5 INSTALLATION AND STRUCTURAL EVALUATION

5.1 Conduct of Review

This chapter describes the staff's review of the installation and structural evaluation presented in Chapter 4 of the Humboldt Bay ISFSI Safety Analysis Report (SAR) (Pacific Gas and Electric Company, 2004a). The staff also reviewed related information from Chapters 2, 3, 5, and 8 of the SAR. The objective of the structural evaluation review is to ensure the structural integrity of structures, systems, and components (SSCs) with emphasis on those that are important to safety.

Spent nuclear fuel (SNF) dry storage facilities are designed for the safe confinement and storage of SNF. The design of the proposed Humboldt Bay ISFSI is based on the use of the HI-STAR HB system, which is a modified version of the HI-STAR 100 system (Holtec International, 2002), which has been reviewed and approved for general use by the NRC (U.S. Nuclear Regulatory Commission, 2001a). Where applicable, the staff relied on the review carried out during the certification process of the HI-STAR 100 system, as documented in the HI-STAR 100 System Safety Evaluation Report (SER) (U.S. Nuclear Regulatory Commission, 2001b). The major categories of safety protection systems discussed in the following sections include (i) confinement SSCs, (ii) reinforced concrete structures, (iii) other SSCs important to safety, and (iv) SSCs not important to safety.

The staff's review considered how the SAR and related documents address the regulatory requirements of 10 CFR §72.24(a–d), §72.24(i), §72.103(b), §72.103(f)(2)(i), §72.103(f)(2)(iv), §72.120(a), §72.122(a), §72.122(b)(1), §72.122(b)(2), §72.122(b)(3), §72.122(b)(4), §72.122(c), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), §72.122(i), §72.122(l), and §72.128(a). Complete citations of these regulations are provided in the Appendix of this SER.

5.1.1 Confinement Structures, Systems, and Components

There are three confinement barriers for the radioactive contents stored in the HI-STAR HB System: fuel cladding of intact fuel assemblies, the multipurpose canister (MPC-HB), and the overpack. No credit is taken for the fuel cladding or the overpack in the confinement system storage design. The MPC-HB, which is a strength-welded enclosure vessel, provides the confinement boundary for all normal, off-normal, and accident conditions, including natural phenomena. The discussion about confinement SSCs is presented in Sections 3.3.1 and 4.2.3 of the SAR.

Section 4.5 of the SAR presents the classification of SSCs. The SSCs important to safety are divided in Categories A and B. Category A refers to items critical to safe operation and includes SSCs whose failure or malfunction could directly result in a condition adversely affecting public health and safety. The failure of a single item could cause loss of containment, leading to the release of radioactive material, loss of shielding, or unsafe geometry compromising criticality control. Category B items have a major impact on safety and include SSCs whose failure or malfunction could indirectly result in a condition adversely affecting public health and safety. Table 4.5-1 of the SAR provides a list of important to safety and not important to safety items.

5.1.1.1 Description of Confinement Structures

The MPC-HB is the main confinement structure of the HI-STAR HB system. The MPC-HB is a modified version of the MPC of the generic HI-STAR 100 system. A detailed description of the generic MPC is provided in the HI-STAR 100 System Final Safety Analysis Report (FSAR) (Holtec International, 2002). The modifications of the MPC-HB with respect to the generic MPC are listed in Section 4.2.3 of SAR. In addition to being a shorter confinement system, the MPC-HB can store up to 80 Humboldt Bay Power Plant (HBPP) fuel assemblies versus 68 fuel assemblies in the generically certified system. The staff finds that the confinement structure is sufficiently described in the SAR in accordance with 10 CFR §72.24(a–b); §72.122(h)(1), §72.122(h)(4), and §72.122(i).

5.1.1.2 Design Criteria for Confinement Structures

The design criteria for the generic MPC are presented in the HI-STAR 100 System FSAR (Holtec International, 2002) and evaluated in the related SER (U.S. Nuclear Regulatory Commission, 2001b). A summary of the design criteria is contained in Table 2.01 of the HI-STAR 100 System FSAR (Holtec International, 2002). Design criteria for the MPC-HB system are summarized in Table 3.4-2 of the SAR.

The design, fabrication, and inspection of the MPC-HB is in accordance with the guidelines followed for the generic MPC (Holtec International, 2002). Thus, the MPC-HB confinement boundary is designed in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, Articles NG-3200 and NG-3300 (ASME International, 2001a). Fabrication of the MPC-HB is in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsections NB, Article NB-4000, and NG, Article NG-4000 (ASME International, 2001a). The MPC-HB inspection is in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Articles NB-5000 and NG-5000 (ASME International, 2001a), and Section V (ASME International, 2001b).

Nondestructive examination techniques and acceptance criteria for the MPC-HB welds are provided in Sections 8.1 (transport) and 9.1 (storage) of HI-STAR 100 System FSAR (Holtec International, 2002). MPC-HB confinement boundary welding is in accordance with the ASME Boiler and Pressure Vessel Code, Section IX (ASME International, 2001c); and Section III, Subsections NB and NG (ASME International, 2001a). As indicated in Table 2.01 of the HI-STAR 100 System FSAR (Holtec International, 2002), the design criteria for the MPC-HB lifting points are in accordance with American National Standard Institute (ANSI) N14.6 (American National Standard Institute, 1993) and NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980).

The staff finds that the design criteria of the confinement structures meet the requirements of 10 CFR §72.24(c)(1), §72.24(c)(2), §72.24(c)4, §72.120(a), §72.122(a), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), §72.122(i), §72.122(l), and §72.128(a).

5.1.1.3 Material Properties for Confinement Structures

Materials Selection

A description of the MPC-HB, including materials of construction, fabrication details, and testing, is provided in Section 4.2.3 of the SAR. Engineering drawings and additional details of the storage system are included in Chapter 3 of the SAR and by reference in the HI-STAR 100 System FSAR (Holtec International, 2002). The nominal physical characteristics of the MPC-HB are provided in Table 4.2-1 of the SAR.

The structural components of the MPC-HB are constructed from Types 304, 304LN, 316, or 316LN austenitic stainless steel (Holtec International, 2002). Stainless steels were selected based on mechanical properties and corrosion resistance. Material procurement is in accordance with ASME Boiler and Pressure Vessel Code, Section II (ASME International, 2001d–f) and Section III, Subsection NG, Article NG-2000 (ASME International, 2001a). The staff concludes that the selection of these materials is acceptable for the MPC-HB, in compliance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Welds

The MPC-HB welds are characterized in Figure 3.3-1 of the SAR. The drawing includes standard welding symbols and notations in accordance with American Welding Society (AWS) Standard A2.4 (American Welding Society, 1998). The stainless steel materials for the MPC-HB are readily weldable using commonly available welding techniques. MPC-HB closure welds are inspected using visual and ultrasonic testing or multilayer penetrant testing. Techniques and acceptance criteria are governed by ASME Sections V and III, respectively. The staff concludes that the welded joints of the MPC-HB meet the requirements of ASME and AWS codes and that the design complies with 10 CFR §72.24(c) and §72.122(a).

Mechanical Properties

Mechanical properties of the structural materials for the MPC-HB are provided in Section 4.2.3.2.1 of SAR and supplemented by Tables 3.3.1–3.3.5 of the HI-STAR 100 System FSAR (Holtec International, 2002). Qualification of the MPC-HB structure is accomplished using the least favorable mechanical and thermal properties of the entire group for all mechanical, structural, neutronic, radiological, and thermal conditions. The values in these tables were obtained from ASME Code Section II, Part D (ASME International, 2001f).

