6 THERMAL EVALUATION

6.1 Conduct of Review

The staff's review of the applicant's thermal evaluation included the following sections of the Diablo Canyon ISFSI SAR: 2.2.2.2, "Hazards From Fires;" 2.2.2.3, "Onsite Explosion Hazards;" 2.3.2, "Local Meteorology;" 3.1.1, "Materials to be Stored;" 3.2.7, "Temperature and Solar Radiation;" 3.3.1.6, "Fire and Explosion Protection;" 4.2.3, "Storage Cask Description;" 4.4.3.6, "Thermal Performance;" 5.1, "Operation Description;" 8.1.2, "Off-Normal Environmental Temperatures;" 8.1.4, "Partial Blockage of Air Inlets;" 8.2.5, "Fire;" 8.2.6, "Explosion;" and 10.2, "Development of Operating Controls and Limits." The staff also reviewed the applicant's responses to the staff's Requests for Additional Information (Pacific Gas and Electric Company, 2002c, 2004a,b), and a Probabilistic Risk Assessment pertaining to explosion hazards (Pacific Gas and Electric Company, 2003b). The design of the proposed Diablo Canyon ISFSI is based on the use of the HI-STORM 100 System as certified in accordance with 10 CFR Part 72 by the U.S. Nuclear Regulatory Commission (2002a) and as described in the Final Safety Analysis Report (FSAR) for the HI-STORM 100 System (Holtec International, 2002). However, in order to address the NRC staff position in Interim Staff Guidance document ISG-11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," PG&E has elected to revise its application to limit spent fuel storage at the Diablo Canyon ISFSI to low burnup fuel ($\leq$ 45 GWd/MTU) (Pacific Gas and Electric Company, 2004b).

6.1.1 Decay Heat Removal Systems

The staff reviewed the discussion on decay heat removal systems with respect to the following regulatory requirements:

- 10 CFR §72.122(h)(1) requires the spent fuel cladding to be protected during storage against degradation that leads to gross ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning of consolidated fuel rods or unconsolidated assemblies or other means as appropriate.

- 10 CFR §72.128(a) requires spent fuel storage, and other systems that might contain or handle radioactive materials associated with spent fuel must be designed to ensure adequate safety under normal and accident conditions. These systems must be designed with (1) A capability to test and monitor components important to safety, (2) Suitable shielding for radioactive protection under normal and accident conditions, (3) Confinement structures and systems, (4) a heat-removal capability having testability and reliability consistent with its importance to safety, and (5) means to minimize the quantity of radioactive wastes generated.

The HI-STORM 100SA storage cask is designed to remove decay heat primarily by convective heat transfer. An active cooling system is not used. The storage cask is equipped with four inlet vents at the bottom and four outlet vents on top. Cool air is drawn into the annulus between the canister and storage cask through the bottom inlet vents. The buoyancy created

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by the heating of the air creates a chimney effect, and the air flows back into the environment through the outlet vents at the top of the cask. The Certificate of Compliance (CoC) (U.S. Nuclear Regulatory Commission, 2002a, Appendix A) includes surveillance requirements for ensuring that the cask heat-removal system is operational during storage (i.e., the air ducts are inspected every 24 hours to ensure that the ducts are free of blockages). The storage cask design and heat-removal capability are described and evaluated in the HI-STORM 100 System FSAR (Holtec International, 2002). As documented in the HI-STORM 100 System Safety Evaluation Report (SER) (U.S. Nuclear Regulatory Commission, 2002b), the staff has previously determined that the HI-STORM 100SA storage cask provides adequate heat-removal capacity under normal storage conditions as long as the fuel specifications and loading conditions as defined in the CoC (U.S. Nuclear Regulatory Commission, 2002a, Appendix B) are met and the environmental characteristics of the site are bounded by the corresponding design criteria (see Section 6.1.3 of this SER).

As with the HI-STORM 100SA storage cask, the HI-TRAC 125 Transfer Cask is designed to remove decay heat primarily by convective heat transfer. From the outer surface of the Multi-Purpose Canister (MPC) to the ambient atmosphere, heat is transferred within the transfer cask through multiple concentric layers of air, steel, and shielding materials. Heat must propagate through a total of six concentric layers, representing the air gap, the HI-TRAC 125 inner shell, the lead shielding, the outer shell, the water jacket, and the enclosure shell. Heat is dissipated to the atmosphere predominantly by natural convection from the surface of the enclosure shell. The transfer cask design and heat-removal capability are described and evaluated in the HI-STORM 100 System FSAR (Holtec International, 2002). As documented in the HI-STORM 100 System SER (U.S. Nuclear Regulatory Commission, 2002b), the staff has previously determined that the HI-TRAC 125 Transfer Cask provides adequate heat-removal capacity during normal transport conditions as long as the fuel specifications and loading conditions as defined in the CoC (U.S. Nuclear Regulatory Commission, 2002a, Appendix B) are met and the environmental characteristics of the site are bounded by the corresponding design criteria (see Section 6.1.3 of this SER). Furthermore, the CoC (U.S. Nuclear Regulatory Commission, 2002a, Appendix B) limits the minimum ambient temperature for conducting transfer cask loading, onsite transport, and unloading operations to −18 °C [0 °F]. The proposed Diablo Canyon ISFSI Technical Specifications will impose more restrictive limits on fuel types than those for the Holtec HI-STORM 100 system, and the environmental characteristics of the Diablo Canyon ISFSI site are within the corresponding design criteria.

