15 ACCIDENT ANALYSIS

15.1 Conduct of Review

The staff evaluated the applicant's accident analysis by reviewing Chapter 8, "Accident Analysis," of the Diablo Canyon ISFSI SAR (Pacific Gas and Electric Company, 2003), documents cited in the SAR, and other relevant publicly available information, including web sites on the Internet.

In the ISFSI SAR and in its response to the staff's Request for Additional Information (RAI) (Pacific Gas and Electric Company, 2002), PG&E described the basis for selecting off-normal and accident events to ensure that all relevant potential scenarios have been considered. The selection of these off-normal and accident event scenarios is based on guidance in NUREG–1567 (U.S. Nuclear Regulatory Commission, 2000). In addition, PG&E also reviewed other site-specific applications and associated NRC evaluations in developing the spectrum of postulated events to be analyzed.

The dry cask storage system to be used at the proposed facility is the HI-STORM 100 System, which has been reviewed by the NRC and approved for general use under Certificate of Compliance (CoC) No. 1014-1 (U.S. Nuclear Regulatory Commission, 2002a). As discussed in Chapters 4 and 5 of this SER, the design-basis loads considered in the HI-STORM 100 System Final Safety Analysis Report (FSAR) bound the loading conditions at the proposed Diablo Canyon ISFSI. Thus, where applicable, the staff relied on the review carried out during the certification process for the HI-STORM 100 cask system, as documented in the NRC HI-STORM 100 System SER (U.S. Nuclear Regulatory Commission, 2002b).

The staff reviewed the accident analysis to determine if the following regulatory requirements have been met:

- 10 CFR §72.90 requires that: (a) site characteristics that may directly affect the safety or environmental impact of the ISFSI must be investigated and assessed; (b) proposed sites for the ISFSI must be examined with respect to the frequency and the severity of external natural and man-induced events that could affect the safe operation of the ISFSI; (c) design basis external events must be determined for each combination of proposed site and proposed ISFSI design; (d) proposed sites with design basis external events for which adequate protection cannot be provided through ISFSI design shall be deemed unsuitable for the location of the ISFSI; (e) pursuant to subpart A of Part 51 of Title 10 for each proposed site for an ISFSI, the potential for radiological and other environmental impacts on the region must be evaluated with due consideration of the characteristics of the population, including its distribution, and of the regional environs, including its historical and esthetic values; and (f) the facility must be sited so as to avoid to the extent possible the long-term and short-term adverse impacts associated with the occupancy and modification of floodplains.

- 10 CFR §72.92 requires that: (a) natural phenomena that may exist or that can occur in the region of a proposed site must 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; (b) records of the occurrence and severity of those important natural phenomena must be collected for the region and evaluated for reliability, accuracy, and completeness. The applicant shall retain these records until the license is issued; and (c) appropriate methods must be adopted for evaluating the design basis external natural events based on the characteristics of the region and the current state of knowledge about such events.

- 10 CFR §72.94 requires that: (a) the region must be examined for both past and present man-made facilities and activities that might endanger the proposed ISFSI. The important potential man-induced events that affect the ISFSI design must be identified; (b) information concerning the potential occurrence and severity of such events must be collected and evaluated for reliability, accuracy, and completeness; and (c) appropriate methods must be adopted for evaluating the design basis external man-induced events, based on the current state of knowledge about such events.

- 10 CFR §72.98(a) requires that the regional extent of external phenomena, man-made or natural, that are used as a basis for the design of the ISFSI be identified.

- 10 CFR §72.98(c) requires that those regions identified pursuant to paragraphs 10 CFR §72.98(a) and §72.98(b) be investigated as appropriate with respect to: (1) the present and future character and the distribution of population, (2) consideration of present and projected future uses of land and water within the region, and (3) any special characteristics that may influence the potential consequences of a release of radioactive material during the operational lifetime of the ISFSI.

- 10 CFR §72.102(f)(1) requires that the design earthquake for use in the design of structures be determined as follows: (1) for sites that have been evaluated under the criteria of Appendix A of 10 CFR Part 100, the design earthquake must be equivalent to the safe shutdown earthquake for a nuclear power plant; and (2) Regardless of the results of the investigations anywhere in the continental U.S., the design earthquake must have a value for the horizontal ground motion of no less than 0.10 g with the appropriate response spectrum.