The staff finds that the material properties are acceptable for the expected loading conditions during the license period and comply with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Coatings

No coatings are used on the MPC-HB.

Chemical and Galvanic Reactions

Evaluation of possible chemical, galvanic, and other reactions among the materials in the range of possible exposure environments is included in Section 4.6 of the SAR. The evaluation includes stainless steels used in the MPC-HB. The staff finds that no adverse reactions are anticipated for stainless steels used in the MPC-HB.

Based on the previous discussion of the mechanical properties, coating, and chemical and galvanic reaction of the selected materials, the staff finds that the material selection for the confinement structures meets the requirements of the ASME and AWS codes, as applicable. The staff finds that the material properties for the confinement structure have been acceptably identified in accordance with 10 CFR §72.24(c)(3), §72.120(a), and §72.122(a).

5.1.1.4 Structural Analysis for Confinement Structures

Section 4.2.3.3.2 of the SAR states that the MPC-HB is identical in design to the generic MPC except for the height. Thus, the structural evaluation for the generic MPC forms the structural licensing basis for the MPC-HB. The structural design and analysis of the HI-STAR HB components have been performed for the following normal, off-normal, and accident conditions:

- Dead and Live Loads (SAR Section 4.2.3.3.2.1)
- Internal and External Pressure Loads (SAR Section 4.2.3.3.2.2)
- Thermal Expansion (SAR Section 4.2.3.3.2.3)
- Handling Loads (SAR Section 4.2.3.3.2.4)
- Overpack Tipover and Drop (SAR Section 4.2.3.3.2.5)
- Tornado Winds and Missiles (SAR Section 4.2.3.3.2.6)
- Flood and Tsunami (SAR Section 4.2.3.3.2.7)
- Earthquake (SAR Section 4.2.3.3.2.8)
- Explosion Overpressure (SAR Section 4.2.3.3.2.9)
- Humboldt Bay-Specific Structural Analyses (SAR Section 4.2.3.3.2.10)
- Turbine Missiles (SAR Section 4.2.3.3.2.11)

The review and acceptance of the generic MPC is documented in the HI-STAR 100 System SER (U.S. Nuclear Regulatory Commission, 2001b), which shows that the HI-STAR 100 system maintains structural integrity under all credible loads. Based on the similarity of the two designs, the staff finds that the stresses in the MPC-HB under the most critical load combinations are less than the allowable stresses of ASME Boiler and Pressure Vessel Code Section III (ASME International, 2001a) for the confinement materials.

Although the structural configuration of the generic MPC and the MPC-HB are very similar, the decelerations due to potential seismic events for the MPC-HB are not bounded by the generic MPC. The peak ground accelerations of the design basis earthquakes are larger than the maximum acceptable seismic acceleration level for the HI-STAR 100 system (U.S. Nuclear Regulatory Commission, 2001a) for the top surface of an ISFSI pad. The Humboldt Bay ISFSI SAR, therefore, presents seismic dynamic analyses of the cask-storage vault interaction to ensure that the maximum impact forces do not impose a deceleration loading on the cask that exceeds the cask design basis (Holtec International, 2005a, HI-2033014). The analyses are carried out in the program Visual Nastran (MSC Software Corporation, 2002), and the obtained peak accelerations are below the design basis value when subjected to four design basis seismic events. The validation of this program for the computations required in the cask-vault dynamic interaction has been found acceptable by the staff. The staff, therefore, finds that the confinement structure analysis complies with 10 CFR §72.24(d)(1), §72.24(d)(2), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), and §72.122(l).

5.1.2 Pool and Pool Confinement Facilities

This provision is not applicable to 10 CFR Part 72 dry storage facilities.

5.1.3 Reinforced Concrete Structures

This section contains a review of Section 4.2.2 of the SAR. The staff reviewed the discussion about reinforced concreted structures that are important to safety with respect to the applicable regulatory requirements.

5.1.3.1 Description of Reinforced Concrete Structures

The Humboldt Bay ISFSI reinforced concrete storage vault has been classified as important to safety. Its function is to provide a structurally competent facility for storing the loaded storage casks for all design-basis loading conditions. The storage vault is composed of six below-grade, cylindrical storage cells of reinforced concrete with a carbon steel liner. The storage vault will accommodate five HI-STAR HB casks and one Greater than Class C (GTCC) certified cask in individual storage cells. Figure 4.1-1 of the SAR shows the layout of the cask storage cells. The storage vault will be inspected by a camera for overall cleanliness (Pacific Gas and Electric Company, 2004b). Figure 3.2-1 of the SAR shows the dimensions of the storage vault and components, and Drawing 4105 (Pacific Gas and Electric Company, 2004b) presents the properties of the concrete and steel reinforcement. Section 4.2.2.5 of the SAR presents a description of the storage vault and associated operations procedures, including inspection, maintenance, and testing. The staff finds that the design description of the vault provided in the SAR and supporting documents is sufficiently detailed to support a review and evaluation in accordance with 10 CFR §72.24(a), §72.24(b), §72.122(f), and §72.122(i).

5.1.3.2 Design Criteria for Reinforced Concrete Structures

The design bases for the reinforced concrete storage vault are given in Sections 3.3.2 and 4.2.2.5 of the SAR. Table 3.4-3 of the SAR identifies details of the storage vault design in compliance with the general design criteria of 10 CFR Part 72, Subpart F.

The cask storage vault design is based on a loaded-cask weight that bounds the loaded weight of each HI-STAR HB overpack and the GTCC cask stored the ISFSI. The reinforced concrete vault is designed in accordance with the ultimate strength design methods specified in American Concrete Institute (ACI) 349-01 (American Concrete Institute, 2001) and NUREG-1536 (U.S. Nuclear Regulatory Commission, 1997). The ACI 349-01 Code specifies the minimum requirements for the design and construction of nuclear safety-related concrete structures and structural elements for nuclear power-generating stations. Load combinations for the vault design are provided in ACI-349-01 (American Concrete Institute, 2001) and supplemented by the factored load combinations from Table 3-1 of NUREG-1536 (U.S. Nuclear Regulatory Commission, 1997). In addition, based on the assessment of the potential settlement of the reinforced concrete vault (Pacific Gas and Electric Company, 2004b), the staff concludes that the storage casks can be retrieved from the reinforced concrete storage vault.

The staff finds that the reinforced concrete structures design criteria and relevant codes and standards have been identified in accordance with 10 CFR §72.24(c)(1), §72.24(c)(2), §72.24(c)(4), §72.120(a), §72.122(a), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), §72.122(i), §72.122(l), and §72.128(a).

5.1.3.3 Material Properties for Reinforced Concrete Structures

The staff reviewed the construction materials for the reinforced concrete storage vault, as identified in Section 4.2.2.4 of the SAR. The material selected is concrete with a compressive strength of 27.6 MPa [4,000 psi] at 28 days and reinforcing steel bars that meet ASTM A615, Grade 60, specifications. Additional information related to the durability of the reinforced concrete and rebar corrosion is presented in the applicant’s response to the staff’s RAI (Pacific Gas and Electric Company, 2004b). In this document, the applicant indicates that the cement used to fabricate the vault will be Type II. The upper limit of the concrete water-to-cement ratio shall be 0.45 to limit any possible attack on the cement paste. The applicant also indicates that the concrete cover (7.6 cm [3 in] minimum on all surfaces, except 5.1 cm [2 in] on the top surface) for the reinforcement will limit any aggravated corrosion of the reinforcement. This concrete cover complies with ACI 349-01 specifications (American Concrete Institute, 2001) and is measured to the outer edge of stirrups or ties. The water-to-cement ratio and concrete cover should be carefully monitored during the construction process because they are the two main factors that will prevent rebar corrosion in the reinforced concrete storage vault. The staff finds that materials for the reinforced concrete storage vault have been adequately identified in accordance with 10 CFR §72.24(c).