The staff reviewed the information provided by the applicant regarding the spent nuclear fuel heat-removal capacity of the HI-STORM 100 System for normal, off-normal, and accident conditions. The staff found the analysis acceptable because

- The staff has previously determined (U.S. Nuclear Regulatory Commission, 2002b) that the HI-STORM 100 System provides adequate heat-removal capacity for normal, off-normal, and accident conditions so long as the fuel specifications as defined in the CoC (U.S. Nuclear Regulatory Commission, 2002a, Appendix B) are met and the environmental characteristics of the site are bounded by the corresponding design criteria (see Section 6.1.3 of this SER).

- The Diablo Canyon ISFSI fuel specifications and normal, off-normal, and accident-loading conditions identified in the SAR are sufficient to ensure the decay heat-removal capacities of the HI-STORM 100 System will not be exceeded.

The staff's review of the submitted information provides reasonable assurance that the Diablo Canyon ISFSI spent nuclear fuel will not exceed the decay heat-removal capacities of the HI-STORM 100 System. Based on the foregoing evaluation, the staff finds that the requirements of 10 CFR §72.122(h)(1) and §72.128(a) have been adequately satisfied.

6.1.2 Fuel Cladding Performance

The staff performed an evaluation of the cladding performance for the low burnup fuel to be stored at the Diablo Canyon ISFSI. This evaluation was done to confirm reasonable assurance that the fuel cladding integrity will be maintained during normal conditions of storage, short-term Part 72 operations, and off-normal/accident conditions of storage. The staff's evaluation was conducted with respect to the following regulatory requirements:

- The requirements of 10 CFR 72.122(h)(1) seek to ensure safe fuel storage and handling and to minimize post-operational safety problems with respect to the removal of the fuel from storage. In accordance with this regulation, the spent fuel cladding must be protected during storage against degradation that leads to gross rupture of the fuel and must be otherwise confined such that degradation of the fuel during storage will not pose operational problems with respect to its removal from storage. Additionally, 10 CFR 72.122(l) and 72.236(m) require that the storage system be designed to allow ready retrieval of the spent fuel from the storage system for further processing or disposal.

<u>Cladding Integrity for Low Burnup Fuel</u>

PG&E proposes to store low-burnup fuel at the Diablo Canyon ISFSI (Pacific Gas and Electric Company, 2004b). For low-burnup fuel, cladding integrity is maintained if the fuel rod temperatures do not result in failures due to creep and hydride reorientation. To provide reasonable assurance that creep failure will not occur under short-term and off-normal conditions, a temperature limit of $570^{o}C$ is used. To ensure that hydride reorientation would not occur, an applicant could either limit the cladding temperature from increasing above $400^{o}C$ or, if the cladding temperature increases above $400^{o}C$ but stays below $570^{o}C$, the cladding hoop stress should not exceed approximately 90 MPa at the point of hydride precipitation.

The applicant's calculated peak cladding temperatures for normal conditions of storage for low-burnup fuel are summarized in Table 6-1. Based on these temperatures, the staff concludes that the low burnup Diablo Canyon fuel meets the guidance in ISG-11, Revision 3, for normal conditions of storage.

Table 6-1. Calculated peak rod clad temperature for low burnup Fuel (from Holtec International, 2002; Table 4.3.7)

Fuel Age at Initial Loading (Years)	Low-Burnup Zircaloy/ZIRLO Fuel Cladding Temperature Limit °C [°F]
5	366.0 [691]
6	358.0 [676]
7	335.0 [635]
10	329.6 [625]
15	323.2 [614]

The Diablo Canyon spent fuel inventory includes some fuel assemblies designed for high burnup (Vantage 5 IFBA rods) that did not experience burnups above 45 GWd/MtU, and are thus considered low burnup assemblies. Some of the fuel designs include enriched boron and natural boron IFBAs (integral fuel burnable assemblies). IFBA rods are designed with a thin layer of zirconium di-boride on the fuel pellets. The cladding for these rod types is composed of the zirconium alloys ZIRLO and Zircaloy-4.

The staff requested additional information from the applicant to assess whether the Vantage 5 fuel design (at low burnups up to 45 GWd/MTU) meets the intent of the guidance of ISG-11, Revision 3, to minimize hydride reorientation in the spent fuel cladding. Based on responses by PG&E (Pacific Gas and Electric Company, 2004a) and confirmatory analyses performed by the staff with assistance from the Pacific Northwest National Laboratory (PNNL, 2004), the staff concluded that the cladding hoop stresses for the Vantage 5 fuel at burnups up to 45 GWd/MTU would not exceed 83 MPa for fuel containing natural boron, and would not exceed 93 MPa for fuel with enriched boron. The staff finds that based on these results, in conjunction with the fact that the analyzed short-term peak clad temperatures for canister drying, cask transfer, and off-normal and accident conditions do not exceed 570°C (1058°F), the low burnup fuel to be stored at the Diablo Canyon ISFSI meets the intent of ISG-11, Revision 3.

The NRC staff concludes that the Diablo Canyon ISFSI meets the regulatory requirements of 10 CFR 72.122(h)(1) and (l), and 72.236(m) for safe storage of low burnup spent nuclear fuel.

6.1.3 Thermal Loads and Environmental Conditions

The staff reviewed the discussion on thermal loads and environmental conditions with respect to the following regulatory requirements:

- 10 CFR §72.92(a) requires that the natural phenomena that may exist or that can occur in the region of a proposed site be identified and assessed according to their potential effects on the safe operation of the ISFSI. The important natural phenomena that affect the ISFSI design must be identified.