- 10 CFR §72.106(b) requires that any individual located on or beyond the nearest boundary of the controlled area not receive from any design basis accident the more limiting of a total effective dose equivalent of 0.05 Sv (5 rem), or the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) of 0.5 Sv (50 rem). The lens of the eye dose equivalent shall not exceed 0.15 Sv (15 rem) and the shallow dose equivalent to skin or to any extremity shall not exceed 0.5 Sv (50 rem). The minimum distance from the spent fuel or high-level radioactive waste handling and storage facilities to the nearest boundary of the controlled area must be at least 100 meters.

- 10 CFR §72.122(b) requires that (1) structures, systems, and components important to safety 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; and (2) Structures, systems, and components important to safety must be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lighting, hurricanes, floods, tsunami, and seiches, without impairing their capability to perform safety functions. The design bases for these structures, systems, and components must reflect: (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, high-level radioactive waste or on to structures, systems, and components important to safety.

- 10 CFR §72.122(c) requires that structures, systems, and components important to safety must 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.

- 10 CFR §72.122(h)(1) requires that the spent fuel cladding must 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 §72.122(h)(4) requires that storage confinement systems must have the capability for continuous monitoring in a manner such that the licensee will be able to determine when corrective action needs to be taken to maintain safe storage conditions. For dry spent fuel storage, periodic monitoring is sufficient provided that periodic monitoring is consistent with the dry spent fuel storage cask design requirements. The monitoring period must be based upon the spent fuel storage cask design requirements.

- 10 CFR §72.122(h)(5) requires that the waste must be packaged in a manner that allows handling and retrievability without the release of radioactive materials to the environment or radiation exposures in excess of 10 CFR Part 20 limits. The package must be designed to confine the high-level radioactive waste for the duration of the license.

- 10 CFR §72.122(i) requires that instrumentation and control systems must be provided to monitor systems that are important to safety over anticipated ranges for normal operation and off-normal operation.

- 10 CFR §72.122(l) requires that Storage systems must be designed to allow ready retrieval of spent fuel, high-level radioactive waste for further processing or disposal.

- 10 CFR §72.124(a) requires spent fuel handling, packaging, transfer, and storage systems must be designed to be maintained subcritical and to ensure that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. The design of handling, packaging, transfer, and storage systems must include margins of safety for the nuclear criticality parameters that are commensurate with the uncertainties in the data and methods used in calculations and demonstrate safety for the handling, packaging, transfer and storage conditions and in the nature of the immediate environment under accident conditions.

- 10 CFR §72.128(a)(2) requires that spent fuel storage be designed with suitable shielding for radioactive protection under normal and accident conditions.

The proposed ISFSI facility must be sited, designed, constructed, and operated so the above-mentioned regulatory requirements are met to adequately protect public health and safety during all credible off-normal and accident events.

15.1.1 Off-Normal Events

The off-normal events are described in Section 8.1, “Off-Normal Operations,” of the SAR. This section of the SER discusses results from the review of potential off-normal conditions, which include cask drop from less than design allowable height, partial vent blockage, and operational events. Where applicable, the staff relied on the analyses in the HI-STORM 100 System FSAR and the related staff evaluation as documented in the HI-STORM 100 System SER (U.S. Nuclear Regulatory Commission, 2002b).

15.1.1.1 Cask Drop Less Than Design Allowable Height

Due to the design features and administrative controls applied to the ISFSI-related activities conducted within the DCPP FHB/AB, a potential drop of the HI-TRAC 125 Transfer Cask is only considered during the period that the loaded Transfer Cask is moved between the FHB/AB and the Cask Transfer Facility (CTF). Similarly, the drop of a loaded storage cask is only considered during movement between the CTF and the ISFSI storage pads. In its response to the staff's RAI (Pacific Gas and Electric Company, 2002), PG&E committed to design the cask transporter so it will have redundant drop protection features and will conform to the criteria of NUREG–0612 (U.S. Nuclear Regulatory Commission, 1980), American National Standards Institute (ANSI) N14.6 (American National Standards Institute, 1993), and ASME B30.9-1996 (ASME International, 1996). The staff previously determined that a specific limit on cask lift height during transfers between the FHB/AB, CTF, and the storage pads is not necessary if these cask transporter design requirements are met (U.S. Nuclear Regulatory Commission, 2002a). Therefore, based on the applicant's commitment to these design standards, transfer and storage cask drop events are not considered credible and an evaluation of a cask drop less than the design allowable height is not required.

15.1.1.2 Partial Vent Blockage

The staff previously determined that the HI-STORM 100 storage cask provides adequate heat removal capacity under partial vent blockage conditions, so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are adhered to and the environmental characteristics of the site are bounded by the corresponding design criteria (see Section 6.1.3 of this SER). The proposed Diablo Canyon ISFSI Technical Specifications include 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).

15.1.1.3 Operational Events

Failure of Instrumentation

No off-normal events that involve failure of instruments and control systems are postulated because the passive dry cask storage system does not rely on permanent instruments to monitor the heat and radiation at the ISFSI storage pad site. The HI-STORM 100 storage casks will be visually inspected as required by the Technical Specifications to ensure that the overpack inlet and outlet air ducts remain free from blockages. If a blockage is detected, it will be removed within one operating shift. Radiation and airborne radioactivity will be monitored using portable hand-held radiation protection instruments and dosimeters during transfer operations at the CTF and routine maintenance at the ISFSI storage area.

Based on the staff's review of the information provided regarding failure of instrumentation, there is reasonable assurance that important to safety functions will not be affected for the proposed cask system or the proposed ISFSI.

Vehicular Impact

The staff reviewed the information presented in the ISFSI SAR Chapters 3 and 4, "Principal Design Criteria," and, "ISFSI Design;" and Section 8.2.4, "Drops and Tip-Over." Vehicular impact is postulated by the staff to occur during movement of a loaded transfer cask from the FHB/AB to the CTF, or movement of a loaded storage overpack from the CTF to the storage pads, or in the storage pad area. Vehicular impacts are postulated to result from an interaction between the cask transporter, an onsite service vehicle, or an off-site vehicle used by site personnel and a loaded transfer or storage cask. Equipment failure, operator error, or a natural event (e.g., tornado) may lead to this off-normal event. Occurrence of this event would be easily identifiable from visual evidence, such as dents or scratches on casks, onsite vehicles, and other ISFSI facility structures, systems, and components (SSC).

As discussed in the HI-STORM 100 System FSAR, the HI-STORM 100SA storage cask and HI-TRAC 125 Transfer Cask are designed to withstand a tornado missile equivalent to the impact of an automobile weighing 1,800 kg [3,968 lb] traveling at a speed of 202 km/h [56 m/s] {126 mph [185 ft/s]} (SAR Table 3.2-2). This tornado-missile analysis for the storage cask and the staff evaluation are provided in the HI-STORM 100 System FSAR and the related NRC SER. That analysis indicated that such impacts would not result in damage to the cask contents. Since onsite vehicles at the DCPP are assumed to be traveling at a much lower speed than that assumed in the tornado missile analysis, postulated vehicular impacts for the HI-STORM 100 System transfer and storage casks are bounded by the tornado missile analysis, and no damage to the spent fuel contents will result from these events.

The cask transporter and CTF are designed to withstand a tornado missile equivalent to the impact of an automobile weighing 1,800 kg [3,968 lb] traveling at a speed of 15 m/s {48.8 ft/s (33.3 mph)} (SAR Table 3.2-2) (Pacific Gas and Electric Company, 2003). The tornado missile analysis and the staff's evaluation are provided in Section 8.2.2 the ISFSI SAR and Section 15.1.2.10 of this SER, respectively. Onsite vehicles will generally be traveling at a much lower speed. Therefore, vehicular impacts for the cask transporter and CTF are also bounded by the tornado missile analysis.

The staff finds that potential vehicular impact will not impair the ability of the SSCs to maintain subcriticality, confinement, and sufficient shielding of the stored fuel.

Loss of Electrical Power

The staff reviewed the information presented in Section 8.1.6, "Loss of Electrical Power," of the SAR as an off-normal event. Total loss of external alternating current power is postulated to occur during the facility operations. The loss of electrical power at the Diablo Canyon ISFSI facility may occur because of natural phenomena, such as lightning or high winds, or as a result of failure of the electrical distribution system or equipment. A loss of electrical power will be detected through loss of functions of the electric-powered equipment.

No safety features required for lifting, upending, and lowering of the HI-TRAC 125 Transfer Cask, multi-purpose canister (MPC) and HI-STORM 100SA storage cask at the CTF will be affected by a loss of power, because these operations will be conducted by the cask transporter, which is driven by an on-board diesel engine. Similarly, the emplacement operations of a HI-STORM 100SA storage cask on the ISFSI storage pad location are also conducted using the cask transporter and do not rely on electric power from other onsite or offsite sources.

Electrical power is supplied through onsite sources to each of the three lifting screw jack motors and control systems that operate the CTF lifting platform. The CTF lifting platform will raise and lower the MPC during the transfer operation of the MPC from the HI-TRAC 125 Transfer Cask to a HI-STORM 100SA storage cask. In the event of a power loss during the operations of the lifting platform, all three screw jack motors will stop simultaneously to prevent a potential uncontrolled descent of the storage cask inside the CTF. The lift jacks will remain stopped and will require manual action to restart upon restoration of power. In the unlikely event of an extended period of power loss, the storage cask (including the MPC) will be raised to grade level from the CTF lifting platform within 22 hours using the cask transporter to ensure that short-term cladding temperature limits will not be exceeded.

No radiological impact is expected from a loss of electric power because there is no loss of MPC confinement during this off-normal event. In addition, the transfer cask is designed to provide adequate shielding and decay heat removal from the canisters. The operators would take measures to maintain adequate distance and additional shielding between themselves and the CTF to minimize exposure until power is restored and the transfer operation is resumed.

The staff concludes the applicant’s evaluation of loss of electrical power as an off-normal event is adequate in providing reasonable assurance that Diablo Canyon ISFSI operations can be conducted without endangering the health and safety of the public.

<u>Cask Transporter Off-Normal Operation</u>

The staff reviewed the information provided in Section 8.1.7 of the SAR, “Cask Transporter Off-Normal Operation.” The transporter with a loaded transfer cask will travel a distance of 1.9 km [1.2 mi] along the transporter route from the DCPP to the CTF and will take approximately 3.0 hours per transport. The transporter is also used in the transfer operation of an MPC from the HI-TRAC 125 Transfer Cask to a storage cask at the CTF and in the emplacement of storage casks on the ISFSI pads. The off-normal events from operation of the cask transporter could arise from driver error or incapacitation, transporter engine failure because of mechanical failure, or loss of hydraulic fluid in the hydraulic system. A support team will walk with the transporter and observe the driver and transporter movement. At the sight of driver distress or swerving of the transporter, the support personnel can stop the transporter using either of two stop switches located outside the transporter. The transporter is also equipped with automatic shutoff control to stop the vehicle in the event of incapacitation of the driver. The same control will also be used for emergency stops during the lifting operation at the CTF. Transporter engine failure would stop the vehicle or hydraulic brakes would engage to stop lifting operations. Hydraulic system failure would be detected by pressure instrumentation on the transporter, and any loss of hydraulic fluid will engage hydraulic brakes to stop lifting operations. The transporter is designed to operate in a “fail-safe” mode so any uncontrolled lowering of a transfer cask loaded with an MPC or storage cask is precluded.

Off-normal events associated with cask transporter operation are not expected to cause radiological dose as the confinement and shielding of spent nuclear fuel will not be affected.

The staff concludes that the applicant’s assessment of cask transporter off-normal operation is adequate in providing reasonable assurance that Diablo Canyon ISFSI operations can be conducted without endangering the health and safety of the public.

15.1.1.4 Off-Normal Ambient Temperatures

The off-normal environmental temperature range for the Diablo Canyon ISFSI is −4.4 to 36.1°C [24 to 97°F]. This off-normal temperature range is bounded by the previously evaluated off-normal temperature ranges for the HI-STORM 100 storage casks and HI-TRAC 125 Transfer Cask. Specifically, the previously evaluated off-normal temperature range for the HI-STORM 100SA storage cask is −40 to 38 °C [−40 to 100 °F] and for the HI-TRAC 125 Transfer Cask, −18 to 38 °C [0 to 100 °F]. The staff previously determined that the HI-STORM 100SA storage casks and HI-TRAC 125 Transfer Cask designs provide adequate heat removal capacity during off-normal ambient temperature conditions so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The Diablo Canyon ISFSI Technical Specifications will ensure that the relevant conditions assumed in the previous analysis for the HI-STORM 100 system are also met for the Diablo Canyon spent fuel.

15.1.1.5 Off-Normal Pressures

Section 8.1.1.1 of the Diablo Canyon ISFSI SAR indicates that the off-normal pressure within the MPC, which is the sole pressure boundary for the HI-STORM 100SA storage cask, is evaluated considering a concurrent rupture of 10 percent of the stored fuel rods while exposed to off-normal ambient temperatures of 38 °C [100 °F]. Note that this off-normal temperature bounds the off-normal temperature for the proposed Diablo Canyon site (see Section 6.1.3 of this SER). The staff previously determined that the methodology used to assess this off-normal condition is acceptable and that there are no consequences that affect the public health and safety so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The Diablo Canyon ISFSI Technical Specifications will ensure that the relevant conditions assumed in the previous analysis for the HI-STORM 100 system are also met for the Diablo Canyon spent fuel.

15.1.2 Accidents

The ISFSI SAR includes a discussion of potential accidents resulting from both external natural and man-induced events at the proposed facility. Natural phenomena events are discussed in Chapter 2, “Site Characteristics” of the SAR. The staff’s evaluation of those events is discussed in Chapter 2 of this SER. The accident analysis review focused on the effects of the natural phenomena and human-induced events on SSCs important to safety. Analytical techniques, uncertainties, and assumptions were examined. Each event was examined to ensure that it includes: (1) a discussion of the cause of the event, (2) the means of detection of the event, (3) an analysis of the consequences and the protection provided by devices or systems designed to limit the extent of the consequences, and (4) any actions required of the operator.

The Diablo Canyon ISFSI will use the HI-STORM 100 dry cask storage system. Where applicable, the staff relied on the analyses in the HI-STORM 100 System FSAR and the related staff evaluation as documented in the HI-STORM 100 System SER.

15.1.2.1 Cask Tip-Over

The staff has previously determined that cask tip-over events need not be considered for the approved HI-STORM 100SA system, based on the cask anchorage system used and the storage pad design specifications (U.S. Nuclear Regulatory Commission, 2002a,b). Sections 3.3.2 and 4.2.1.1of the ISFSI SAR (Pacific Gas and Electric Company, 2003) describe the cask anchoring system that will be used for the Diablo Canyon ISFSI, and this design also precludes the need for consideration of cask tip-over events. The staff's evaluation of the storage pad and anchorage system design can be found in Section 5.1.3 of this SER.

15.1.2.2 Cask Drop

Due to the design features and administrative controls applied to load handling activities in the FHB/AB, a potential drop of the loaded HI-TRAC 125 Transfer Cask is only considered during movement between the FHB/AB and the CTF. Similarly, a drop of a loaded HI-STORM 100SA storage cask is only considered during transport between the CTF and the ISFSI storage pads. In its response to the staff's RAI (Pacific Gas and Electric Company, 2002), PG&E committed to design the cask transporter so it will have redundant drop protection features and will conform to the criteria of NUREG–0612 (U.S. Nuclear Regulatory Commission, 1980), American National Standards Institute (ANSI) N14.6 (American National Standards Institute, 1993), and ASME B30.9-1996 (ASME International, 1996). Based on the applicant's commitment to these design standards, transfer and storage cask drop events are not considered credible. Therefore, a lifting height limit need not be specified for the loaded casks during movements between the FHB/AB, CTF and the storage pads, provided that all of these cask transporter design requirements are met.

15.1.2.3 Flood

The applicant has not considered flooding a credible accident at the Diablo Canyon ISFSI. As discussed in Section 2.1.4, "Surface Hydrology," of this SER, PG&E demonstrated that local natural and man-made drainage systems are sufficient to prevent flooding of the ISFSI pad site and CTF.

15.1.2.4 Fire and Explosion

<u>Fire</u>

The staff reviewed the information presented in Section 8.2.5, "Fire," of the ISFSI SAR. Additional information presented in SAR Sections 4.2.3.3.2.10, "Fire;" and 4.2.3.3.2.11, "Lightning," was also considered in this review.

Locations pertaining to the proposed ISFSI that fall within the purview of 10 CFR Part 72 review are the transport route from the DCPP FHB/AB to the CTF, within the CTF, and within the cask storage area. Credible fire accidents potentially affecting SSCs important to safety at the proposed facility identified by PG&E 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; and

(6) Fire from mineral oil from the Unit 2 transformers.

Additional information and the staff's evaluation are provided in Section 6.1.5.1 of this SER.

The cask transporter will be used to move the spent nuclear fuel in an 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 will be used to move the loaded storage cask onto the storage pad. To limit the potential exposure of the HI-TRAC 125 Transfer Cask and HI-STORM 100SA storage casks to a fire attributable to the transporter diesel fuel, the fuel tank used for the transporter will be limited to a 189-L [50-gal] capacity by the ISFSI Technical Specifications.

One postulated fire scenario for the CTF or the storage pads involves the diesel-fueled cask transporter with a 189-L [50-gal] fuel tank. The tank may rupture, resulting in the spilling and ignition of all of the diesel fuel. 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), and these findings also apply to the Diablo Canyon ISFSI for this analyzed event.

As described in Section 8.2.5.2 of the ISFSI SAR, administrative controls will be implemented to ensure that transient sources of fuel in volumes larger than 189 L [50 gal] will be at a sufficient distance away from the ISFSI storage pads at all times, the CTF during active MPC transfer operations, and the transport route during cask transfer. There is at least a 30.5-m [100-ft] clearance between the storage area, CTF, or the cask transport route, and any onsite stationary fuel tanks, as described in SAR Section 2.2.2.2.

In its response to NRC additional questions on supplemental blasts and explosions (Pacific Gas and Electric Company, 2003b), PG&E indicated that a 3,028-L [800-gal] gasoline 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 six times a week. The tanker truck transport route passes by the storage casks on the north side of the proposed dry storage area. To determine the potential consequences of a gasoline tanker truck fire occurring near the proposed storage facility, a bounding 7,570-L [2,000-gal] fire loading analysis was conducted to assess the potential effects on the HI-TRAC 125 Transfer Cask, which bounds the potential effects on a HI-STORM 100SA storage cask (Pacific Gas and Electric Company, 2003a). 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 a HI-STORM 100SA storage cask at the Diablo Canyon ISFSI.

Onsite stationary fuel sources include:

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

(2) The Unit 2 main bank transformers filled with mineral oil.

The separation distance between the three stationary fuel tanks and the transport route is 366 m [1,200 ft]. Because of the separation distance, radiation is the only mechanism through which released heat would be transferred to the cask. The surface area of a hemisphere with a 366-m [1,200-ft] radius is in excess of 836,131 m^2 [9×10^6 ft^2]. The projected area of the cask is approximately 20 m^2 [220 ft^2]. Therefore, only 0.0025 percent of the total heat energy released simultaneously from these tanks would be directed toward a single cask. This is a small amount of energy, and consequently, a fire in the transporter fuel tank would be bounding.

The potential for a fire within the CTF as the result of a cask transporter or gasoline tanker truck fuel spill was addressed in response to additional NRC questions (Pacific Gas and Electric Company, 2003c). To mitigate the potential effects of these postulated fire events, the transporter will be designed with a removable fuel tank, and the CTF opening will be located at a higher elevation than the surrounding area so any fuel spilled will flow away from the facility. Moreover, administrative controls will prohibit any transient fuel sources beyond that of the cask transporter from coming into close proximity of the CTF during transfer operations.

Vegetation surrounding the storage pad area is primarily grass with no significant brush or trees (Pacific Gas and Electric Company, 2003). A potential fire in the vegetation may be started by an offsite fire spreading onto the proposed site or by a lightning or a transmission line strike. As discussed in Section 8.2.5.2 of the SAR, “Accident Analysis” (Pacific Gas and Electric Company, 2003), no combustible materials will be stored within the security fence of the proposed facility at any time. A walk-down of the general area and the transport route will be conducted prior to any loaded cask transport to ensure that all combustible materials are controlled according to the administrative procedures. PG&E will implement a maintenance program to prevent uncontrolled growth of vegetation surrounding the storage area.

PG&E submitted an analysis of potential effects of wildfires on the HI-STORM 100SA storage casks (Holtec International, 2001a). This analysis evaluated two scenarios: (1) no wind and (2) 24-km/hr [15-mph] wind in the uphill direction. Although it is expected that facility personnel will try to suppress or control the fire quickly, it is postulated that no fire fighting activities occur. Using simulation codes FARSITE and FLAMMAP, Holtec International developed the values for the parameters necessary to describe the wildfire characteristics (namely, fire intensity, rate of spread, and flame length)(Pacific Gas and Electric Company, 2003).

There will be a minimum of a 15.2-m [50-ft] gap between the storage pads and the security fence on the north side of the proposed facility. The gap will be at least 12.2 m [40 ft] on the other three sides. The restricted area fence surrounds the area protected by the security fence and is approximately 30.5 m [100 ft] from the storage pads. Holtec International (2001a) assumed that the area within the proposed storage facility nuisance fence would be covered with either gravel or concrete. Therefore, the area surrounding the storage pads would be covered with noncombustible materials, which will not only act as a barrier for progression of wild fires but also will not add any additional fuel to the fire.

Electrical transformers are located approximately 73 m [240 ft] from the transporter route. The mineral oil within these transformers could be ignited by lightning strike, vehicle crash, or internal electrical faults (Pacific Gas and Electric Company, 2003c). Administrative procedures will prohibit movement of the loaded transporter during inclement weather. Additionally, DCPP transition operations significantly reduce the potential for transformer mineral oil being ignited by lightning or internal electric faults. Each active transformer has a fire-suppression system that will activate in case of a fire. Administrative procedures will also prohibit use of onsite vehicles during transporter operation, negating the potential of a vehicle accident initiating a transformer fire. Moreover, even if a transformer mineral oil fire were to occur, its effect on the transfer cask during transport would be bounded by the nonengulfing 7,570-L [2,000-gal] fire-loading analysis.

The staff reviewed the information provided by the applicant regarding potential onsite fires and wildfires at the proposed facility. The staff found the applicant's analysis acceptable because:

- Through design and administrative procedures, potential fire events will be minimized for the CTF.

- The storage casks are designed to withstand a fire from 50 gallons of diesel fuel in the fuel tank of the cask transporter.

- Both the transfer and storage casks will be able to withstand a nonengulfing 7,570-L [2,000-gal] fuel fire.

- Adequate analysis was presented about potential effects of the tanker truck fire on storage casks sitting on the pads.

- The area surrounding the storage pads will be covered with noncombustible materials.

<u>Onsite and Offsite Explosion</u>

The staff has reviewed the information presented in SAR Sections 2.2.2.3, "Onsite Explosion Hazards"; 8.2.6, "Explosion"; and 3.3.1.6, "Fire and Explosion Protection." In addition, the staff also reviewed analyses of potential explosion events in Holtec International (2002) and PG&E Calculation No. PRA01-01, "Risk Assessment of Dry Cask/Spent Fuel Transportation Within the DCPP Owner Controlled Area," (Pacific Gas and Electric Company, 2003c). Potential sources of explosions within the proposed facility include:

(1) Detonation of a transporter or onsite vehicle fuel tank

(2) Detonation of a 3,028-L [800-gal] tanker truck while transporting fuel near the storage pad

(3) