HI-STAR 100 dynamic analysis.

The sensitivity study results presented in Table 10.2 of the Topical Report demonstrate that the shear forces in the anchor bolts are sensitive to the radial gaps between the SNF and fuel basket. According to Table 10.1 of the Topical Report, the maximum half-gap between the SNF and fuel basket used in the sensitivity study for the HI-STAR 100 dynamic analysis was 0.2 in. Table 2.1.11 of the HI-STAR 100 Cask TSAR (Holtec International, 1999a), however, indicates that a cell half-gap of 0.31 in. exists between the MPC68 fuel basket and stainless steel clad SNF assembly. Even though the stainless steel clad SNF assembly weight is lighter than that used in the sensitivity analysis, it needs to be demonstrated that larger cell half-gaps between the SNF and MPC68 fuel basket are indeed bounded by the heavier SNF and smaller cell half-gap scenario.

This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-19 Justify using a 0.2825-in. radial gap between the overpack and MPC for the bounding value in the dynamic analysis of the HI-STORM 100 anchor system.

Table 2.2 of the Topical Report indicates that the overpack-to-MPC radial gap within the HI-STORM 100 cask is 0.2825 in. Drawing DRG.5014-1495, Sht. 2 of 6 and Sht. 5 of 6 provided in the HI-STORM 100 Cask TSAR (Holtec International, 1999b), however, indicate that the overpack-to-MPC radial gap is 0.5626 in. Results for the HI-STORM 100 anchor system dynamic analysis presented in Table 10.6 of the Topical Report demonstrate that the shear forces in the anchor bolts are sensitive to the radial gaps between the overpack and MPC. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-20 Justify using the full lengths of the anchor bolts to calculate their spring constants for the HI-STORM 100 and HI-STAR 100 systems.

The free length of the anchor bolts above the concrete should be used to determine their effective spring constants. The embedment length of the bolt should not be included in the determination of the stiffness because the bolts can be expected to become bonded with the surrounding concrete. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-21 Justify the assumption of using a 6-in.-diameter patch acting on an elastic half-space in Appendix G to calculate the overpack-to-MPC contact spring constant within the HI-STORM 100 cask.

The approximated spring constants will affect the results of the nonlinear dynamic analyses which, in turn, provide the loads used to size the individual components of the HI-STAR 100 anchor system. This justification is necessary to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-22 Verify that all arithmetic simplifications and calculations provided in the Topical Report have been accomplished correctly.

Spot checks of the arithmetic simplifications and calculations provided in the Topical Report identified the following errors:

(i) The second term of the denominator in the k_{shear} equation provided in Appendix B.7.3 of the Topical Report appears to be missing a factor of 0.33, and

(ii) The adjustment for the closure plate thickness in determining the fuel basket-to-MPC vertical contact spring constant for the top of the MPC was not calculated properly in Appendix E of the Topical Report (see page E4).

This verification is necessary for the staff to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

10-23 Justify the use of a cross section shape factor of 4/3 instead of 10/9 in Section B.7.3, page B-13 of the Topical Report.

Roark's Formulas for Stress & Strain (Young, 1989), Article 7.10 pertaining to beams of relatively great depth indicates that the appropriate cross section shape factor for solid circular sections is 10/9. This justification is necessary for the staff to assess the adequacy of the analysis methodology adopted in the Topical Report and to verify compliance with 10 CFR 72.122(b).

CHAPTER 11—STRUCTURAL ANALYSIS

11-1 Justify the methodology employed to establish the HI-STAR 100 clevis bolt and cask base plate engagement length provided in response to Round 1 RAI 11-2 (Singh, 1999).

The response to Round 1 RAI 11-2 indicates that the engagement length for the HI-STAR 100 clevis bolt and cask base plate was determined using the formulation provided in the Machinery's Handbook (Industrial Press, 1996). On review of Attachment 4 referenced in this response, however, the actual calculations were completed using a combination of the Screw-Thread Standards for Federal Services (National Bureau of Standards, 1991) and the ASME B&PV Code, Section III, Division 1, Appendix F (American Society of Mechanical Engineers, 1998).

The limiting stress criteria used in Attachment 4 is presumably based on the requirements of ASME B&PV Code, Section III, Division 1, Appendix F, Subparagraphs F-1335.1 and F-1335.2. These limiting stress criteria, which were used to justify the current engagement length of the clevis bolt, were not implemented properly. Specifically, the allowable tensile strength used to establish the allowable tensile bolt force did not take into consideration the 0.7 ultimate tensile strength multiplication factor required in ASME B&PV Code, Section III, Appendix F, Subparagraph F-1335.1. The reference to the special requirements pertaining to a "faulted condition event" cited in Attachment 4 could not be found in Appendix F.

Standard engineering practice typically entails the use of specific engagement length formulations to ensure that the bolt strength can be fully developed. Variations of these engagement length formulations can be found in the Machinery's Handbook, Federal Screw Thread Standard, or ASME B&PV Code, Section 8, Division 1, Subparagraph UG-43(g). The methodology used, as described in the response to Round 1 RAI 11-2, will not ensure that the bolt strength will be fully developed.

Moreover, credit was taken for the 0.125-in. filet radius at the base of the bolt as being part of the engagement length and no allowance was made for the 0.5-in. thickness of the HI-STAR 100 anchor top plate shown in Figure 7.2 of the Topical Report (Holtec International, 1998).