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- 10 CFR §72.122(b) requires that (1) structures, systems, and components important to safety must be designed to accommodate the effects of, and to be compatible with, site characteristics and environmental conditions associated with normal operation, maintenance, and testing of the ISFSI and to withstand postulated accidents. (2)(i) structures, systems, and components important to safety must be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, hurricanes, floods, tsunami, and seiches, without impairing their capability to perform their intended design functions. The design bases for these structures, systems, and components must reflect: (A) Appropriate consideration of the most severe of the natural phenomena reported for the site and surrounding area, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated, and (B) Appropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena. (ii) The ISFSI also should be designed to prevent massive collapse of building structures or the dropping of heavy objects as a result of building structural failure on the spent fuel waste or on to structures, systems, and components important to safety. (3) Capability must be provided for determining the intensity of natural phenomena that may occur for comparison with design bases of structures, systems, and components important to safety.

The meteorological conditions of the proposed ISFSI are documented in the DCPP FSAR Update (Pacific Gas and Electric Company, 2001, Section 2.3), which is maintained in accordance with 10 CFR §50.71(e). The SAR for the proposed ISFSI (Pacific Gas and Electric Company, 2002a, Section 2.3) provided a summary of the relevant meteorological information and data documented in the DCPP FSAR Update. The meteorological conditions for the proposed ISFSI site and the adjacent power plant are expected to be the same because of their close proximity to each other {i.e., approximately 0.35 km [0.22 mi]} and negligible difference in elevation {i.e., approximately 68.6 m [225 ft]}. The highest hourly temperature recorded at the site was 36 °C [97 °F], which occurred in October 1987. Temperatures below freezing were measured over a several hour period in December 1990. The average annual temperature at the site is approximately 13 °C [55 °F]. In addition, Table 6-2 conveys relevant monthly and annual mean temperatures for Morro Bay, California (Pacific Gas and Electric Company, 2001, Table 2.3-7), which is located on the California coast approximately 16 km [10 mi] northwest of the DCPP site. The mean temperatures documented in Table 6-2 were derived from data accumulated during a 14-year period.

Table 6-2. Temperatures for Morro Bay, California (Pacific Gas and Electric Company, 2001, Table 2.3-7)

Month	Mean Temperature °C [°F]	Mean Maximum Temperature °C [°F]	Mean Minimum Temperature °C [°F]	Extreme Maximum Temperature °C [°F]	Extreme Minimum Temperature °C [°F]
January	11.4 [52.6]	16.7 [62.0]	6.2 [43.2]	27.8 [82]	−1.1 [30]

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February	12.1 [53.8]	17.2 [63.0]	7.0 [44.6]	27.8 [82]	−1.1 [30]
March	11.7 [53.1]	16.9 [62.5]	6.4 [43.6]	29.4 [85]	0.0 [32]
April	12.3 [54.1]	17.5 [63.5]	7.1 [44.7]	33.9 [93]	0.6 [33]
May	12.8 [55.1]	17.2 [62.9]	8.5 [47.3]	36.7 [98]	0.6 [33]
June	14.2 [57.5]	18.0 [64.4]	10.3 [50.5]	36.7 [98]	4.4 [40]
July	14.6 [58.2]	18.4 [65.1]	10.7 [51.3]	31.7 [89]	1.1 [34]
August	13.1 [55.5]	19.3 [66.7]	11.5 [52.7]	34.4 [94]	7.2 [45]
September	15.9 [60.7]	20.4 [68.8]	11.4 [52.5]	38.3 [101]	6.1 [43]
October	16.0 [60.8]	21.4 [70.5]	10.6 [51.0]	37.2 [99]	3.3 [38]
November	13.9 [57.0]	18.9 [66.0]	8.8 [47.8]	33.3 [92]	0.0 [32]
December	11.3 [52.4]	16.4 [61.6]	6.2 [43.2]	26.1 [79]	−1.7 [29]
Annual	13.3 [55.9]	18.2 [64.8]	8.7 [47.7]	38.3 [101]	−1.7 [29]

The extreme ambient temperature range design criteria for the proposed ISFSI is −4 °C [24 °F] to 40 °C [104 °F] (Pacific Gas and Electric Company, 2002a, Table 3.4-1). These temperatures correspond to the extreme minimum and maximum temperatures recorded at Pismo Beach, California (Pacific Gas and Electric Company, 2001, Table 2.3-7) during a 12-year period. Pismo Beach is also located on the California coast approximately 24 km [15 mi] east-southeast of the proposed Diablo Canyon ISFSI site. These extreme temperatures bound the values recorded for Morro Bay, California (see Table 6-2). In addition, the mean daily maximum temperature (defined as the mean of peak temperatures for a month) for Morro Bay, California, is 21.4 °C [70.5 °F].

According to the HI-STORM 100 System CoC (U.S. Nuclear Regulatory Commission, 2002a), the maximum average yearly temperature allowed for the site is 26.7 °C [80 °F]. Moreover, the allowed temperature extremes, averaged during a 3-day period, shall be greater than −40 °C [−40 °F] and less than 51.7 °C [125 °F]. Based on information provided in the DCPP FSAR (Pacific Gas and Electric Company, 2001, Table 2.3-7) and proposed ISFSI SAR (Pacific Gas and Electric Company, 2002a), the cask design criteria (Holtec International, 2002) bound the temperatures measured at the site and nearby towns.

According to Section 2.3.2 of the ISFSI SAR, solar-insolation data collected by the California Polytechnic State University, Department of Water Resources, and cataloged in the California Irrigation Management Information System, are applicable to the Diablo Canyon ISFSI site. These data are measured at approximately 19.3 km [12 mi] northeast of the proposed Diablo Canyon ISFSI. For data collected between 1986 and 1999, the maximum measured insolation for a 24-hour period was 766 g-cal/cm^2 per day {371 W/m^2 [118 BTU/hr-ft^2]} and, for a 12-hour period, 754 g-cal/cm^2 per day {365 W/m^2 [116 BTU/hr-ft^2]}. The daily (24 hour) average for the period of record was 430 g-cal/cm^2 per day {208 W/m^2 [66 BTU/hr-ft^2]}.