5.1.3.4 Structural Analysis for Reinforced Concrete Structures

Section 8.2.1.2.4.2 of the SAR summarizes the seismic analysis of the reinforced concrete storage vault. The objectives are to ensure that (i) the concrete maintains shielding under normal factored dead and live loads and (ii) cask spacing is maintained and the cask-to-vault liner shims maintain their ability to transfer loads under applicable load combinations that include seismic events.

Structural analyses were carried out to ensure that the storage vault would be able to withstand extreme environmental and natural phenomena without impairing its capability to perform its design functions. The storage vault was analyzed for the following normal, off-normal, and accident loading conditions:

- Dead loads
- Live loads
- Soil pressure loads
- Temperature gradients
- Earthquake loads
- Tornado-generated missile loads

- Lightning
- Blast and explosion overpressures

Flooding is inapplicable to the ISFSI site. This has been evaluated in Section 2.1.4.2 of this SER. Wind and tornado wind loads are also inapplicable because the vault is buried, and only the pressure differential was considered for the design of the vault lid. The relationship between the design criteria identified in Chapter 3 of the SAR and the analysis procedures was established in accordance with the requirements of 10 CFR §72.24(c)(2). The applicable codes and standards used in the analyses of the reinforced concrete structures also have been identified in the SAR, in accordance with the requirements of 10 CFR §72.24(c)(4).

The reinforced concrete storage vault was analyzed using the ANSYS finite element analysis code (ANSYS, Inc,.2002) to determine the end forces and displacements of the structure (Pacific Gas and Electric Company, 2004b; Holtec International, 2004a, HI-2033013). In the analyses, all materials are assumed to be homogenous, isotropic, and linear elastic. The capacities of the critical sections of the vault were calculated using the program ShapeBuilder (Integrated Engineering Software Inc., 2002), which produces axial force-bending moment interaction diagrams.

The following sections describe the specific analyses related to the reinforced concrete vault provided by the applicant.

Thermal analysis

The thermal analysis of the storage vault is a two-step process consisting of (i) calculating the temperature distribution and (ii) calculating the thermal stresses. For the temperature distribution, a loaded cell was assumed to have the maximum allowable local temperature applied to its inner surface. Empty cells were assumed to have adiabatic boundary conditions applied to their inner surfaces. The far-field boundary conditions were set at the site annual average soil temperature. Adiabatic boundary conditions were also assumed to exist over the top surface of the soil and vault. A steady-state solution method was used to solve for the nodal temperatures. The nodal temperatures were then used as input to the thermal stress analysis. The maximum local temperature of 93.3E C [200E F] is assumed as the temperature of the inside of cells. The thermal boundary conditions are discussed in Section 8.2 of Holtec International (2004a, HI-2033013) and evaluated in Chapter 6 of this SER. The staff concludes that the analysis performed complies with 10 CFR §72.24(d).

Soil Stability

Analysis of the stability of the subsurface materials under the reinforced concrete vault and the potential for failure are provided in the applicant's response to the staff's RAI (Pacific Gas and Electric Company, 2004b). Two loading cases have been considered for the vault settlement analysis: (i) one cell filled and (ii) all cells filled. The applicant indicates that the vault loading configurations were chosen to maximize the structural demand on various facets of the configuration. The staff determined that all intermediate loading cases are not necessarily bounded by these loading configurations, as the case with three cells loaded results in a larger vertical load and overturning moment than the case for one cell loaded. However, the settlement and bearing capacity results presented by the applicant have large safety factors because the load imposed by the vault is similar to the weight of the soil excavated. The staff determined that these large safety factors provide sufficient margin to compensate for any differences in the calculated maximum load; therefore, the staff finds that the applicant's subsurface soil stability analysis conclusions remain valid. Thus, the staff concludes that the analysis complies with 10 CFR §72.24(d) and §72.103(f)(2)(iv).

Seismic Analysis

The applicant used a static seismic analysis to apply the earthquake loads to the storage vault using the Newmark method for combining orthogonal seismic components. Because the vault is considered a rigid structure, inertial loads due to vault self-weight are computed based on the zero period acceleration of the deterministic uniform hazard spectra (UHS) evaluated in Chapter 2 of the SAR. Although the analysis does not consider potential amplifications of acceleration forces due to soil-structure interaction (SSI), several counteracting conservative factors have not been taken into account in the analysis. An independent staff analysis identified most of these conservative assumptions and quantitatively evaluated the assumptions that directly modify the input acceleration forces and the design safety factors. The main conservative assumptions quantitatively estimated are (i) the use of the deterministic UHS instead of the 2000 year probabilistic UHS, which present smaller spectral accelerations; (ii) the use of an elastic design without considering the structural performance of the reinforced concrete vault in the nonlinear range; and (iii) the conservatism in the capacity reduction factors used in the reinforced concrete design. Based on these conservative assumptions, the staff has concluded that the design of the reinforced concrete vault is acceptable, even if amplifications of acceleration forces occur in the soil-vault cask system due to SSI.

There are other conservative factors, such as additional damping of the soil-vault system and embedment of the vault that cannot be quantified without a comprehensive SSI analysis and have not been included in the review. The staff concludes that the reinforced concrete vault design complies with the requirements of 10 CFR §72.24(d), §72.103(b), §72.103(f)(2)(i), and §72.122(b)(2).

Soil Surcharge Pressure

The applicant indicates that the crawler (transporter) load on the crawler track extensions will not give rise to significant soil surcharge pressures on the walls of the vault (Holtec International, 2004a, HI-2033013). The crawler load is assumed to be a uniformly distributed pressure acting over the footprint of the treads. This load has been distributed over an approximate area consistent with the mesh density in the finite element model. The staff finds that this procedure complies with 10 CFR §72.24(d).

5.1.4 Other Structures, Systems, and Components Important to Safety

This section contains a review of Sections 4.2, 4.3, 4.4, 4.5, 4.6, and 8.2 of the SAR. The staff reviewed the discussion of other SSCs classified as important to safety with respect to the applicable regulatory requirements.

5.1.4.1 Description of Other Structures, Systems, and Components Important to Safety

The following SSCs were identified in the SAR as other SSCs important to safety.

HI-STAR HB Overpack [Quality Assurance (QA) Category A]

The HI-STAR HB overpack is a carbon steel cylindrical vessel that contains the MPC-HB. The overpack serves as a missile barrier and radiation shield and provides flow paths for natural convective heat transfer and stability for the system (SAR Section 4.2.3.2.3).

The HI-STAR HB overpack is shorter than the generic HI-STAR 100 overpack, does not include pocket trunnions, and has an updated design of the neutron shield enclosure (SAR Section 4.2.3.2.3). The neutron shield enclosure of the HI-STAR HB overpack is a one-piece cylindrical shell instead of several channels and steel plate panels welded together to form the enclosure shell. This neutron shield enclosure provides better shielding and simplified fabrication than the generically certified system.

The staff finds that HI-STAR HB overpack has been sufficiently described in accordance with 10 CFR §72.24(a), §72.24(b), §72.122(h)(1), §72.122(h)(4), and §72.122(i).

Fuel Basket (QA Category A)

The fuel basket provides support for the fuel assemblies and the geometry and fixed neutron absorbers for criticality control. In the SAR, a description of the fuel basket is provided in Section 4.2.3.2.1, and a layout is presented in Figure 3.3-2. The MPC-HB fuel basket is designed to store 80 fuel assemblies, whereas the generic MPC is designed to store only 68 fuel assemblies. The structural components of the MPC-HB fuel basket are similar to those of the generic MPC and are sufficiently described in the Humboldt Bay ISFSI SAR and in the HI-STAR 100 system FSAR (Holtec International, 2002), in accordance with 10 CFR §72.24(b).

