February 28, 2008

Ms. Tammy Morin, Licensing Manager
Holtec International
Holtec Center
555 Lincoln Drive West
Marlton, NJ 08053

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE HOLTEC INTERNATIONAL HI-STORM 100U SYSTEM AMENDMENT APPLICATION (TAC NO. L24085)

Dear Ms. Morin:

Holtec International's (Holtec's) original application requesting an amendment to its Certificate of Compliance (CoC) No. 1014 from the U.S. Nuclear Regulatory Commission (NRC) for inclusion of a subsurface design option to the HI-STORM 100 spent fuel dry cask storage system (HI-STORM 100U) was originally submitted in May 16, 2005. After an extended review history of the HI-STORM 100U concept, the staff was unable to reach any conclusions and findings based on the information provided by Holtec. Holtec requested that the HI-STORM100U application be withdrawn from consideration for approval on November 29, 2006. By letter dated April 27, 2007, Holtec re-submitted its HI-STORM 100U application, in accordance with 10 CFR Part 72.

The NRC staff has determined that we need additional information identified in the enclosure to this letter in order to complete our safety review of your application and determine compliance with the requirements of 10 CFR Part 72. When NRC staff discontinued its earlier review of Holtec's subsurface storage system concept, the staff provided Holtec an evaluation outlining the technical areas reviewed up to the time the review was discontinued and where the staff was unable to make requisite safety findings. This evaluation was forwarded by a letter dated January 24, 2007 (ADAMS No. ML070250251). This was done to facilitate a future NRC review should Holtec choose to resubmit this design concept for NRC approval.

However, as can be seen from the type of requests enclosed, the problematic areas noted in the January 24, 2007, letter were not adequately addressed in Holtec's April 27, 2007, re-submittal. Specifically, the staff still has significant questions related to both Holtec's structural and thermal analyses. Thus, it is clear to the staff that key design features of the HI-STORM 100U design and surrounding soil structures need to be clearly defined and constrained in order to certify it within the safety requirements of 10 CFR Part 72. In accordance with our standard review plan guidance, we have included questions to better define and constrain the HI-STORM 100U design structural features and surrounding features that are important to safety.

In accordance with 10 CFR 72.236(b) the approval and fabrication of spent fuel storage casks require that the "design bases and design criteria must be provided for structures, systems, and components important to safety." Further, 10 CFR 72.3, states that the "design bases means that information that identifies the specific functions to be performed by a structure, system or component of a facility or of a spent fuel storage cask and specific values or ranges of values chosen for controlling parameters as reference bounds for design…" Therefore, the enclosure to this letter includes several requests for specific design limitations rather than the broad design methodologies proposed (*e.g.*, Request No. C-6). These limitations are needed to bound the supporting analyses.

We ask that you provide the requested information by May 2, 2008. Please inform us in writing no later than 2 weeks prior to that date if you are not able to provide the information by the requested date, and include a new proposed submittal date to assist us in re-scheduling your review, if necessary. Assuming that these issues can be resolved expeditiously and without the need for a second request for additional information, the proposed CoC Amendment No. 6 and draft Safety Evaluation Report should be completed and forwarded for rulemaking in July 2008. We are ready to work with you to meet this goal, and as the next step, we suggest a meeting at the earliest opportunity to discuss the enclosed request for additional information.

In addition to information requested related to our safety review the staff has determined that we need additional information to complete our environmental review. Therefore, Holtec is requested, under the provisions of 10 CFR 51.60, to submit a supplemental Environmental Report (ER). This ER should address the potential environmental impacts that could result from the proposed action. Upon review of the ER, additional information may be needed to complete the environmental review.

Please reference Docket No. 72-1014 and TAC No. L24085 in future correspondence related to this licensing action. If you have any comments or questions, please contact me at (301) 492-3317.

Sincerely,

/RA/
Stewart W. Brown, Senior Project Manager
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 72-1014
TAC No. L24085

Enclosure: Request for Additional Information methodologies proposed (*e.g.*, Request No. C-6). These limitations are needed to bound the supporting analyses.

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Docket No. 72-1014

TAC No. L24085

Enclosure: Request for Additional Information

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HOLTEC INTERNATIONAL

DOCKET NO. 72-1014

REQUEST FOR ADDITIONAL INFORMATION

RELATED TO THE HI-STORM 100U SYSTEM

This request for additional information (RAI) identifies additional information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its safety review of the HI-STORM 100U application. The requested information is listed by chapter number and title in the applicant's Safety Analysis Report (SAR). NUREG -1536, "Standard Review Plan for Dry Cask Storage Systems," was used by the staff in its review of the application.

Each individual RAI section describes information needed by the staff to complete its review of the application and the SAR and to determine whether the applicant has demonstrated compliance with the regulatory requirements.

In addition, NRC staff has added a RAI section "Certificate of Compliance Comments" to specifically request information necessary to better delineate the design bases of the HI-STORM 100U system in order for the staff to determine compliance with the requirements of 10 CFR Part 72. Specifically, 10 CFR 72.236(b) requires for spent fuel storage cask approval and fabrication that the "design bases and design criteria must be provided for structures, systems, and components important to safety." Further, 10 CFR 72.3, states that the "design bases means that information that identifies the specific functions to be performed by a structure, system, or component of a facility or of a spent fuel storage cask and specific values or ranges of values chosen for controlling parameters as reference bounds for design…"

GENERAL COMMENT

G-1. Provide a copy of the proposed Certificate of Compliance (CoC) and Technical Specifications (TS) that include all the items requested to be included in the currently proposed amendment, and provide a Safety Analysis Report (SAR) containing all modifications needed to support the proposed CoC and TS.