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As reported by Holtec International (2000, Table 4.1; 2002, Section 4.4.1.1), the models analyzing the transport of heat from the heat-generation regions of the HI-STORM 100 System storage and transfer casks to the outside environment use insolation boundary conditions on the cask surfaces that are based on the 12-hour levels prescribed in 10 CFR Part 71, averaged over a 24-hour period, after accounting for partial blockage conditions on the sides of the overpack. These insolation values correspond to 800 g-cal/cm^2 per day {387 W/m^2 [123 BTU/hr-ft^2]}. Based on the foregoing information, the staff concludes that the insolation values used to evaluate the thermal performance of the HI-STORM 100 System storage and transfer casks adequately bound the site-specific insolation design parameters for the Diablo Canyon ISFSI.

Table 4-2 of the HI-STORM 100 System SER (U.S. Nuclear Regulatory Commission, 2002b) indicates that the bounding annual average earth temperature for the HI-STORM 100SA storage cask is 25 °C [77 °F]. Although the average storage pad or earth temperature was not explicitly provided in the SAR for the proposed ISFSI, it can be inferred that this temperature is less than the bounding 25 °C [77 °F] requirement. This inference is based on the recognition that the average annual earth temperature will not be greater than the average annual air temperature at the site, which is reported to be approximately 13 °C [55 °F].

The staff reviewed the local meteorological data and discussions presented in the SAR (Pacific Gas and Electric Company, 2002a) and found them acceptable because reliable data sources were used and the data are appropriately summarized. The applicant adequately presented information regarding temperatures recorded by the onsite measurement program and at other nearby sites, and, therefore, satisfied the requirement of 10 CFR §72.92(a). The staff confirmed that temperatures and solar loads at the site are bounded by the HI-STORM 100 System storage and transfer cask design parameters.

The staff reviewed the information provided by the applicant pertaining to the Diablo Canyon ISFSI thermal loads and environmental conditions. The staff found the analysis acceptable because:

- Reliable data sources have been used to present temperatures and solar insolation at nearby sites.
- Environmental data recorded during the onsite measurement program correlate well with data recorded at nearby sites.
- The temperatures and solar loads at the Diablo Canyon ISFSI site are bounded by the HI-STORM 100 System design parameters.

The staff finds that the submitted information provides reasonable assurance that the Diablo Canyon ISFSI thermal loads and environmental conditions are bounded by the HI-STORM 100 System design parameters. Based on the foregoing evaluation, the requirements of 10 CFR §72.92(a) and §72.122(b) have been adequately satisfied.

6.1.4 Analytical Methods, Models, and Calculations

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The staff reviewed the discussion on analytical methods, models, and calculations with respect to the following regulatory requirements:

- 10 CFR §72.122(h)(1) requires the spent fuel cladding to be protected during storage against degradation that leads to gross ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning of consolidated fuel rods or unconsolidated assemblies or other means as appropriate.

- 10 CFR §72.128(a) requires spent fuel storage and other systems that might contain or handle radioactive materials associated with spent fuel must be designed to ensure adequate safety under normal and accident conditions. These systems must be designed with: (1) a capability to test and monitor components important to safety, (2) suitable shielding for radioactive protection under normal and accident conditions, (3) confinement structures and systems, (4) a heat-removal capability having testability and reliability consistent with its importance to safety, and (5) means to minimize the quantity of radioactive waste generated.

The staff reviewed the information provided by the applicant pertaining to the Diablo Canyon ISFSI analytical methods, models, and calculations. The staff found the analysis acceptable because:

- The analytical methods, models, and calculations used to establish the thermal characteristics of the HI-STORM 100 System were previously reviewed and found to be acceptable by the staff (U.S. Nuclear Regulatory Commission, 2002a,b).

The staff finds that the submitted information provides reasonable assurance that the Diablo Canyon ISFSI is adequately designed to protect SSCs important to safety from all postulated normal, off-normal, and accident thermal loads and environmental conditions. Based on the foregoing evaluation, the requirements of 10 CFR §72.122(h)(1) and §72.128(a) have been adequately satisfied.

6.1.5 Fire and Explosion Protection

6.1.5.1 Fire

The staff reviewed the discussion on fire with respect to the following regulatory requirement:

- 10 CFR §72.122(c) requires that structures, systems, and components important to safety be designed and located so that they can continue to perform their safety functions effectively under credible fire and explosion exposure conditions. Noncombustible and heat-resistant materials must be used wherever practical throughout the ISFSI, particularly in locations vital to the control of radioactive materials and to the maintenance of safety control functions. Explosion and fire detection, alarm, and suppression systems shall be designed and provided with sufficient capacity and capability to minimize the adverse effects of fires and

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> explosions on structures, systems, and components important to safety. The design of the ISFSI must include provisions to protect against adverse effects that might result from either the operation or the failure of the fire suppression system.

The proposed Diablo Canyon ISFSI is collocated with the DCPP within the owner-controlled area. A plan drawing of the proposed ISFSI was provided in Figure 2.1-2 of the ISFSI SAR. The loaded HI-STORM 100SA storage casks will be anchored to concrete storage pads within a separate protected area. A security fence is used to demarcate the protected area. According to Figure 2.1-2 of the SAR, the restricted area fence, which encompasses the security fence, is at least 30.5 m [100 ft] from the storage casks. Up to seven storage pads will be constructed within the protected area to accommodate 140 storage casks (i.e., 20 storage casks per pad arranged in a 4 by 5 rectilinear array) over a 152 × 32-m [500 × 105-ft] footprint. The ISFSI protected area will have applicable barrier, access, and surveillance controls consistent with the requirements of 10 CFR §73.55. The Canister Transfer Facility (CTF) is located next to the storage area but outside the protected area.