Upper Fuel Spacers in MPC-HB (QA Category B)

The upper fuel spacers are fabricated from W14X13 beams and welded to the bottom of the MPC-HB lid. These spacers are described in Section 4.2.3 of the SAR and in Holtec International (2005b, HI-2033035). Because the intact fuel assemblies are shorter than a damaged fuel container (DFC), the function of these spacers is to maintain the position of the intact fuel assemblies relative to the fuel basket. The staff finds that the upper fuel spacers have been sufficiently described in accordance with 10 CFR §72.24(b) and §72.122(i).

Fuel Basket Spacers in MPC-HB Fuel Basket (QA Category A)

The MPC-HB fuel basket includes longitudinal fuel basket spacers welded to the top of the basket at several locations around the periphery to prevent the upper fuel spacers from impacting the top of the basket. The fuel basket spacers are described in Section 4.2.3 of the SAR and in Holtec International (2004b, HI-2033035). The staff concludes that fuel basket spacers have been sufficiently described in accordance with 10 CFR §72.24(b) and §72.122(i).

Damaged Fuel Container (QA Category A)

The description of the DFC is provided in Section 4.2.3.2.2 and Figure 4.2-3 of the SAR. The DFC is a long, square, stainless steel container used to retain the damaged fuel in its storage cell and to provide the means for ready retrievability. The DFC permits gaseous and liquid media to escape into the interior of the MPC-HB, but minimizes the dispersal of gross particles during interim storage. The staff finds that the DFC has been described adequately in accordance with 10 CFR §72.24(b) and §72.122(i).

Storage Cell Lid and Storage Cell Lid Closure Bolts (QA Category B)

The storage cell lid layout is presented in Figure 3.2-1 of the SAR. The lid consists of a steel bottom plate {2.5 cm [1 in] thick}, a steel top plate {0.6 cm [0.25 in] thick}, and a concrete fill {~38.1 cm [15 in] thick}. The lid has eight bolts to anchor it to the steel liner. The staff concludes that the description of the storage cell lid and lid bolts complies with 10 CFR §72.24(b).

Storage Cell Steel Liner and Seismic Lateral Restraints (QA Category B)

There are fixed cask seismic restraints at the bottom of the liner and removable seismic restraints at the top of the liner (SAR Figure 3.2-1). The staff finds that the storage cell steel liner and seismic lateral restraints have been sufficiently described in accordance with 10 CFR §72.24(b).

Lift Links (QA Category A), Transporter Connection Pins (QA Category B), and Lateral Cask Restraining System

As identified in Section 4.3.2.1.2 of the SAR, the cask transporter uses steel lift links that engage the HI-STAR HB overpack lifting trunnions via connector pins. The lateral cask restraining system is used to secure the load during transfer operations. The restraint system is designed to prevent lateral and transverse swinging of the load. The lift links, connector pins, and lateral restraining system are classified as important to safety, purchased commercial grade, and qualified for loading operations by testing prior to service. The design of the associated lifting devices also allows for control of loads in the event of emergencies. The staff concludes that lifting devices have been sufficiently described in accordance with 10 CFR §72.24(b), §72.122(f), and §72.122(g).

Cask Transporter (QA Category A)

Section 4.3 of the SAR indicates that the cask transporter is designed to lift, handle, and transfer a loaded HI-STAR HB overpack from the Refueling Building (RFB) to the ISFSI site. The cask transporter is a self-propelled, open front, tracked vehicle used for the handling and onsite transfer of loaded overpacks (SAR Figures 4.3-1–4.3-3). The same cask transporter licensed for use at the Diablo Canyon ISFSI will be used at the Humboldt Bay ISFSI.

The description of the cask transporter in Section 4.3.2.1 of the SAR includes consideration of inspection, maintenance, and testing in accordance with ANSI N14.6 (American National Standards Institute, 1993) and NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980). This design also allows for emergency load carrying capability. The staff finds that the cask transporter has been sufficiently described in accordance with 10 CFR §72.24(b), §72.122(b)(4), §72.122(f), and §72.122(g).

5.1.4.2 Design Criteria for Other Structures, Systems, and Components Important to Safety

The design bases for other SSCs important to safety are given in Table 3.4-2 of the SAR. The design bases identify details of the design criteria of other SSCs important to safety and comply with the general design criteria of 10 CFR Part 72, Subpart F. The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for SSCs important to safety.

HI-STAR HB Overpack (QA Category A)

The design criteria for the HI-STAR HB overpack are addressed in Section 3.3.1.1.2 of the SAR. A detailed description and summary of the design criteria for the certified HI-STAR 100 overpack are provided in Sections 1.2.1.2 and 2.0.2 of the HI-STAR 100 System FSAR (Holtec International, 2002). Due to the fact that the HI-STAR HB overpack design features are similar to the HI-STAR 100, the overpack top flange, closure plate, inner shell, and bottom plate are designed and fabricated in accordance with ASME Code, Section III (ASME International, 2001a), Subsection NB. The remainder of the HI-STAR HB overpack steel structure is designed and fabricated in accordance with the requirements of ASME Code Section III, Subsection NF (ASME International, 2001a). The overpack is designed for all normal, off-normal, and design basis accident condition loadings.

Welding of the overpack structure is in accordance with the ASME Boiler and Pressure Vessel Code Sections III and IX (ASME International, 2001a,c) Subsection NB [pressure (containment) boundary welds] and Subsection NF (noncontainment boundary welds) (ASME International, 2001a).

Section 4.2.3.3.2.10 of the SAR indicates that the overpack neutron shield enclosure shell was analyzed for 0.2 MPa gauge [30 psig] internal design pressure. The hoop stress and longitudinal stress were computed, and the larger of the two (hoop stress) was compared to the allowable stress from ASME Section III, Subsection NF (ASME International, 2001a).

The staff concludes that the HI-STAR HB overpack design criteria and relevant codes and standards have been identified in accordance with 10 CFR §72.24(c), §72.120(a), §72.120(b)(2), §72.120(b)(3), §72.122(f), §72.122(g), and §72.122(h)(1).

Fuel Basket (QA Category A)

The design criteria for the fuel basket are discussed in Section 4.2.3.3.2.10 of the SAR. The MPC-HB fuel basket is designed in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NG (ASME International, 2001a). Fabrication of the MPC-HB internals is in accordance with ASME Code Section III, Subsection NG (ASME International, 2001a), and inspection of MPC-HB internals are in accordance with ASME Code Section III, Subsection NG-5000 (ASME International, 2001a), and Section V (ASME International, 2001b).

The staff finds that the design criteria of the MPC-HB basket meet the requirements of the ASME Code, and are in accordance with 10 CFR §72.24(c), §72.120(a), §72.122(b)(2), and §72.122(b)(3).

Upper Fuel Spacers in MPC-HB (QA Category B)

The upper fuel spacers are designed to remain intact under a 60 g deceleration. In the applicant’s calculations for the design of the upper fuel spacers (Holtec International, 2004b, HI-2033035), the stresses generated by normal and accident conditions are compared with the appropriate stress limit from Section III, Subsection NF of the ASME Code (ASME International, 2001a). The staff concludes that the upper fuel spacers design criteria and relevant codes have been identified in accordance with 10 CFR §72.24(c), §72.120(a), §72.122(b)(2), and §72.122(b)(3).