An adequate technical basis for the current engagement length of the clevis bolt has yet to be provided. The staff needs to verify that the design basis for the HI-STAR 100 anchor system is correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

RAI-2

11-2 Provide the technical basis for the 4 in.-anchor bolt and threaded coupling engagement length for the HI-STORM 100 anchor system shown in Figure 8.4 of the Topical Report (see RAI 11-1).

An adequate engagement length is required to fully develop the bolt strength. The staff needs to verify that the design basis for the HI-STORM 100 anchor system is correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

11-3 Provide the technical basis for the thickness of the nut at the top of the anchor bolt that is used to secure the sector lugs to the HI-STORM 100 anchor system as shown in Figure 8.4 of the Topical Report (see RAI 11-1).

An adequate engagement length is required to fully develop the bolt strength. The staff needs to verify that the design basis for the HI-STORM 100 anchor system is correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

11-4 Provide and account for strength reduction of the anchor components due to corrosion degradation in the context of the ASME B&PV Code, Section III, Subsection NCA, Subarticle NCA-3250.

The staff needs to verify that the design bases for the HI-STAR 100 and HI-STORM 100 anchor systems are correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

11-5 Clarification of the clevis bolt block bearing load evaluation procedure is required along with the rationale for assuming that the ASME B&PV Code, Section III, Appendix F, Subparagraph F-1334.10 does not apply.

The ASME B&PV Code, Section III, Appendix F, Subparagraph F-1334.10 states that "Except for pinned and bolted joints, bearing stresses need not be evaluated for loads for which Level D Service Limits are specified." Because the clevis bolt block is, in essence, supporting the bearing loads for the clevis bolt, it would appear that the requirements of Subparagraph F-1334.10 are applicable. To accomplish this task, the Topical Report uses a methodology that is inconsistent with the primary stress limit requirements of ASME B&PV Code, Section III, Appendix F, Subarticle F-1330 or Article A-9000. Moreover, the methodology used to evaluate the bearing capacity of the clevis bolt block on page 11-3 appears to be in error because (i) the projected area of the pin is calculated incorrectly for evaluating the compressive bearing stress, and (ii) the load bearing area used for tensile loading should correspond to the minimum cross section of the clevis bolt block. And finally, the results were provided for only one of the candidate materials that may be used for the clevis bolt. A complete evaluation for all potential materials is required.

RAI-2

The staff needs to verify that the design basis for the HI-STAR 100 anchor system is correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

11-6 Provide the rationale for not applying the allowable tensile stress requirements of ASME B&PV Code, Section III, Appendix F, Subparagraph F-1335.1 in full, for the stress analysis of the clevis bolts of the HI-STAR 100 anchor system.

ASME B&PV Code, Section III, Appendix F, Subparagraph F-1335.1 states, in part, that:

> "When high strength bolts or threaded parts having an ultimate tensile strength greater than 100 ksi at operating temperature are used in component applications, the maximum value of the stress at the periphery of the bolt cross section resulting from direct tension plus bending and excluding stress concentrations shall not exceed S_U [maximum tensile strength]. The bolt load shall be the sum of the external load and any bolt tension resulting from prying action produced by deformation of the connected parts."

The current tensile stress evaluation presented in the Topical Report is limited to consideration of the average tensile stress without bending. The staff needs to verify that the design basis for the HI-STAR 100 anchor system is correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

11-7 Justify the inequality relationships given on pages 11-21 and 11-22 of the Topical Report for the HI-STORM 100 cask. Specifically,

$$(9.66184 \times 10^{-9})Vh + 0.01961p \leq 1.0$$

and

$$(9.66184 \times 10^{-9})Vh + 0.01961p \leq 0.7843$$

This information is necessary to determine the adequacy of the specified bounds for hydrological pressure and impact loading conditions. Based on values given in Appendix J, the coefficients of the second term should be 0.03423. The staff needs to verify that the design basis for the HI-STORM 100 anchor system is correctly implemented, consistent with applicable codes and standards, and is in compliance with 10 CFR 72.122(b).

11-8 Justify the exclusion of φ in the equation for V_{c1} on pages K-5, K-7, L-5, and L-7, and its implications on the factors of safety identified in Appendices K and L of the Topical Report. Identify if the effective stress area used in the calculation is based on the base plate circular area on the surface of the slab or the base plate circumference times the depth of the embedment.

This information is necessary to determine the adequacy of the design of the "reference pad" under various loading conditions. As identified in Appendix B.4.2 of ACI 349-97 (American Concrete Institute, 1997), the design pullout strength of concrete for any embedment shall be based on a uniform tensile stress of $4 \varphi\sqrt{f_c'}$ acting on an effective stress area, but the analyses in Appendices K and L of the Topical Report do not take φ into account. The staff needs to verify that the design basis for the HI-STORM 100 anchor system is correctly implemented, consistent with applicable codes and standards, and to determine compliance with 10 CFR 72.122(b).

11-9 Verify that the sensitivity study results, reported in a January 5, 2000, Holtec letter, are based on the latest stiffness values, and describe how the results will be incorporated into the anchorage system design criteria.

Since the need for a sensitivity study was discussed in December 14, 1999, the need to revise the anchorage system stiffness values had been raised in subsequent discussions. Therefore, there is a need to confirm that the analysis/conclusions are based on the latest design, and that the study results are incorporated into the design, if appropriate.

CHAPTER 12—ACCEPTABLE CARRY HEIGHTS FOR HI-STAR 100 AND HI-STORM 100

No RAIs for this chapter.

CHAPTER 13—TECHNICAL SPECIFICATION

No RAIs for this chapter.

CHAPTER 14—INSTALLATION PROCEDURES

No RAIs for this chapter.

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