Other than the DCPP, no industrial facilities, public transportation routes, rail lines, or military bases are within 8 km [5 mi] of the ISFSI site. Local shipping tankers may come within 16 km [10 mi] of the coast site, but will remain outside a 8-km [5-mi] range. No natural gas or other pipelines pass within 8 km [5 mi] of the site. Similarly, no combustible or explosive materials, beyond those associated with the DCPP, are stored within 8 km [5 mi] of the site.

Locations pertaining to the proposed ISFSI that fall within the purview of the 10 CFR Part 72 review are the transport route from the DCPP Fuel-Handling Building/Auxiliary Building (FHB/AB) to the CTF, the CTF, and the cask storage area. The postulated fire events that could potentially affect these areas that have been identified by PG&E in Subsection 8.2.5 of the ISFSI SAR and in the response to additional staff questions (Pacific Gas and Electric Company, 2003b) are:

(1) An onsite cask transporter fuel tank fire
(2) Other onsite vehicle fuel tank fires
(3) Combustion of other local stationary fuel tanks
(4) Combustion of other local combustible materials
(5) Fire in the surrounding vegetation
(6) Electrical transformer fire

The onsite cask transporter is used to move the spent nuclear fuel (contained within the MPC) from the FHB/AB to the CTF using the HI-TRAC 125 Transfer Cask. After the MPC has been transferred to the HI-STORM 100SA storage cask at the CTF, the cask transporter is used to move the storage cask onto the storage pad. To ensure that the potential exposure of the HI-TRAC 125 transfer and HI-STORM 100SA storage casks to a fire remain bounded by previously approved analyses, the Diablo Canyon ISFSI Technical Specifications will limit the diesel fuel tank used for the transporter to a 189-L [50-gal] capacity. The ability of the HI-TRAC 125 Transfer Cask and HI-STORM 100SA storage casks to provide confinement and protect the spent nuclear fuel from gross degradation as the result of a 189-L [50-gal] diesel fuel fire was previously reviewed and found to be acceptable by the staff (U.S. Nuclear Regulatory Commission, 2002a,b).

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Administrative controls will be implemented to ensure transient sources of fuel in volumes larger than 189 L [50 gal] will be a sufficient distance from the ISFSI storage pads at all times, the CTF during active MPC transfer operations, and the transport route during cask transport (Pacific Gas and Electric Company, 2002a, Section 8.2.5.2). However, a 3,028-L [800-gal] fuel tanker truck will use the transport route near the storage area to deliver fuel to the vehicle maintenance shop located approximately 610 m [2,000 ft] northeast of the storage area approximately six times per week. This amount of fuel exceeds the 189-L [50-gal] limit. To determine the potential consequences of a fuel tanker truck fire occurring near the storage area, the applicant submitted a bounding 7,570-L [2,000-gal] fire-loading analysis (Pacific Gas and Electric Company, 2003a), to assess the potential effects on the HI-TRAC 125 Transfer Cask, which would bound the potential effects on a HI-STORM 100SA storage cask. This fire-loading analysis adequately demonstrated that a nonengulfing 7,570-L [2,000-gal] fuel tanker fire will not adversely affect the HI-TRAC 125 Transfer Cask, or the HI-STORM 100SA storage casks.

There is at least a 30.5-m [100-ft] clearance between the storage area, CTF, and the cask transport route and any onsite stationary fuel tanks (Pacific Gas and Electric Company, 2002a, Section 2.2.2.2). Onsite stationary fuel tanks include:

(1) Three fuel tanks {946 L [250 gal] propane; 7,571 L [2,000 gal] No. 2 diesel; and 11,356 L [3,000 gal] gasoline} located beside the main plant road, 366 m [1,200 ft] from the cask transport route at its nearest point;

(2) The Unit 2 main bank transformer mineral oil storage tank, located approximately 73 m [240 ft] from the transport route; and

(3) the bulk hydrogen storage facility (consisting of six individual hydrogen storage tanks) located approximately 4.6 m [15 ft] from the transport route.

The stationary propane, diesel, and gasoline fuel tanks are far enough away from the transporter route so as not to pose a fire hazard to the HI-TRAC 125 Transfer Cask. The 7,570-L [2,000-gal] fuel tanker fire-loading analysis adequately demonstrated that nonengulfing fires originating from the mineral oil and hydrogen storage tanks will not adversely affect the HI-TRAC 125 transfer cask.

No combustible materials will be stored within the confines of the storage area demarcated by the security fence.

The native vegetation surrounding the storage area is primarily grass. Maintenance programs will prevent uncontrolled growth of the surrounding vegetation. Moreover, the consequences of this potential fire hazard are bounded by the 7,570-L [2,000-gal] fuel tanker fire-loading analysis.

Electrical transformers are located approximately 73 m [240 ft] from the HI-TRAC 125 Transfer Cask transport route. The mineral oil within these transformers could be ignited by lightning strike, vehicle crash, or internal electrical faults. Administrative procedures that prohibit transport of the transfer cask during inclement weather and DCPP transition operations significantly reduce the potential for transformer mineral oil fire being ignited by lightning or internal electrical faults. Administrative procedures will also prohibit the use of onsite vehicles

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during transport of the transfer cask, negating the potential for a vehicle accident serving as the initiating event for a transformer fire. Moreover, even if a transformer mineral oil fire were to occur, its effect on the transfer cask during transport is bounded by the nonengulfing 7,570-L [2,000-gal] fire-loading analysis.

The potential for a fire within the CTF as the result of a cask transporter fuel spill was addressed in response to the staff's request for additional information (Pacific Gas and Electric Company, 2002c). To mitigate the potential for these postulated fire events, the CTF opening will be located at a higher elevation than the surrounding area so that any fuel spilled will flow away from the Diablo Canyon ISFSI. Moreover, administrative controls will prohibit any transient fuel sources other than the cask transporter from coming into close proximity of the CTF during transfer operations.

The emergency plan for the DCPP has been augmented to address the potential fire hazards that are uniquely associated with the ISFSI storage area. The DCPP Emergency Plan also provides for the availability of a fire brigade and fire-fighting equipment and gear. The fire brigade is organized, operated, trained, and equipped in accordance with the requirements of 10 CFR Part 50. The equipment and gear will be stocked and maintained in accordance with 10 CFR Part 50. Changes to the DCPP site emergency plan to accommodate the ISFSI were reviewed and found to be acceptable by the staff, as discussed in Chapter 10 of this SER.

The staff reviewed the information provided by the applicant pertaining to the Diablo Canyon ISFSI fire protection. The staff found the analysis acceptable because:

- The HI-STORM 100 System has been evaluated for a bounding, hypothetical fully engulfing fire caused by a 189-L [50-gal] spill of diesel fuel and the evaluation, described in detail in the HI-STORM 100 System FSAR, was previously reviewed and found to be acceptable by the staff (U.S. Nuclear Regulatory Commission, 2002a,b).

- Based on the assessment of the potential fire hazards and the fire protection measures established for the Diablo Canyon ISFSI, there is reasonable assurance that the HI-STORM 100 System will not be exposed to fires that exceed the design basis fire.

- The restricted area has been adequately described.

- Noncombustible and heat-resistant materials will be used wherever practical.

- Through design of the CTF and administrative procedures, combustible material (e.g., spill of diesel fuel from cask transporters) will be kept out of the cask transfer cell during canister transfer operations.

- The DCPP Emergency Plan provides for the availability of a fire brigade and fire-fighting equipment and gear.

- The information provided is also acceptable for use in other sections of the SAR to develop the design bases of the Diablo Canyon ISFSI and perform additional safety analyses.

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The staff's finds that the submitted information provides reasonable assurance that the Diablo Canyon ISFSI is adequately designed to protect SSCs important to safety from all postulated onsite fires and wildfires. Based on the foregoing evaluation, the requirements of 10 CFR §72.122(c) have been adequately satisfied.

Further evaluation of the effects of credible fires at the Diablo Canyon ISFSI is given in Chapter 15, "Accident Analysis," of this SER.

6.1.5.2 Explosion

The staff reviewed the information presented in Section 2.2.1.2, "Hazards from Facilities and Ground Transportation;" Section 2.2.2.3, "Onsite Explosion Hazards;" Section 3.3.1.6, "Fire and Explosion Protection;" and Section 8.2.6, "Explosion," of the ISFSI SAR (Pacific Gas and Electric Company, 2002a) and in the response to additional staff questions (Pacific Gas and Electric Company, 2003b) in connection with the protection against potential onsite and offsite explosions. That information has been reviewed for conformance with the following regulatory requirement:

- 10 CFR §72.122(c) requires that structures, systems, and components important to safety be designed and located so that they can continue to perform their safety functions effectively under credible fire and explosion exposure conditions. Noncombustible and heat-resistant materials must be used wherever practical throughout the ISFSI, particularly in locations vital to the control of radioactive materials and to the maintenance of safety control functions. Explosion and fire detection, alarm, and suppression systems shall be designed and provided with sufficient capacity and capability to minimize the adverse effects of fires and explosions on structures, systems, and components important to safety. The design of the ISFSI must include provisions to protect against adverse effects that might result from either the operation or the failure of the fire suppression system.

U.S. Highway 101 passes approximately 14.4 km [9 mi] east of the proposed ISFSI site. The Irish Hills separate the highway from the ISFSI site. The proposed ISFSI site is also approximately 16 km [10 mi] south of U.S. Highway 1. The nearest county roads in Clark Valley and See Canyon are 8 km [5 mi] from the proposed ISFSI site. A county road, Avila Beach Drive, provides access to the DCPP private road system.

The Southern Pacific Transportation Company rail line runs adjacent to U.S. Highway 101 and, therefore, is located approximately 14.4 km [9 mi] from the proposed ISFSI site. The Irish Hills shield the ISFSI site from any potential explosion hazards that may be transported along these two routes. There is no spur track into the PG&E DCPP property.

Shipping lines near the proposed ISFSI are approximately 32 km [20 mi] offshore. Since 1998, tanker traffic into either Port San Luis or Estero Bay has stopped. Some petroleum products and crude oil are currently stored at Estero Bay, approximately 16 km [10 mi] from the proposed ISFSI site. Port San Luis Harbor is approximately 9.6 km [6 mi] south-southeast of the proposed ISFSI.

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Based on Regulatory Guide 1.91 (U.S. Nuclear Regulatory Commission, 1978), the maximum probable hazardous solid cargo for a single highway truck is 23,000 kg [50,000 lb]; for a single railroad box car, approximately 60,000 kg [132,000 lb]; and for a ship, approximately 4,500,000 kg [10,000,000 lb]. No potential explosion hazards that exceed these limits within the prescribed safe distances for each transport mode were identified. Therefore, the staff finds that no potential offsite explosion hazards need to be considered.

The potential onsite explosion hazards that could affect the HI-TRAC 125 Transfer Cask or HI-STORM 100SA storage casks identified in the ISFSI SAR (Pacific Gas and Electric Company, 2002a, Subsection 8.2.6) are as follows:

(1) Detonation of a transporter or onsite vehicle fuel tank
(2) Detonation of mineral oil from the DCPP Unit 2 main bank transformers
(3) Detonation of propane bottles transported past the ISFSI storage pad
(4) Detonation of acetylene bottles transported past the ISFSI storage pad
(5) Explosive decompression of a compressed gas cylinder
(6) Detonation of large stationary fuel tanks in the vicinity of the transport route
(7) Detonation of the bulk hydrogen facility
(8) Detonation of acetylene bottles stored on the east side of the cold machine shop

Regulatory Guide 1.91 (U.S. Nuclear Regulatory Commission, 1978) recommends that the setback distance for a potential explosion hazard correspond to an air overpressure of 6.9 kPa [1 psi], below which the potential effects of explosion-generated missiles do not have to be evaluated. Alternatively, Regulatory Guide 1.91 states that if estimates of explosion rate, frequency of shipment, and exposure distance are made on a realistic or best-estimate basis, an exposure rate less than 10^{-7} per year is sufficiently low to screen out potential explosion hazards. If conservative estimates are used, an exposure rate less than 10^{-6} per year is sufficiently low.

The flash point for diesel fuel {52 $^\circ$C [125 $^\circ$F]} exceeds the maximum expected ambient temperature {40 $^\circ$C [104 $^\circ$F]} for the proposed site. As a result, an additional accident event sequence would be required to produce the conditions needed to ignite this particular type of fuel. No credible accidents capable of producing the conditions necessary to cause an explosion of the transporter diesel fuel were identified. The flash point of the mineral oil {135 $^\circ$C [275 $^\circ$F]} from the DCPP Unit 2 main bank transformers also exceeds the maximum expected ambient temperature. Although an electrical fault may occur within one of the transformers, the resulting rupture of the transformer case may cause the mineral oil to ignite and burn, but not explode. Therefore, the annual frequency of occurrence for this event was not considered in assessing the potential explosion hazard exposure for the HI-TRAC 125 Transfer Cask (Pacific Gas and Electric Company, 2003b).

In its response to additional questions (Pacific Gas and Electric Company, 2003b), PG&E assessed the potential hazard arising from standard vehicle fuel tank explosions assuming an average tank capacity of 76 L [20 gal]. Two standard vehicle fuel tank explosions scenarios were addressed. The first scenario considered the annual frequency of occurrence for a parked vehicle fuel tank explosion, applicable to the HI-TRAC 125 Transfer Cask explosion hazard assessment. The second scenario evaluated the frequency of occurrence for a fuel tank explosion of vehicles passing within close proximity of the storage area (i.e., vehicles passing within the 53-m [175-ft] setback distance of the HI-STORM 100SA storage casks).

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PG&E also assessed the hazard posed by a fuel tanker truck that passes the storage casks on the north side of the proposed dry-storage area approximately six times per week. The setback distance calculated by PG&E for the 3,028-L [800-gal] tanker truck, based on an explosion overpressure limit of 6.9 kPa [1 psi], is 183 m [600 ft]. The fuel tanker truck will pass near the ISFSI storage area, and thus will violate the required setback distance. PG&E submitted a probabilistic risk assessment to address the scenario of the fuel tanker coming into close proximity of the ISFSI storage area (Pacific Gas and Electric Company, 2003b).

No onsite stationary fuel storage facilities pose an explosion hazard to the ISFSI storage area. It is estimated, however, that one acetylene bottle per year and one propane bottle per week will pass within the required setback distance of the ISFSI storage area. Therefore, the annual frequency of occurrence for this particular explosion hazard was also accounted for in PG&E's assessment.

PG&E's assessment demonstrated that the potential effect of explosion-generated missiles originating from the explosive decompression of a compressed gas cylinder on the HI-TRAC 125 Transfer Cask and HI-STORM 100SA storage casks is inconsequential (Pacific Gas and Electric Company, 2002a, Subsection 8.2.6.2.2); therefore this scenario was not considered to contribute to the overall explosion hazard.

Three onsite stationary fuel tanks {946 L [250 gal] propane, 7,571 L [2,000 gal] No. 2 diesel, and 11,356 L [3,000 gal] gasoline} could pose an explosion hazard to the HI-TRAC 125 Transfer Cask during transport of spent nuclear fuel to the CTF. These tanks are located beside the main plant road, approximately 366 m [1,200 ft] from the cask transport route at its nearest point. Given their distance from the transport route, however, in Subsection 8.2.6.2.1 of the ISFSI SAR, PG&E showed that an explosion of the propane and gasoline tanks would subject the HI-TRAC 125 Transfer Cask to an explosion overpressure less than 6.9 kPa [1 psi] . As a result, this particular explosion hazard does not have to be considered. Also, an explosion of the diesel fuel tank is considered to be an incredible event.

The bulk hydrogen facility is comprised of six individual tanks that represent a combined 8.5-m^3 [300-ft^3] storage capacity. This facility is located near the FHB/AB and is approximately 4.6 m [15 ft] from the HI-TRAC 125 Transfer Cask transport route. The hydrogen storage tanks are enclosed within a seismic-qualified vault on three sides. The open face of the vault is oriented toward the transfer cask transport route. Therefore, PG&E considered the annual frequency of occurrence for this event in assessing the potential explosion hazard exposure for the HI-TRAC 125 transfer cask.

According to PG&E's assessment, the potential detonation of seismically constrained acetylene bottles stored on the east side of the cold machine shop is not a credible event. The basis for this conclusion is that administrative procedures will prohibit transport of the transfer cask during inclement weather, significantly reducing the potential for lightning being the initiating event for an explosion. Moreover, administrative procedures will also prohibit the use of on-site vehicles during transport of the transfer cask, negating the potential for a vehicle accident being the initiating event for an acetylene bottle explosion. As a result, the occurrence of an explosion from this potential hazard does not have to be included in the total explosion frequency of occurrence for the HI-TRAC 125 Transfer Cask.

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In summary, the potential explosion hazards that could affect the Diablo Canyon ISFSI storage area are transient in nature. These explosion hazards are the 76-L [20-gal] standard vehicle fuel tanks, a 3,028-L [800-gal] fuel tanker truck, and propane and acetylene bottles that pass within close proximity of the storage area on a regular basis. The potential explosion hazards that could affect the transporter during transfer of the spent nuclear fuel from the FHB/AB to the CTF are stationary standard vehicle fuel tanks (parked in the lot adjacent to the FHB/AB) and the bulk hydrogen facility.

The staff reviewed the information provided by the applicant pertaining to the Diablo Canyon ISFSI explosion protection. The staff found the analysis acceptable because:

- Descriptions of potential explosion sources are adequate.
- The credible explosion hazard sources are sufficient distances from important-to-safety SSCs, including the storage cask and transfer cask during spent fuel transport, to ensure the air overpressure 6.9-kPa [1-psi] limit is not exceeded.
- PG&E performed a probabilistic risk assessment (Pacific Gas and Electric Company, 2003b, Enclosure 2) to demonstrate the following explosion hazards for the storage area that could exceed the 6.9-kPa [1-psi] air overpressure limit are not credible (i.e., the combined annual frequency of occurrence for these potential explosion hazards is below the 1×10^{-6} threshold defined by Regulatory Guide 1.91): (1) 3,028-L [800-gal] tanker truck that routinely passes near the ISFSI storage pad area, (2) 76-L [20-gal] fuel tanks of the standard vehicles routinely passing within 53 m [175 ft] of the ISFSI storage pad area, and (3) transport of acetylene bottles along the transport route near the ISFSI storage pad area.
- PG&E performed a probabilistic risk assessment (Pacific Gas and Electric Company, 2003b, Enclosure 2) to demonstrate that the following explosion hazards along the HI-TRAC 125 Transfer Cask transport route that could exceed the 6.9-kPa [1-psi] air overpressure limit are not credible (i.e., the combined annual frequency of occurrence for these potential explosion hazards is below the 1×10^{-6} threshold defined by Regulatory Guide 1.91): (1) the bulk hydrogen tank facility; and (2) 76-L [20-gal] fuel tanks of standard vehicles parked near the FHB/AB.

The staff finds that the submitted information provides reasonable assurance that the Diablo Canyon ISFSI is adequately designed to protect SSCs important to safety from all postulated explosion hazards. Based on the foregoing evaluation, the requirements of 10 CFR §72.122(c) have been adequately satisfied.

6.2 Evaluation Findings

The thermal evaluation of the Diablo Canyon ISFSI, as presented in the SAR, is based on the assumption that the HI-STORM 100 System will be used for the storage and on-site transport of the Diablo Canyon spent nuclear fuel. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose appropriate limits on the fuel to be stored and that the environmental characteristics of the ISFSI site are within the corresponding design criteria for the HI-STORM 100 system; therefore, the thermal evaluation for the Diablo Canyon ISFSI is acceptable. The staff's findings based on this review follow.

Sufficient information was provided by the applicant to demonstrate that the Diablo Canyon ISFSI spent nuclear fuel specifications will not exceed the decay heat-removal capacities of the HI-STORM 100 System under normal, off-normal, and accident loading conditions. Therefore, the requirements of 10 CFR §72.122(h)(1) and §72.128(a) have been adequately demonstrated.

The staff finds that the low burnup fuel to be stored at the Diablo Canyon ISFSI meets the intent of ISG-11, Revision 3. As a result, the requirements of 10 CFR §72.122(h)(1) have been adequately demonstrated.

Reliable data sources have been used to present temperatures and solar insolation at nearby sites. Data recorded by the DCPP onsite measurement program have also been presented. These data correlate well with data recorded at nearby sites. Therefore, the ISFSI SAR shows that information on temperatures and solar insolation at the proposed site is acceptable and in compliance with 10 CFR 72.92(a). The temperatures and solar loads at the site are bounded by the HI-STORM 100 System design parameters.

The analytical methods, models, and calculations used to establish the thermal characteristics of the HI-STORM 100 System were previously reviewed and found to be acceptable by the staff (U.S. Nuclear Regulatory Commission, 2002a,b).

The SAR adequately describes the potential fire hazards for the Diablo Canyon ISFSI storage area and HI-TRAC 125 Transfer Cask transport route. In addition, adequate descriptions of potential sources of accidental onsite and offsite explosions have been presented. Through design of the CTF and administrative procedures, combustible material (e.g., spill of diesel fuel from cask transporters) will be kept out of the cask transfer cell during canister transfer operations. PG&E performed a probabilistic risk assessment to determine whether or not potential fire and explosion hazards are credible. In summary, the ISFSI SAR and supplemental analyses show that the fire and explosion hazards at the site are acceptable and in compliance with the requirements of 10 CFR 72.122(c). Based on the assessment of the fire protection measures and the potential fire and explosion hazards at the site, there is reasonable assurance that the HI-STORM 100 System to be used at the Diablo Canyon ISFSI will not be exposed to fires or explosions that are beyond the design basis for the cask system.

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6.3 References

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