Fuel Basket Spacers in MPC-HB Fuel Basket (QA Category A)

Section 4.2.3.3.2.10 of the SAR states that manual calculations were performed to qualify the fuel basket spacer, fuel spacer, and associated weld designs for the loads imparted by a 60 g deceleration. The applicant’s computed stresses (Holtec International, 2004b, HI-2033035) are compared with the appropriate stress limits from ASME Code Section III (ASME International, 2001a) for acceptance. The staff finds that the fuel basket spacers design criteria and relevant codes have been identified according to 10 CFR §72.24(c), §72.120(a), and §72.122(b).

Damaged Fuel Container (QA Category A)

The design criteria for the damaged fuel container are summarized in Table 3.4-2 of the SAR. The steel structure of the DFC is constructed in accordance with ASME Code Section III, Subsection NG (ASME International, 2001a). The lifting device at the top of the DFC is designed to meet the guidance of ANSI N14.6 (American National Standards Institute, 1993). The staff concludes that the design criteria of the DFC comply with 10 CFR §72.24(c) and §72.120(a).

Storage Cell Lid and Storage Cell Lid Closure Bolts (QA Category B)

The storage cells with the lids installed provide radiation shielding, security protection, protection from the environment, and defense-in-depth protection from tornado and explosion generated missiles. The steel storage cell liner includes internal support attachments that provide lateral restraint during seismic events to ensure that the casks will continue to provide adequate structural integrity, decay heat removal, shielding, and criticality control for the stored contents (SAR Section 4.2.2.1). The vault lids and closure bolts do not perform a design function with regard to restraining uplift of the cask.

Section 3.3.2 of the SAR details the design criteria for the storage vault, and a summary is provided in Table 3.4-3 of the SAR. The staff finds that the design criteria for the storage cell lid and lid closure bolts comply with 10 CFR §72.24(c), §72.120(a), §72.122(b)(2), and §72.122(b)(3).

Storage Cell Steel Liner and Seismic Lateral Restraints (QA Category B)

The steel storage cell liner includes internal support attachments that provide lateral restraint during a seismic event (SAR Section 4.2.2.1). The design criteria for the storage cell steel liner, seismic and lateral restraints, and storage cell lid are summarized in Table 3.4-3 of the SAR. The staff concludes that the design criteria of the steel liner and seismic lateral restraints meet the requirements of the ASME Code and have been sufficiently described in accordance with 10 CFR §72.24(b), §72.120(a), §72.122(b)(2), and §72.122(b)(3).

<u>Lift Links (QA Category A), Transporter Connection Pins (QA Category B), and Lateral Cask Restraining System</u>

Section 4.3.2.1.2 and Table 4.3-1 of the SAR indicate that the lift links and connector pins are designed in accordance with ANSI N14.6 (American National Standards Institute, 1993), per applicable guidance from Section 5.1.6 of NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980). As identified in Section 4.3.2.1.2 and Table 4.3-1 of the SAR, the lateral cask restraining system is purchased commercial grade and tested prior to use to confirm its commercial rated capacity with a ultimate safety factor of 5. Details of the lateral cask restraining system and associated lifted hardware design criteria and relevant codes and standards are presented in the HI-STAR 100 System FSAR (Holtec International, 2002). The staff finds that this description is adequate and complies with 10 CFR §72.24(c) and §72.120(a).

<u>Cask Transporter (QA Category A)</u>

As identified in Section 4.3.2.1.2 and Table 4.3-1 of the SAR, the cask transporter will be purchased commercial grade and tested prior to use in accordance with NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980). Section 4.3.2.1.2 of the SAR indicates that the cask transporter design is suitable for conditions at the ISFSI site, including the transfer route, with its maximum grade of approximately 8.5 percent. During cask handling activities at the storage vault, the transporter will remain stable and will not overturn or experience structural failure under the design seismic event. In addition, the cask transporter is designed to withstand HBPP design-basis tornado winds and tornado-generated missiles without overturning, dropping the load, or leaving the transfer route. Other natural phenomena, such as lightning strikes, floods, and fires have been evaluated and accounted for in the cask transporter design. The description of the cask transporter includes consideration of inspection, maintenance, and testing in accordance with ANSI N14.6 (American National Standards Institute, 1993) and NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980). The staff concludes that the cask transporter design criteria and relevant codes and standards have been identified in accordance with 10 CFR §72.24(c), §72.120(a), and §72.122(b)(4).

5.1.4.3 Material Properties for Other Structures, Systems, and Components Important to Safety

The staff findings regarding the material properties for other SSCs important to safety with respect to the applicable regulatory requirements are described below.

<u>HI-STAR HB Overpack</u>

The overpack materials for the HI-STAR HB are the same as those specified in Table 2.2-6 of the HI-STAR 100 System FSAR (Holtec International, 2002). Mechanical properties of the overpack structural materials are provided in Tables 3.3-2, 3.3-3, and 3.3-4 of the HI-STAR 100 System FSAR (Holtec International, 2002). The inner and outer cylindrical shells, base plate, and lid are constructed from SA516 Grade 70 carbon steel. The bottom plate, closure plate, and top flange are constructed from SA350-LF3. The neutron shield is Holtite-A neutron shielding material. This information is identified in Figure 3.3-3 of the SAR.

All weld materials utilized in the welding of overpack components comply with the provisions of Section III, Subsection NB (ASME International, 2001a), and Section IX of the ASME Code (ASME, International, 2001c). All noncode welds will also be made using welding procedures that meet Section IX of the ASME Code (ASME International, 2001c). The minimum tensile strength of the weld wire and filled material (where applicable) will be equal to or greater than the tensile strength of the base metal listed in the ASME Code.

The staff concludes that the overpack materials have been identified in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Fuel Basket (QA Category A)

MPC-HB basket structural materials are the same as those used in the HI-STAR 100 MPC basket and comply with the requirements of ASME Section II, Part A (ASME International, 2001d). All structural materials are Alloy X, which correspond to any of the following stainless steel types: 316, 316 LN, 304, and 304LN. A summary of the materials and components of the fuel basket is presented in Table 2.2-6 of the HI-STAR 100 System FSAR (Holtec International, 2002). Table 3.1-17 of HI-STAR 100 System FSAR presents the structural properties of Alloy X, and Table 4.2-1 of the SAR provides a summary of the nominal physical characteristics of the MPC-HB cask.

MPC-HB welding will be performed using welders and weld procedures that have been qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX (ASME International, 2001c) and Section III, Subsections NB and NG (ASME International, 2001a).

The staff finds that the material properties of the fuel basket have been described in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Upper Fuel Spacers in MPC-HB (QA Category B)

The material properties of the W14X13 beams are taken from ASME Section II, Part D (ASME International, 2001f) at 287.8 EC [550 EF] (Holtec International, 2004b, HI-2033035). This is consistent with the normal design temperature of the MPC-HB lid (Holtec International, 2002, Table 2.2.3). The staff finds that the material properties of the upper fuel spacers are acceptable and in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Fuel Basket Spacers in MPC-HB Basket (QA Category A)

Section 4.2.3.3.2.10 of the SAR states that material properties for the fuel basket spacers were taken from ASME Section II, Part D (ASME International, 2001f). Table 4.2-7 of SAR provides the results of calculations using accident allowable stresses from the ASME code. The staff finds that the material properties are in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Damaged Fuel Container (QA Category A)

The material used in fabricating the DFC will meet the requirements of ASME Section II, Part A (ASME International, 2001d). All DFC material is type 304 stainless steel, except bolts (SA-193-B8-Class 2), hex nuts (SA-194-GR 8), and washers (any type of stainless steel). The materials of construction for the DFC are readily weldable using commonly available welding techniques. The welding materials meet the requirements of ASME Section II, Part C (ASME International, 2001d).

The selection of materials for the DFC is acceptable and meets the requirements of ASME and alternative codes. The staff concludes that the DFC materials have been identified in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Storage Cell Lid and Storage Cell Lid Closure Bolts (QA Category B)

Information about the material for the storage cell components is provided in Section 4.2.2.4 of the SAR. The storage cell lids are constructed of SA-36 or SA-516 Grade 70 carbon steel plates, whereas the storage cell lid closure bolts are constructed of SA-193-B7 material. The staff finds that the storage cell lid and lid bolts materials have been identified in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Storage Cell Steel Liner and Seismic Lateral Restraints (QA Category B)

Section 4.2.2.4 of the SAR indicates that the steel liner and seismic restraints are constructed of SA-36 or SA-516 Grade 70 carbon steel and are coated with Carboline 890 (SAR Table 4.6-1) for protection against corrosion. The staff finds that the materials for construction of the storage cell steel liner and seismic lateral restraints have been selected in accordance with 10 CFR §72.24(c), §72.122(a), and §72.122(c).

Lift Links (QA Category A), Transporter Connection Pins (QA Category B), and Lateral Cask Restraining System

Materials for the lift links, transporter connection pins and lateral cask restraining system are not explicitly identified in the SAR. These components, however, are custom-designed and will be designed and fabricated in accordance with the applicable codes and standards. These standards identify the acceptable material characteristics. Additional details of the material properties for the associated lifting devices are provided in the HI-STAR 100 System FSAR (Holtec International, 2002). The staff concludes that the materials for the lift links, transporter connection pins, and lateral cask restraining system will be in accordance with 10 CFR §72.24(c)(3).

Cask Transporter (QA Category A)

Materials for the cask transporter are not explicitly identified in the SAR. This is a custom-designed system that will be designed and fabricated in accordance with the applicable codes and standards. These standards identify the acceptable material characteristics. The staff finds that use of the applicable codes and standards for the materials of construction will be in accordance with 10 CFR §72.24(c)(3).

5.1.4.4 Structural Analysis for Other Structures, Systems, and Components Important to Safety

Other SSCs important to safety were designed and analyzed to resist the loads and loading combinations specified in the design criteria.

HI-STAR HB Overpack

The structural functions of the HI-STAR HB overpack are to (i) serve as a missile barrier for the MPC-HB, (ii) ensure stability of the HI-STAR HB system, (iii) provide structurally robust support for the radiation shielding, and (iv) provide a helium retention boundary. The overpack also facilitates handling of the loaded system. The HI-STAR HB overpack is equipped with lifting trunnions that, along with the top flange of the overpack at the trunnion-overpack interface, are designed to meet the safety requirements of NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980) and ANSI N14.6 (American National Standards Institute, 1993) for single-failure-proof lifting equipment (Appendixes 3.D and 3.Y of the HI-STAR 100 System FSAR (Holtec International, 2002). The structural analyses of the HI-STAR 100 system overpack are provided in the HI-STAR 100 System FSAR (Holtec International, 2002), and these analyses are generally applicable to the HI-STAR HB system.

However, the staff has identified a difference between the trunnion-top flange drawing in the Humboldt Bay ISFSI SAR and the structural calculations presented in the HI-STAR 100 System FSAR (Holtec International, 2002). The trunnion presented in Figure 3.3-3 of the Humboldt Bay ISFSI SAR has a larger diameter and length than that used in the structural calculation of Appendix 3.Y of HI-STAR 100 System FSAR (Holtec International, 2002). The staff agrees with the applicant that this modification to the HI-STAR HB overpack provides more contact area and reduces the stresses in the trunnion-top flange interface. The modification, however, also reduces the minimum dimension of the wall flange and produces a stress redistribution that cannot be accurately predicted based on available information. The single-failure-proof criterion used for lifting loads requires that the maximum primary stress near the trunnion-cask interface must be limited to the yield stress when three times the lifted load is applied. Failure of the top flange wall could result in overpack breaching, but the lifting operations would not be adversely affected. The top flange is part of several cask engineered barriers, and the cask (overpack) does not form part of the confinement boundary. In addition, the HI-STAR HB cask is lighter than the HI-STAR 100 cask weight assumed in the structural calculations. The staff, therefore, has reasonable assurance that there is adequate safety margin against breaching of the top flange during cask lifting activities, because it is extremely unlikely that the HI-STAR HB cask trunnion redesign will result in stress redistribution and residual stresses significant enough to result in structural failure of the overpack.

The loading conditions considered in the HI-STAR 100 System FSAR (Holtec International, 2002) are the following loads:

- Dead and live loads
- Tipover
- Handling accident
- Flood
- Explosion overpressure

- Tornado
- Earthquake
- Lightning

Section 8.2 of the Humboldt Bay ISFSI SAR demonstrates the capability of SSCs important to safety to withstand postulated accidents and environmental conditions. Based on the results presented in the HI-STAR 100 System FSAR (Holtec International, 2002) for corresponding components, the stresses in the HI-STAR HB overpack structures for the most critical load combinations are less than the allowable stresses of ASME Boiler and Pressure Vessel Code Section III (ASME International, 2001a) for the structure materials.

The decelerations in the HI-STAR HB overpack due to potential seismic events are not bounded by the design of the generic overpack. For the seismic response of the HI-STAR HB cask in the vault, dynamic seismic analyses were performed using Visual Nastran Desktop (Holtec International, 2004c, HI-2033014). The analyses ensure that the maximum impact forces do not impose a deceleration loading on the overpack that exceeds the cask design basis. The analyses are carried out in the program Visual Nastran (MSC Software Corporation, 2002).

The applicant did not perform an SSI analysis to demonstrate that the free field input ground motion accelerations are not amplified when filtered into the soil-vault-cask system. Thus, the dynamic properties of the soil-vault-cask system have not been identified, and the UHS presented in Section 2 of the SAR can only be used to estimate the maximum potential amplifications (i.e., the bounding amplification values). The applicant, however, has reevaluated the dynamic model of the HI-STAR HB cask-vault using vertical input time histories amplified by a factor of 2, 3, 5, and 10 (Holtec International, 2004c, HI-2033014, Appendix E). The amplified accelerations in the vertical direction are intended to account for potential amplifications of the soil-vault-cask system due to SSI. The horizontal input time histories are not altered because the embedment of the vault and the lack of surface masses will prevent significant amplifications of accelerations in the horizontal direction. The maximum factors used to amplify the vertical time history are larger than the maximum expected amplification of accelerations due to SSI, and even in these cases, the resulting decelerations at the top and bottom of the cask are below the design basis limit value for the cask.

The design of the overpack neutron shield enclosure shell is presented in Section 4.2.3.2.3 of the SAR. The cylindrical shell design was analyzed for a 0.2 MPa gauge [30 psig] internal design pressure and a 60 g end drop. The structural calculations are shown in Supplement 5 of Holtec International (2003, HI-2033042) and Appendix 3.AG of the HI-STAR 100 System FSAR (Holtec International, 2002).

The HI-STAR HB overpack design meets the loading conditions identified in the HI-STAR 100 System FSAR (Holtec International, 2002), and the additional seismic loading conditions at the Humboldt Bay site. Thus, the staff conclusions for the HI-STAR 100 System SER (U.S. Nuclear Regulatory Commission, 2001b), with respect to the structural integrity of the HI-STAR 100 system overpack, are valid for the Humboldt Bay ISFSI. The staff concludes that the analysis complies with 10 CFR §72.24(c), §72.120(a), §72.122(a), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(h)(1), §72.122(l), and §72.128(a).

Fuel Basket (QA Category A)

The fuel basket is designed and fabricated as a core support structure in accordance with the applicable requirements of Section III, Subsection NG, of the ASME Code (ASME International, 2001a). Supplement 1 of Holtec International (2004b, HI-2033035) presents a two-dimensional finite element model (FEM) of the cross-section of the fuel basket used to perform the analysis in ANSYS (2000). The method of analysis and the model are similar to those used previously to license the generic MPC designs. Supplement 2 of Holtec International (2004b, HI-2033035) presents the strength and stability capabilities of the fuel basket cell walls to withstand the compressive load transferred by the fuel basket spacers.

The staff concludes that the analyses of the MPC-HB fuel basket meet the requirements of the ASME Code and comply with 10 CFR §72.24(d), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(h)(1), and §72.128(a).

Upper Fuel Spacers in MPC-HB (QA Category B)

The upper fuel spacers, as well as the welds connecting the upper fuel spacers to the MPC-HB top plate, are designed to withstand a 60 g bottom end drop. The stresses are calculated using strength of materials formulae and compared with the appropriate stress limits from Section III, Subsection NF, of the ASME Code (ASME International, 2001a). The applicant has provided this information in Supplement 3 of Holtec International (2004b, HI-2033035). The staff finds that the upper fuel spacers in the MPC-HB, therefore, are adequate to withstand the normal and accident loads and comply with 10 CFR §72.24(d), §72.122(b)(2), §72.122(b)(3), and §72.122(c).

Fuel Basket Spacers in MPC-HB Basket (QA Category A)

The structural analysis of the MPC-HB fuel spacers was not bounded by structural calculations of the generic MPC. The applicant has provided a structural analysis of the fuel basket spacers for the MPC-HB (Pacific Gas and Electric Company, 2005, and Supplement 2 of Holtec International, 2005b, HI-2033035). The staff concludes that the analysis meets the requirements of 10 CFR §72.24(d), §72.122(b)(2), and §72.122(c).

Damaged Fuel Container (QA Category A)

The applicant performed an analysis of the DFC for the HI-STAR HB system (Holtec International, 2003, HI-2033042, Supplement 1). The analysis demonstrates that the storage container is structurally adequate to support the loads developed during normal lifting operations and an end drop. The lifting bolt of the container is designed to meet the requirements set forth for ANSI N14-6 (American National Standards Institute, 1993). The stress levels of the remaining components of the DFC are compared to allowable stress levels in ASME Code Section III, Subsection NG (ASME International, 2001a). The staff concludes that the DFC structural analysis has been adequately described and complies with 10 CFR §72.24(c), §72.24(d), §72.122(b)(2), and §72.128(a).

Storage Cell Lid and Storage Cell Lid Closure Bolts (QA Category B)

The storage cell lids are not included in the FEM of the storage vault (Holtec International, 2004a, HI-2033013), although the weight of the lids is applied as a uniformly distributed pressure in mechanical load cases. The structural analysis of the storage cell lid is performed separately from the FEM. This analysis only includes static and dynamic loads associated with the weight of the storage cell lid. Tornado missile analysis was not performed on the vault or lid because the overpack is qualified to withstand the impact of tornado missiles exceeding those required by the ISFSI site conditions according to Section 4.2.2 of the SAR and the HI-STAR 100 System FSAR (Holtec International, 2002).

The calculations include the structural adequacy of the bolts under seismic reactions on the lid considering self-weight for the seismic mass. Because the cask storage vault is buried, wind and tornado wind loads are not applicable; however, a tornado pressure drop on the outside of the vault produces an internal pressure on the lid. The net hydrostatic load on the lid, which is standing water on top of the lid caused by tsunami, is considered in the calculation.

The vault storage lids and lid closure bolts may be exposed to accidental loads that have not been analyzed by the applicant. As mentioned previously, the applicant reevaluated the dynamic model of the HI-STAR HB cask-vault system using amplified vertical time histories (Holtec International, 2005a, Appendix E, HI 2033014). As a result of the most severe of these vertical amplifications, the dynamic analysis of the cask-vault system indicates that the cask will impact the storage cell lid. However, the applicant calculated that the HI-STAR HB overpack would not exceed its design basis deceleration limit of 60 g for a value of vertical amplification from SSI effects up to 9.5, which is not considered credible for the Humboldt Bay site. Therefore, the overpack will maintain its integrity and continue to perform its design function following a seismic event. Thus, for beyond design basis seismic scenarios involving extreme vertical SSI amplification effects, the storage cell lid and lid closure bolts are not relied upon to perform a safety function, and are classified as not important to safety. In addition, the storage cell lid is not relied upon to provide a shielding function in this scenario, as the accident dose limits of 72.106(c) would not be exceeded even if the lid were damaged. The staff concludes that the structural analysis of the storage cell lid and lid bolts has been adequately described and complies with 10 CFR §72.24(c), §72.24(d), §72.122(b)(2), and §72.128(a).

Storage Cell Steel Liner and Seismic Lateral Restraints (QA Category B)

Structural calculations for the steel liner are not performed because its primary purpose is to provide a form for pouring concrete.

The applicant has provided static and dynamic analysis to demonstrate the structural integrity of the seismic lateral restraints to punching and potential buckling failure of the cask alignment plates due to seismic events (Pacific Gas and Electric Company, 2004b; Holtec International, 2004a, HI-2033013). The staff concludes that the structural analysis of the seismic lateral restraints meet the requirements of 10 CFR §72.24(d), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(h)(1), and §72.128(a).

Lift Links (QA Category A), Transporter Connection Pins (QA Category B), and Lateral Cask Restraining System

Structural analysis of the associated lifting hardware is provided in the HI-STAR 100 System FSAR (Holtec International, 2002). The staff evaluation of the HI-STAR 100 system is documented in the HI-STAR 100 System SER (U.S. Nuclear Regulatory Commission, 2001b). No additional review was performed for this SER, as these components are identical for the HI-STAR HB system.

The lift links are designed as nonredundant lifting devices with a safety factor of 10 or greater for material ultimate strength and 6 or greater for yield strength. A dynamic load increase factor of 10 percent has been applied to the lifting loads. These elements, therefore, meet the NUREG-0612 stress limits (U.S. Nuclear Regulatory Commission, 1980) for nonredundant special lifting devices.

The connector pins are designed with a minimum safety factor of 3 for material yield strength and 5 for material ultimate strength, as well as a dynamic load increase factor of 10 percent. Multiple elements are used, and each can totally support the weight of the canister, thereby making them single-failure proof in accordance with NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980).

The lift links, transporter connection pins, and lateral cask restraining system are custom designed for the site-specific criteria. Structural analysis to be completed by the applicant in accordance with the design criteria will demonstrate that these components are designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events, in accordance with the requirements of 10 CFR §72.122(b)(1). The structural analysis will also demonstrate that these components are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, and floods, without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR §72.122(b)(2).

Cask Transporter (QA Category A)

The applicant analyzed the potential for the transporter to slide off the roadway during a seismic event. In the analysis, design basis earthquake (DBE) and ground motions are applied in three orthogonal directions to the HI-STAR HB cask carried by the transporter at various locations on the path from the RFB to the ISFSI. The simulations are performed using Visual Nastran (MSC Software Corporation, 2002). The code models large motions of rigid bodies that may contact each other during the event. The HI-STAR HB overpack and the cask transporter are modeled as solid bodies using Solidworks, Inc. (2001). The HI-STAR HB overpack is assumed to be fixed to the transporter and to acquire the motion of the transporter for all degrees of freedom except for vertical relative movement. The HI-STAR HB overpack is supported by two long vertical arms that are given an appropriate spring stiffness reflecting anticipated system elasticity in the vertical direction. The ground is assumed fixed, and the driving seismic inputs are applied as known inertia forces to the mass centers of the HI-STAR HB and the transporter, respectively. The structural analysis demonstrates that the cask transporter will remain on the roadway and not tipover when subjected to the DBE (Holtec International, 2004d, HI-2033036).

The cask transporter is custom designed for the site-specific criteria in accordance with NUREG-0612 (U.S. Nuclear Regulatory Commission, 1980). As required by Humboldt Bay ISFSI Technical Specification 4.3.3, lifting of a cask outside the RFB shall be performed with load handling equipment that is designed, fabricated, inspected, maintained, operated and tested in accordance with the applicable guidelines of NUREG-0612. Structural analysis to be completed by the applicant in accordance with the criteria in NUREG-0612 will demonstrate that the cask transporter is designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events, in compliance with the requirements of 10 CFR CFR §72.122(b)(1). The structural analysis also will demonstrate that the cask transporter is designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, and floods, without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR §72.122(b)(2) and §72.122(b)(4).

5.1.5 Other Structures, Systems, and Components Not Important to Safety

Section 5.4.5 of NUREG-1567 (U.S. Nuclear Regulatory Commission, 1998) identifies the regulatory requirements that are applicable to other SSCs subject to NRC approval. There are no specific requirements identified in 10 CFR Part 72 for other SSCs not important to safety.

5.1.5.1 Description of Other Structures, Systems, and Components Not Important to Safety

As identified in Section 4.5.5 and summarized in Table 4.5-1 of the SAR, security systems, lighting and poles, electrical power, communication systems, rail dolly, and perimeter fencing are considered SSCs not important to safety. Also, portions of the cask transfer system, cask storage vault, drainage pipe (Pacific Gas and Electric Company, 2004b), and ancillary equipment without design functions directly related to protecting health and safety are classified as not important to safety (e.g., automated welding system, overpack vacuum drying system).

Descriptions of the other SSCs not important to safety are briefly described in Section 4.4.4 of the SAR to satisfy the requirements of 10 CFR §72.24(a) and §72.24(b). The descriptions are limited to a general description of the various systems. The majority of these systems will be based on commercially available systems that are designed, fabricated, constructed, tested, and maintained in accordance with approved engineering practices.

The HI-STAR HB system is a passive system, and no electrical power is required to ensure the safe, long-term storage of the SNF.

5.1.5.2 Design Criteria for Other Structures, Systems, and Components Not Important to Safety

The design criteria identified for SSCs not important to safety are based on applicable commercial codes and standards to ensure, where interfaces exist, that there is compatibility with SSCs important to safety. The design of the other SSCs not important to safety permits inspection, maintenance, and testing.

5.1.5.3 Material Properties for Other Structures, Systems, and Components Not Important to Safety

No specific material properties are identified in the SAR for SSCs not important to safety. Material properties, however, will satisfy the codes or standards applicable to the SSCs as required and, therefore, satisfy the requirement of 10 CFR §72.24(c)(3).

5.1.5.4 Structural Analysis for Other Structures, Systems, and Components Not Important to Safety

SSCs not important to safety will be designed based on standard engineering practices that are in accordance with the applicable codes and standards. This demonstrates compliance with the requirements of 10 CFR §72.24(d) and §72.24(i) and the applicable section of 10 CFR §72.122.

5.2 Evaluation Findings

Based on the review of the Humboldt Bay ISFSI SAR and supporting documents, the staff made the following determinations:

- The SSCs important to safety are designed, fabricated, erected, and tested to quality standards commensurate with the functions to be performed. The SSCs important to safety are classified based on their primary function and importance to overall safety. The requirements of 10 CFR §72.122(a), therefore, have been satisfied.

- The SAR and docketed materials relating to the description of confinement SSCs important to safety meet the requirements of 10 CFR §72.24(a–b) in sufficient detail to allow evaluation of their structural effectiveness.

- The SAR and docketed materials relating to the design criteria of confinement SSCs important to safety, including applicable codes and standards meet the requirements of 10 CFR §72.24(c)(1), §72.24(c)(2), §72.24(c)(4), §72.120(a), §72.122(a), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), §72.122(l), and §72.128(a).

- The SAR and docketed materials relating to the suitable material properties used in the design and construction of the confinement SSCs meet the requirements of 10 CFR §72.24(c).

- The SAR and docketed materials provide adequate analytical reports to ensure the structural integrity of the confinement SSCs important to safety. These SSCs are designed to accommodate the combined loads of normal, off-normal, accident, and natural phenomena events with an adequate margin of safety. Thus, the SSCs important to safety meet the requirements of 10 CFR §72.24(d)(1), §72.24(d)(2), §72.122(b)(2), §72.122(b)(3), §72.122(c), §72.122(f), §72.122(h)(1), §72.122(h)(4), §72.122(i), and §72.122(l).

- The design of the dry cask storage system and the selection of materials adequately protect the SNF cladding from degradation that might otherwise lead to gross rupture of the cladding. The applicant has met the requirements of 10 CFR §72.122(h)(1).

- The description of SSCs important to safety considers inspection, maintenance, and testing. Components requiring inspection and maintenance are identified, and operational procedures are summarized adequately. The requirements of 10 CFR §72.122(f), therefore, have been satisfied.

- The design of the lift links, transporter connection pins, and lateral cask restraining system also allows for emergency capabilities because access to critical locations and regions in the event of emergencies is possible. In addition, the lifting components are designed to hold the load in the event of emergencies. The requirements of 10 CFR §72.122(g), therefore, have been satisfied.

- The SAR and docketed materials relating to the description of the reinforced concrete storage vault meet the requirements of 10 CFR §72.24(a) and §72.24(b).

- The reinforced concrete storage vault is designed in accordance with ACI-349-01 (American Concrete Institute, 2001), and other applicable codes and standards. Structural analyses demonstrate that the reinforced concrete storage vault is designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events. The reinforced concrete storage vault meets the requirements of 10 CFR §72.24(c)(1), §72.24(c)(2), §72.24(c)(4), §72.103(b), §72.103(f)(2)(i), §72.103(f)(2)(iv), §72.120(a), §72.122(a), §72.122(b–c), §72.122(f–g), §72.122(h)(4), §72.122(l), and §72.128(a).

- The SAR and docketed materials relating to suitable material properties used in the design and construction of the reinforced concrete SSCs meet the requirements of 10 CFR §72.24(c)(3).

- The SAR and docketed materials relating to the description of other SSCs important to safety meet the requirements of 10 CFR §72.24(a), §72.24(b), §72.122(b)(4), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), and §72.122(i).

- The SAR and docketed materials relating to design criteria of other SSCs important to safety, including applicable codes and standards, meet the requirements of 10 CFR §72.24(c), §72.120(a), §72.122(a), §72.122(b)(1–4), §72.122(c), §72.122(f–g), §72.122(h)(1), §72.122(h)(4), §72.122(i), and §72.122(l).

- The SAR and docketed materials relating to the suitable material properties for use in the design and construction of other SSCs important to safety meet the requirements of 10 CFR §72.24(c), §72.122(a) and §72.122(c).

- The SAR and docketed materials provide adequate analytical reports to ensure the structural integrity of other SSCs important to safety and meet the requirements of 10 CFR §72.24(c)(1), §72.24(c)(2), §72.24(c)(4), §72.24(d), §72.120(a), §72.122(a), §72.122(b)(2), §72.122(b)(3), §72.122(b)(4), §72.122(c), §72.122(f), §72.122(g), §72.122(h)(1), §72.122(h)(4), §72.122(i), §72.122(l), and §72.128(a).

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