The CoC, TS and SAR pages submitted for the currently proposed amendment are not consistent with all the changes sought for incorporation under this amendment. It is understood from the submittal letter that the current amendment request relies upon, in part, analyses and changes proposed for Amendment 5 to the HI-STORM 100 cask system; however, Amendment 5 is yet to be certified. It should also be noted that each amendment to a CoC is considered as codifying a new design basis for a cask; each CoC amendment is considered a separate and distinct design accompanied by its own TS. Therefore, the application should include a proposed CoC and TS clearly showing all that is being sought to be included in the CoC and TS for the currently requested amendment. Modifications to the SAR evaluations made to support the proposed CoC and TS should also be provided. The provided modifications should also reflect changes, or updates, from the Amendment 5 licensing activities that impact the current amendment request. Submittal of a CoC, the TS and a SAR showing these changes will ensure that the CoC and TS for the requested amendment incorporate all items sought by Holtec and that the necessary supporting evaluations are consistent with and do indeed support the application request. This information is needed to ensure compliance with 10 CFR 72.230(a) and 72.244.

1.I GENERAL DESCRIPTION

1-1. Define the material(s) comprising the pink areas included in the concrete region of the closure lid concrete in SAR Figure 1.I.6 and account for these materials in the SAR evaluations, as appropriate.

Figure 1.I.6 of the SAR includes vertical regions that extend from the closure lid base through the lid concrete to the lid top. However, the technical drawings only show concrete in this portion of the lid. The shielding model also only includes concrete. If other materials are also present in this region of the closure lid, these materials and their dimensions should be included in the technical drawings and appropriately addressed in the SAR evaluations. For example, the presence of different materials may result in radiation streaming that is currently unaccounted for in the present shielding evaluation. If this region is only concrete, Figure 1.I.6 should be modified to indicate this configuration. This information is needed to ensure compliance with 10 CFR 72.236(d).

3.I STRUCTURAL EVALUATION

3.1 Provide the diameter of the VVM Lateral Support Recessed Region into which the VVM will rest as shown in Section B-B of Drawing 4501, Sheet 3, Revision 2. This information is being requested to allow verification of modeling parameters for the structural analyses.

Section B-B, Sheet 3, Revision 2 illustrates a radial space between the 3 inches vertical face of the recess in the concrete support foundation and the 1 inch vertical face of the Cavity Enclosure Container (CEC) bottom plate, but there does not appear to be a dimension to define this space. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.2 Provide information regarding the capability of the external coating of the CEC to maintain its intended function in the area of the flexible joint with the surrounding concrete. Differential movement between the CEC and concrete could abrade the coating and expose the CEC shell. Subsequent moisture intrusion could corrode this area of the CEC shell.

Section 1.I.2.1 describes that all external surfaces of the VVM are coated with an appropriate surface preservative that is identified in Reference 3.I.10 as a polyamide-epoxy. The acceptance criteria for the coating identified in Section 3.I.4.1.i. does not directly address the ability of the coating to withstand abrasive conditions. The structural integrity of the CEC shell is necessary to ensure the capability of the inlet air ducts. This information is necessary to ensure compliance with 10 CFR 72.230(a) and 10 CFR 72.236(g).

3.3 Describe the criteria used for determining the correct “site-specific basis” inlet screen openings size and total perforation area adjustments that must be made within the area defined as 2 inch high and around the entire circumference of the closure lid, minus the portion of the circumference blocked by the closure lid radial ribs and there will be no dimensional changes to the structure of the closure lid. Also indicate how this design criteria will be controlled either via technical specification or other means to ensure that design requirements are met.

In Section 1.I.2.1.xi. (page 1.I-5) it is noted that a statement is made that indicates the surface area of the screen may be enlarged as a function of site-specific conditions. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.4 Describe the effect of not using the inside 3/8 inch fillet weld between the CEC bottom plate and the CEC shell on the results of the analyses current being reviewed.

Drawing 4501, Sheet 4, Revision 2 include the words “where possible” in the Section C-C weld note. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.5 Provide a discussion addressing any change in analyses results under review that would be a consequence of the design change of not anchoring the CEC. The CEC originally proposed in the Amendment 3, Revision 1 request in May of 2005, and carried in all proposed revisions to the SAR related to the HI-STORM 100U since that time until the Amendment 6 request of April 2007, at which time the concept is now a shear key for the entire CEC bottom plate with no anchorage.

Section 1.I.2.1 and Drawing 4501, Sheet 3, Revision 2 identify this concept. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.6 Provide information on the structural attachment or other support mechanism that has been integrated into the design of the divider shell that will retain the insulation on the outside face of the divider shell under all conditions in order to ensure that the inlet air passage remains open.

The licensing drawing set, identified as Drawing 4501 with six sheets, does not apparently provide the design of the connection between the divider shell and the insulation and there does not appear to be a description in the text information. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.7 Explain how the value of “K”, the minimum stiffness of the Support Foundation based on the configuration and other material properties are used in the calculations for the System for Analysis of Soil Structure Interaction (SASSI) analysis.

Table 2.I.2 does not provide the information. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.8 Describe, using appropriate calculations, specifically how the equivalent linear elastic soil properties generated by the SHAKE program were converted to elastic perfectly plastic soil properties for the LS-DYNA SSI analysis.

The HI-STORM FSAR Section 3.I.4.7.1, Design Basis Seismic Model, states that "A recognized Code, such as Shake 2000 or similar, shall be used to establish the seismic time-history profile of the substrate continuum…" Section 3.I.4.7.2 states that in the LS-DYNA Soil Structure Interaction (SSI) model "The substrate is modeled using solid elements with defined effective yield stress in the near field surrounding the VVM." The SHAKE program generates equivalent linear elastic soil properties using an iterative process based on the magnitude of the strain imposed on the soil by the input time-history. The SHAKE program does not generate elastic-plastic soil properties. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.9 Revise Section 3.I.4.7.1, Design Basis Seismic Model, to incorporate the guidance provided in ASCE Standard 4-98, Seismic Analysis of Safety-Related Nuclear Structures and Commentary, Section 3.3, Soil-Structure Interaction Modeling and Analysis, and ASCE/SEI Standard 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities. The NRC has endorsed both standards. This information is necessary to ensure compliance with 10 CFR 72.230(b).

3.10 Justify the omission of an evaluation of uncertainty in the SSI analysis.

The ASCE Standard 4-98, which is endorsed by the NRC, states: "The uncertainties in the SSI analysis shall be considered… Low strain shear modulus shall be varied between the best estimate value times (1 + Cv) and the best estimate value divided by (1 + Cv), where Cv is a factor that accounts for uncertainties in the SSI analysis and soil properties… When insufficient data are available to address uncertainties in soil properties, Cv shall be taken as no less than 1.0." This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.11 Provide the basis and criteria for establishing when substrate layers (soil to soil and soil to concrete/steel) become free to slide and separate. Provide copies of references cited in your response.

Section 3.I.4.7.1.viii, states that "The substrate shall be modeled using an appropriate material model and substrate layers of differing material type or density shall be free to slide and separate relative to one another (as appropriate)." This information is necessary to ensure compliance with 10 CFR 72.11.

3.12 Provide calculations showing how the moments and shear forces, which are necessary to establish the concrete thickness and steel reinforcement requirements of the Support Foundation, are calculated from the LS-DYNA model results.

The Support Foundation is modeled as a single padlet in the LS-DYNA SSI analysis. However, the moment and shear forces that would exist in a continuous Support Foundation model cannot be directly extracted from the LS-DYNA SSI model results. This information is necessary to ensure compliance with 10 CFR 72.230(a).

3.13 Provide: (1) calculations demonstrating that the concrete foundation in the SASSI SSI analysis remains uncracked for the various cases analyzed; (2) an evaluation of the foundation finite element mesh on foundation stiffness; and (3) the effect on response of using an upper bound foundation stiffness in the SASSI model.

The Support Foundation modeling assumptions used in the SASSI SSI analysis result in an upper bound stiffness for the foundation. These assumptions include the use of gross concrete properties and only one brick element thru the foundation thickness, with the former being the larger contribution to upper bound stiffness. While the assumption of gross concrete properties may be valid, no evaluation of bending stresses in the foundation was made to determine that the concrete remained uncracked. Furthermore, ASCE Standard 43-05, Section 3.4.1 states that "In lieu of a detailed stiffness calculation, the effective stiffness of reinforced concrete members provided in Table 3-1 shall be used in linear elastic static or dynamic analysis." From Table 3-1 the appropriate foundation stiffness would be half of the gross concrete stiffness. This information is necessary to ensure compliance with 10 CFR 72.230(a)

3.14 Provide a comparison of the Support Foundation accelerations from the SASSI analysis with those from the LS-DYNA analysis. [Note: No acceleration results were provided for the SASSI analysis.] This information is required to understand how each model amplifies the bedrock input motion. This information is necessary to ensure compliance with 10 CFR 72.11.

3.15 Provide justification for using a 30 inch thick foundation in the SSI analyses, particularly in light of the fact that the foundation modeling assumptions already included in the SASSI analysis lead to an upper bound on foundation stiffness.

Holtec Drawing 4501, Sheet 3, Revision 2, specifies a minimum Support Foundation thickness of 24". Both the LS-DYNA and SASSI analyses use a foundation thickness of 30". The 30" thick foundation is twice as stiff as a 24" foundation. This information is necessary to ensure compliance with 10 CFR 72.11.

3.16 Provide the basis for selecting the limits of the elastic-plastic substrate soil volume surrounding the VVM in the LS-DYNA model.

The only elastic-plastic substrate region in the LS-DYNA model extends vertically along the depth of the VVM and horizontally for a distance of approximately 4.5 feet around the exterior. This information is necessary to ensure compliance with 10 CFR 72.11.

3.17 Provide an explanation for the high concentration of strains at the bottom of the elastic plastic soil volume in the LS-DYNA model. Explain whether these strains are real and what modeling assumptions may have caused them.

In the LS-DYNA model the soil volume surrounding the VVM has elastic perfectly plastic material properties with a yield stress of 25 psi and yield strain of 0.13%. At the bottom of this soil volume the equivalent plastic strain in the SSI analysis reaches 25% along a horizontal strip approximately equal to the diameter of the VVM. This strain is almost 200 times the yield strain of the soil. This information is necessary to ensure compliance with 10 CFR 72.11.

3.18 Within the "I" sections of the FSAR describe each of the basic components of the load handling system that will transfer the MPC from the Transfer Cask to the underground VVM, and provide the specifications and standards to which all of the systems and components in the transfer load path shall be designed, fabricated, inspected and tested. Also, provide the specific verbiage that will be incorporated into the CoC to ensure that the load handling system complies with NUREG-0612 and all specifications and standards.

The single most challenging event to the integrity of the canister confinement boundary is the drop of the canister as it is being lowered from the HI-TRAC transfer cask into the underground VVM. This event is credible, since the probability of occurrence of such an event is greater than $1x10^{-6}$. In addition, this transfer takes place in the open environment outside of the secondary containment isolation system of the nuclear power plant and occurs for every canister transfer at every site where the underground system would be installed. No evaluation of this drop event to demonstrate confinement boundary integrity has been performed. Therefore, it must be demonstrated that all systems and components within the load path of the transfer operation meet the single failure proof guidelines of Section 5.1.6 of NUREG-0612. This information is necessary to ensure compliance with 10 CFR 72.230(a) and 10 CFR 72.236(b).

3-19 Clarify why and how the outlet vent height may be adjusted to suit site conditions. Clarify the type of site conditions that may affect the performance of the HI-STORM 100U storage system and require change of the outlet vent height. Describe how the vent height limits will be controlled via technical specification or other means to ensure that design requirements are met.

General Note 18 on Sheet 1 of drawing No. 4501 of the SAR states that the outlet vent height can be increased to suit site conditions. The height of the outlet vent may affect the thermal performance of the design. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

3-20 Provide a discussion explaining the relevance of the comparison between the SASSI SSI model and the LS-DYNA SSI model given that the two models are so drastically different.

In the HI-STORM-100U design multiple VVMs will be placed on a continuous reinforced concrete Support Foundation. Consistent with this design, the SASSI

SSI model consists of an array of 25 VVMs on a continuous foundation with all VVMs anchored to the foundation. Although, as discussed in other RAIs, the SASSI model of the foundation may not reflect the foundation's actual flexibility, it is geometrically true to the design.

In contrast to the SASSI model, the LS-DYNA model consists of a single VVM on a concrete pad not much larger than the diameter of the VVM, to which the VVM is not anchored. In the previous LS-DYNA SSI analysis submitted to the staff, the VVM was anchored to the foundation, and the foundation extended significantly beyond the VVM to such an extent that it approximated a continuous foundation, unlike the small pad in the current submittal.

Also, the comparison of the CEC shell ovalization between the SASSI and LS-DYNA models suffers from a modeling inconsistency with respect to how the CEC is constrained at the top of the shell in the two models. In the SASSI model ovalization is completely restrained while in the LS-DYNA model ovalization is free to take place. On this basis alone, with all other things being equal, one would expect much more ovalization to take place in the LS-DYNA model. This information is needed to assure compliance with 10 CFR 72.236(b).

4.I THERMAL EVALUATION

4-1 Perform Computational Fluid Dynamics (CFD) analyses to include the effect of surrounding VVMs on a limiting VVM located in the center of a typical ISFSI layout (for example a 5x5 array of VVMs.)

Figure 1.I.3 of the SAR implies that HI-STORM 100U is deployed on a site based on 2x5 arrays, which the staff assumed the thermal analyses was based upon. However, sheet 2 of drawing 4501 states that a typical ISFSI layout may consist of a larger array (e.g., 5x5, 5x8, etc). Also, Section 3.I.4.7.3 of the SAR states that the effect of multiple VVMs, and the effect of pattern loading on the VVM responses directly affecting MPC retrievability is evaluated by considering a representative 5x5 array of VVMs and varied loading patterns. Page 4.I-3 of the SAR states that access to ambient air is artificially restricted in the model by erecting a vertical cylinder above the VVM. It also states that the artificial cylinder is open at the top to allow air ingress and exit. In this manner lateral access to air is blocked and the potential for hot air mixing above the VVM is maximized. Holtec's developed model does not include the thermal effect of other VVMs on the air inlet and outlet vents of a VVM located on a thermally limited location or radiative heating from other VVMs. Assuming an array as large as a 5x5 could result in cooling air mixing more rapidly with hot air which would elevate the VVM inlet temperature and subsequently the peak cladding temperature. Considering a bounding wind speed of 1 mile per hour (see RAI 4-2), this will clearly result in peak cladding temperatures higher than the allowable limit. The revised analytical model to address the 5x5 array can be simplified, but the thermal effect of other casks should be included. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

4-2 Justify why a permissible limit of 1058°F for off-normal events is appropriate to evaluate the effect of wind on peak cladding temperature.

A steady state sustained wind speed of 5 miles per hour (mph) appears to be a normal site condition rather than an off-normal condition. Therefore, it appears that the normal permissible temperature (752°F) should be used for normal wind conditions. Page 11.1-1 of HI-STORM 100 FSAR Revision 1 states that off-normal operations, as defined in accordance with ANSI/ANS-57.9, are those conditions which, although not occurring regularly, are expected to occur no more than once a year. However, it appears that low wind speeds (*e.g.*, $\leq$ 5 mph) would occur much more frequently than once a year.

Also, provide the results from CFD calculations to show the limiting wind speed. The thermal analyses results provided by Holtec considered four discreet values for wind speed at 0, 5, 10, and 15 mph. From these thermal results it appears that a limiting wind speed may be in the range of 0 to 5 mph. As shown in Tables 4.I.2 and 4.I.7 of the SAR there is a significant increase in peak cladding temperature between 0 and 5 mph for the MPC-32 case. Based on additional calculations performed by the staff using Holtec's developed CFD model, the staff's results show that a limiting wind speed may fall in the range of 0 to 5 mph for normal conditions (e.g., 1 mph wind speed analysis results in approximately a peak cladding temperature of 752°F). This trend is also observed by reviewing the Holtec's results where the peak cladding temperature increases as wind speed decreases.

Finally, provide the results of a thermal response evaluation of the HI-STORM 100 U storage system for off-normal wind speed conditions based on the definition of off-normal wind speed (*e.g.*, wind speed as high as 60 mph). Page 4.I-6 of the SAR states that the wind model is used to compute fuel temperatures at several winds speeds and that the results show large margins of safety with respect to the off-normal fuel cladding temperature limits. However, the SAR only shows results up to 15 mph. Holtec should show results that include higher wind speed values to demonstrate the claim that predicted peak cladding temperature decreases as wind speed increases. Although a strong wind may appear to provide an additional cooling effect over the HI-STORM 100U lid, it is not clear whether higher wind speed could actually limit the system's cooling capability, by preventing circulating cooling air flow into and out of the VVM through the inlet and outlet vents.

This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

4-3 Provide a discussion explaining the adequacy of specifying a velocity inlet boundary condition for the wind effect case.

In review of the applicant's Fluent model, there is a warning on the console window stating that velocity inlet boundary conditions are not appropriate for compressible flow problems, and advises the user to change the boundary condition type for the problem being considered. The SAR should provide a general discussion of how error, warning, or advisory messages affect the analysis result. In addition, the Fluent User's Guide (Fluent Inc. September 29, 2006) states that "This boundary condition is intended for incompressible flows, and its use in compressible flows will lead to a nonphysical result because it allows stagnation conditions to float to any level. You should also be careful not to place a velocity inlet too close to a solid obstruction, since this could cause the inflow stagnation properties to become highly non-uniform." As stated in the Fluent User's Guide, evaluation based on this boundary condition assumption may lead to nonphysical results. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

5.I SHIELDING EVALUATION

5-1. Provide the minimum distance between the Multi-Purpose Canister (MPC) and the HI-STORM 100U inlet ducts in the SAR and technical drawings.

The shielding evaluation states (see Section 5.I.3 of the SAR) that the model assumes the MPC is at its highest permissible elevation relative to the inlet ducts. However, the highest permissible elevation of the MPC is not clear from the SAR or from the technical drawings. The drawings indicate a minimum spacing between the base of the closure lid and the MPC and a minimum height for the CEC, from its base to the container flange. However, other dimensions, such as the maximum height of the CEC bottom plenum, affect the highest permissible MPC elevation but are not indicated in the technical drawings. The drawings should clearly indicate the highest permissible elevation of the MPC relative to the inlet ducts. One method is to provide an explicit, not a derived, value for this dimension in the drawings. A sample input file should also be provided that demonstrates that this minimum dimension is used in the shielding calculations. This information is needed to ensure compliance with 10 CFR 72.236(d).

5-2. Demonstrate that the shielding analysis is based upon the bounding source term and configuration.

Based upon a comparison of the source terms for design basis fuel at other burnup and cooling time combinations and the MPC configuration Holtec has used for its other shielding analyses, it is not clear that the current shielding analysis is bounding for the HI-STORM 100U design. First, Holtec's other shielding analyses indicate that dose rates for an overpack containing the MPC-24 were higher than for an overpack containing the MPC-32 except at the inlet vents. Second, it is not clear from a comparison of calculated source terms for the MPC-32 design-basis contents that the selected burnup (69 GWd/MTU) and cooling time (5 years) for the analysis results in bounding dose rates for an MPC-32 (see Tables 5.2.4 and 5.2.15 of the SAR, as modified for Amendment No. 5).

Provide an analysis that results in the maximum dose rates. A comparison of dose rates for a 100U with the MPC-24 and the MPC-32, each loaded with their respective bounding source would identify the source configuration resulting in the highest dose rates. For the source configuration (MPC) yielding the highest dose rates, provide an evaluation (quantitative as well as qualitative) that shows the selected source term results in the maximum dose rates for the source configuration. The evaluation should consider the loading configurations of the contents (i.e., preferential and uniform loading patterns), the shielding configuration, the variation of the gamma and neutron source strengths with burnup, cooling time and minimum enrichment, and the relative contribution of the gamma and neutron sources to the total dose rates. The evaluation may include a few dose rate calculations for different source terms to further show the bounding source term has been identified. Any assumptions should be appropriately justified. This information is needed to ensure compliance with 10 CFR 72.236(d).

5-3. Provide a dose evaluation that includes the steel vertical lid buttress.

The current shielding analysis model neglects the steel vertical lid buttress in the HI-STORM 100U overpack lid. This carbon steel rod can act as a neutron streaming path and result in an increase in the dose rates due to neutrons. Any evaluation of the impact of including, or neglecting, the vertical lid buttress should include quantitative as well as qualitative arguments, such as a comparison of dose rates at location No.4 in Figure 5.I.1 of the SAR determined with and without the buttress included in the model. The shielding analysis should use the shielding configuration that results in bounding dose rates. This information is needed to ensure compliance with 10 CFR 72.236(d).

5-4. Provide in the SAR and the technical drawings the following dimensions:

a. the minimum concrete thickness in the main part of the closure lid extending from the lid's base to its top,
b. the thickness of the closure lid cover plate,
c. the thickness of the upper annular plate of the closure lid,
d. and the thickness of the container flange.

Staff reviewed the technical drawings and the shielding model sketch to determine the appropriateness of the shielding model. The staff was unable to determine the dimensions for the shielding materials in the 100U system listed in this question, both from the model sketch (Figure 5.I.2 of the SAR) and the technical drawings (Drawing No. 4501, Rev. 2). These dimensions are necessary to determine the actual shielding design configuration in the HI-STORM 100U system and to verify that the shielding model appropriately captures the actual configuration. Also provide a sample input that demonstrates that the shielding calculations are based upon the dimensions of the actual design. This information is needed to ensure compliance with 10 CFR 72.236(d).

6.I CRITICALITY EVALUATION

6-1. Provide criticality analyses that include any deformation of the fuel basket as a result of accident conditions.

The current criticality analysis for the HI-STORM 100 system assumes that there will be no basket deformation under accident conditions. However, it is not clear that for the underground module, the HI-STORM 100U, this assumption is still valid. Therefore, the criticality analysis should be modified to include calculations with the most reactive system and fuel configuration that includes any deformation to the basket arising from accident conditions for the HI-STORM 100U. Accident-induced deformation may reduce flux trap size or minimum cell pitch dimensions. These parameters are important for criticality control. While the MPC is dry under storage conditions, this deformation becomes important for cases when unloading may be necessary. A calculation for each basket type (MPC-24, 32, and 68) containing design-basis contents having the least margin to the upper subcritical limit (USL) that demonstrates the USL will still be met with basket deformation is an acceptable method of showing the system meets the criticality safety requirements. The deformation included in the criticality analysis should be based upon the deformation determined in the structural analyses. Also, provide a sample input file that illustrates the inclusion of the deformation. This information is needed to ensure compliance with 10 CFR 72.236(c).

8.I OPERATING PROCEDURES

8-1. Clarify whether the configuration of an empty HI-STORM 100U is with the closure lid and the outlet vent cover in place over the VVM.

Descriptions of operations in SAR Section 8.I indicate that the configuration of an empty HI-STORM 100U is with the closure lid in place on the VVM. Section 8.I.1.7 indicates that the outlet vent cover is not installed on the closure lid until after placing a loaded MPC in the VVM. However, the unloading procedures in Section 8.I.3.2 do not indicate that the outlet vent cover is removed when removing the closure lid to recover an MPC from a VVM. Thus, the actual configuration of an empty HI-STORM 100U needs to be clearly indicated in the SAR, and operations descriptions need to be consistent with that configuration. It would seem that, from an ALARA perspective, the closure lid and outlet vent cover would be installed on an empty HI-STORM 100U to prevent/reduce accumulation of debris in the VVM cavity and the outlet vent cover would always remain attached to the closure lid, thus reducing the time needed to inspect the VVM cavity and remove any debris as well as simplify operations involving the closure lid. This information is needed to ensure compliance with 10 CFR 72.104(b).

9.I ACCEPTANCE CRITERIA

9-1. Provide a description of the shielding effectiveness tests that will be performed for the HI-STORM 100U overpack.

Section 9.I.1.3.ii of the SAR should describe the tests that are performed to confirm shielding effectiveness of the HI-STORM 100U overpack, including the closure lid. This section of the SAR, as currently proposed, does not contain any information regarding such tests. An acceptable testing program would be similar to that described in Section 9.1.5.2 of the FSAR. This information is needed to ensure compliance with 10 CFR 72.236(d).

10.I RADIATION PROTECTION

10-1. Modify SAR Section 10.I to indicate that radiation protection for excavation activities will include dose rate monitoring and verification of the presence of the required minimum amount of soil between the excavation area and loaded VVMs.

The HI-STORM 100U system configuration results in a condition unique from the aboveground overpacks related to ISFSI expansion. Expansion of an ISFSI using the HI-STORM 100U design requires excavation of material, namely the soil, relied upon for shielding. Recognizing this condition, Holtec proposed a TS that limits the minimum proximity of any excavation to an existing HI-STORM 100U array. However, the current radiation protection evaluation does not address excavation. While the user will have a Part 20 radiation protection program, Holtec's radiation protection evaluation should address unique cask design features and appropriate actions related to those features to ensure proper implementation of the radiation protection program with respect to the HI-STORM 100U system. For excavation activities, these actions include confirmation of the minimum soil properties and minimum distances between the excavation area and loaded VVMs upon which TS 5.7.9 is based as well as appropriate radiological monitoring of the excavation area. This information is needed to ensure compliance with 10 CFR 72.126(a) and 72.236(d).

10-2. Provide additional justification to further support the conclusion in SAR Section 10.I that occupational dose incurred with placement of the overpack lid on the HI-STORM 100U will be less than the dose for the same operation with the aboveground overpack.

Section 10.I indicates that the stated conclusion regarding dose rates is based on loading operations not requiring bolting of the lid to the VVM. While this is so, Section 8.I.1.7 indicates the outlet vent cover is installed on the overpack lid after the lid is placed upon the HI-STORM 100U, which installation appears (from the technical drawings) to require bolting. Installation of the outlet vent cover places workers over the lid and near the outlet vent opening and adds time to the operation. Thus, it is not clear that occupational dose for this activity will be less for the HI-STORM 100U than for the aboveground overpack. The additional justification should include an evaluation that considers the time duration, number of operators, operator location, and shielding geometry. If the evaluation indicates that occupational dose is higher for installation of the HI-STORM 100U lid, SAR conclusions should be appropriately modified and the impact on occupational dose estimates examined; notes in the SAR indicating that doses are higher for the HI-STORM 100U should also be added, as appropriate. This information is needed to ensure compliance with 10 CFR 72.236(d).

10-3. Clarify that radiation streaming through an empty VVM adjacent to a loaded VVM is appropriately recognized and captured as part of occupational radiation protection.

The current shielding and radiation protection evaluations do not explicitly address radiation streaming from a loaded overpack through an adjacent empty overpack. Empty VVMs adjacent to a loaded VVM may be potential radiation streaming paths since the soil providing shielding is limited between adjacent VVMs. Thus, radiation passing through the soil to the unloaded VVM will have a path of less shielding and contribute to occupational dose. It is not clear from the current evaluations that this potential dose contribution has been considered. While each site licensee will have a Part 20 radiation protection program, Holtec's radiation protection evaluation should address features of the design which warrant the attention of the licensee to ensure proper implementation of the radiation protection program with respect to use of the HI-STORM 100U system. Consideration of this contribution to occupational dose should also be evident in the descriptions of system operations, such as with the addition of any appropriate ALARA notes/cautions. Determinations in the radiation protection evaluation should be based upon an adequate technical basis, such as a shielding evaluation of streaming through this path. This information is needed to ensure compliance with 10 CFR 72.104 and 10 CFR 20.1101.

10-4. Clarify that potential radiation streaming from the Impressed Current Cathodic Protection System (ICCPS) test station is appropriately recognized and captured as part of occupational radiation protection.

Figure 2.I.1 of the SAR describes an example ICCPS design. The ICCPS design includes test stations (see Figure 2.I.1) that penetrate through the concrete in close proximity to the VVM, representing a potential streaming path. It is not clear from the evaluations currently in the SAR that the impact of these test stations on dose, particularly occupational dose, has been considered. While each site licensee will have a Part 20 radiation protection program, Holtec's radiation protection evaluation should address features of the design which warrant the attention of the licensee to ensure proper implementation of the radiation protection program with respect to use of the HI-STORM 100U system. Consideration of this contribution to occupational dose should also be evident in the descriptions of system operations, such as with the addition of any appropriate ALARA notes/cautions. Determinations in the radiation protection evaluation should be based upon an adequate technical basis, such as a shielding evaluation of streaming through this path, which considers the range of materials and configurations that may be used for these test stations that penetrate through the soil and concrete shielding near the HI-STORM 100U cavity. This information is needed to ensure compliance with 10 CFR 72.104 and 10 CFR 20.1101.

11.I ACCIDENT EVALUATION

11.1 Revise the Chapter 11 accident evaluations to address accidents occurring with construction and excavation activities taking place next to an array of loaded VVMs. Also provide the necessary modifications to the technical evaluations and analyses (e.g., structural, shielding, etc.) that support, or are impacted by, the accident evaluations.

Section 1.I.1 of the application indicates that an ISFSI using the HI-STORM 100U design may be expanded to increase the number of storage modules as the need arises. This expansion requires the excavation of soil adjacent to an existing array of VVMs and further construction activities to install additional modules. The accident evaluations in the currently proposed SAR do not address accidents at an ISFSI using the HI-STORM 100U system with these activities occurring next to the array of loaded VVMs. The occurrence of these activities next to an array of already installed (and loaded) VVMs results in additional conditions that must be considered as part of the accident evaluations for the HI-STORM 100U system due to its unique design. Necessary modifications to other technical analyses and evaluations that support, or are impacted by, the accident evaluations (such as shielding and structural) should also be provided. These analyses and evaluations should consider the current design basis accidents and phenomena and any other accidents unique to construction and excavation activities near an operating ISFSI of HI-STORM 100U VVMs. Conditions that maximize accident consequences, such as the minimum distance between the loaded VVMs and the site of the excavation and construction activities to add new VVMs, should be properly addressed. Any assumptions used in the evaluations and analyses should be adequately justified. Any equipment or engineered features or assumed parameter limits relied upon in the evaluations may need to be included in the conditions of the certificate or the technical specifications. This information is needed to confirm compliance with 10 CFR 72.106(b), 72.236(b) and 72.236(d).

12.I PROPOSED OPERATING CONTROLS AND LIMITS

12-1. Change the dose rate limit proposed in TS 5.7.4.c to 30 mrem/ hr (gamma + neutron) for the top of the underground overpack.

The currently proposed TS 5.7.4.c limit of 40 mrem/ hr is not supported by the shielding analysis. Any limit proposed for this TS should be supported by the analysis in the SAR. This information is needed to ensure compliance with 10 CFR 72.104 and 72.236(d).

12-2. Modify the proposed TS 5.7.6.b and TS 5.7.7 to read as follows:

5.7.6.b Perform a written evaluation to verify whether an overpack, at the ISFSI, containing the as-loaded MPC will cause the dose limits of 10 CFR 72.104 to be exceeded.

5.7.7 If the evaluation performed pursuant to Section 5.7.6 shows that the dose limits of 10 CFR 72.104 will be exceeded, the MPC shall not be placed into or, in the case of the underground overpack or an aboveground overpack loaded at the ISFSI, shall be removed from storage until appropriate corrective action is taken to ensure the dose limits are not exceeded.

Staff understands that Holtec proposed TS changes to paragraphs 5.7.6.b and 5.7.7 to account for the condition that the HI-STORM 100U can only be loaded at the ISFSI. Thus, were a problem to be detected with the HI-STORM 100U overpack, this problem would be detected only after the loaded MPC is in storage at the ISFSI. However, these paragraphs still apply to the aboveground overpacks as well, which may be loaded at the Part 50 structure (e.g., spent fuel building); thus, for the aboveground overpack, a problem may be detected prior to the overpack being placed into storage at the ISFSI. Thus, the staff has determined that the wording requested in this RAI is more appropriate to encompass operations for both the aboveground and the underground overpacks. This information is needed to ensure compliance with 10 CFR 72.104 and 72.236(d).

12-3. Modify the proposed TS definitions in the following manner.

a. Overpack - the TS Appendix A definition should be the same as the TS Appendix B definition.

b. Damaged Fuel – add “based on engineering evaluations” after the word “expected”.

c. Fuel Debris – the SAR definition should be the same as the TS definition; the definition should be that which is supported by the analyses in the SAR that are the basis for this amendment.

d. Transfer Cask – the TS Appendix B definition should be the same as the TS Appendix A definition.

Also, regarding item a in this request, the usage and definition of the terms Overpack and VVM need to be consistent throughout the SAR and the TS. For example, in Section 12.2.9, Overpack is replaced by VVM in several instances. This proposed change does not appear to be consistent with the definitions of Overpack and VVM in the TS. The staff also notes that the current definitions for the terms ZR and Non-Fuel Hardware are not consistent between the SAR and the TS; the staff finds the proposed TS definitions to be acceptable. These changes are necessary to ensure consistency between the SAR and TS and that the TS are based upon, or supported by, the analyses in the SAR. This information is needed to ensure compliance with 10 CFR 72.236(a) and (b).

12-4. Modify TS 5.7.3 to include the establishment of dose rate limits for locations/areas of the HI-STORM 100U overpack that contribute significantly to public and occupational dose and are most indicative of overpack shielding effectiveness. Also, provide the technical basis for the proposed locations.

The currently proposed TS 5.7.3 only includes establishment of dose rate limits for the top and outlet vent of the HI-STORM 100U. However, based upon the shielding analysis, a comparison of the dose rates determined for the selected areas of the overpack shows the dose rate at the inlet vent is also significant. Thus, it seems important, particularly for the licensee to meet 10 CFR 72.104(b), to have a TS also requiring establishment of a dose rate limit for the inlet vent. Staff notes that this inlet vent limit had been included initially but later removed (in the previous submittal); however, the justification for the removal is not sufficient (given the pitch size versus other sample array pitch sizes and the sequential loading of VVMs allowing for inlet vents that are not influenced by neighboring VVMs). Appropriate locations for dose rate limits should be proposed in TS 5.7.3, with selection properly justified. Justification should include evaluation of the different areas of the cask (e.g., inlet vent, outlet vent, closure lid top, VVM interface pad near the VVM cavity), identifying those areas that contribute significantly to occupational and public doses. Consideration should also be given to how indicative of shielding effectiveness a given area of the HI-STORM 100U would be. The remainder of TS 5.7 should be appropriately modified to account for changes to TS 5.7.3. This information is needed to ensure compliance with 10 CFR 72.126(a) and 72.236(d).

12-5. Propose dose rate limits in TS 5.7.4 for areas/locations of the HI-STORM 100U overpack that contribute significantly to doses evaluated against 10 CFR 72.104

and which are most indicative of overpack shielding effectiveness, providing a technical basis for the proposed limits and locations.

The currently proposed TS 5.7.4 includes a dose rate limit for the top of the underground overpack. Staff notes, however, that a limit was previously proposed for the inlet and outlet ducts. While staff had requested the addition of a measurement on the top of the overpack, there was no indication that the location of the proposed limit in TS 5.7.4 should be changed otherwise. Appropriate dose limits and locations should be proposed in TS 5.7.4, with selection properly justified. Justification should include evaluation of the different areas of the cask (e.g., inlet vents, outlet vent, closure lid top, VVM interface pad near the VVM cavity), identifying those areas that contribute significantly to the doses that are evaluated against 10 CFR 72.104(a); limits based upon Holtec's shielding analysis for cask locations where shielding deficiencies may noticeably affect doses at the controlled area boundary should be included in TS 5.7.4. Consideration should also be given to how indicative of shielding effectiveness a given area of the 100U would be. The remainder of TS 5.7 should be appropriately modified to account for changes to TS 5.7.4 limits. This information is needed to ensure compliance with 10 CFR 72.236(d).

12-6. Provide the technical basis for the selection of the size of the Radiation Protection Space (RPS) established in proposed TS 5.7.9.

While the SAR analysis demonstrates that the dose rates at this distance are very low, the basis used to select the proposed size of the RPS is not clear. An appropriate technical basis should include items such as dose rate criteria and ALARA and any other pertinent considerations evaluated by the applicant. This information is needed to ensure compliance with 10 CFR 72.236(d).

12-7. Modify the proposed TS 5.7.9 to clearly indicate that the loaded VVM(s) is enclosed by the RPS.

The current language of the proposed TS states that the RPS is a prismatic column of subgrade adjacent to the VVM(s). The VVM(s) is actually within the subgrade column, the boundaries of which are defined as given in the proposed TS. This information is needed to ensure compliance with 10 CFR 72.236(d).

CERTIFICATE OF COMPLIANCE COMMENTS

C.1 Rewrite CoC Section 3.5, Cask Transfer Facility (CTF) to make it clear what the CTF Structure Requirements are for the HI-STORM 100U underground VVM system.

CoC Section 3.5 does not provide the information necessary in a lucid manner. This information is necessary to ensure compliance with 10 CFR 72.230(a), and 72.234(a).

C.2 Under 1.b. of the proposed CoC, the first sentence of the last paragraph should be deleted and the following text should be inserted.

"The HI-STORM 100U storage overpack is an underground storage system identified with the HI-STORM 100 Cask System. The HI-STORM 100U utilizes a storage design identified as a drywell or caisson. The HI-STORM 100U relies on vertical ventilation instead of conduction through the soil, while it is essentially a below-grade storage cavity."

C.3 Explain the intent and meaning of the described system and the changes proposed in Section 3.5.1 of Appendix B of the CoC. Section 3.5.1 of Appendix B addresses loading of an above ground overpack in a below ground restraint system relative to the HI-STORM 100U and why this system would not have to meet Section 3.5.2. for the CTF. This information is necessary to ensure compliance with 10 CFR 72.230(a).

C.4 Justify why the CTF structure requirements of proposed Section 3.5.2 of Appendix B of the CoC would not have to be met for the loading of an underground overpack which in this case is the HI-STORM 100U VVM. This information is necessary to ensure compliance with 10 CFR 72.236(b).

C.5 Specify the properties of the concrete and the physical dimensions of the concrete encasement with a thickness of at least 5 inches if this optional feature is provided as a corrosion mitigation measure when the surrounding subgrade environment is mildly corrosive, or as an extra enhancement when there is an aggressive corrosive environment. This information is necessary to ensure compliance with 10 CFR 72.236(b).

C.6 Provide specific values or ranges of values for all the parameters involved in the analyses completed to date for the seismic evaluations completed for an isolated HI-STORM 100U VVM in Section 3.4, Site-Specific Parameters and Analyses, and that can be utilized by a potential user of the HI-STORM 100U System to determine whether their proposed site characteristics are encompassed by these values. Item 7. of Section 3.4, Appendix B of the proposed CoC will be replaced with the following information based on the current information available to the NRC staff. For the underground use of an MPC, the cask system drywell or caisson, the HI-STORM 100U VVM, shall be limited to those sites and conditions, whether natural or engineered, that meet the following conditions and the design of the structures, systems, and components shall also meet the applicable conditions listed below:

- Site Elevation is limited to less than 1500 feet above Mean Sea Level.
- The maximum height of the outlet vent is ____________.
- The minimum thickness of the concrete Support Foundation is 30 inches under the CEC Bottom Plate.
- The Support Foundation underlying substrate (assumed to be either natural in-place or engineered materials) shall have a minimum density of 140 pounds per cubic foot (pcf) and shall extend to a depth of at least 30 feet and shall have a minimum strain-compatible shear wave velocity of 800 feet per second (fps).

- The bedrock shall have a minimum density of 155 pcf and shall have a minimum strain-compatible shear wave velocity of 3500 fps.
- The backfill material above the Support Foundation and surrounding the HI-STORM 100U VVMs shall have a minimum density of 120 pcf and shall have a minimum strain-compatible shear wave velocity of 500 fps.
- The foundation and array of storage units will be a square pattern.
- The CEC Bottom Plate minimum dimensions shall be 87 inches in diameter and 1 inch thick.
- The CEC Shell outer diameter (OD) shall be nominally 86 inches and 1 inch thick.
- The Divider Shell OD shall be nominally 75 inches and ¾ inch thick.
- The Divider Shell Insulation shall be nominally 2 inches thick.
- Air Duct Nominal Gap after seismic event of 2½ inches minimum (Inflow air duct radial opening between the Divider Shell Insulation and the ID of the CEC Shell).
- The MPC Nominal Gap (radial gap between the OD of the Divider Shell and the MPC Guides) after seismic event shall be no less than ____ inches.

This information is necessary to ensure compliance with 10 CFR 72.236(b)

C.7 Modify proposed Condition No. 9 (SPECIAL REQUIREMENTS FOR FIRST SYSTEMS IN PLACE) of the CoC to specify that this condition applies separately to the HI-STORM 100U storage overpack. Due to the unique design of this overpack, high heat load, and high burnup fuel, this test should be performed separately for this design to experimentally determine the air mass flow rate. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

C.8 Modify the SAR and proposed CoC to incorporate any changes to Operating Procedures, Conditions of Use, and TS that were included in previous Amendments to the CoC and that affect the thermal evaluation of the HI-STORM 100U storage system. As part of previous amendment reviews, some changes to the SAR and to the TS were incorporated that are not reflected in the current Amendment request. This information is needed to assure compliance with 10 CFR 72.11 and 72.236(f).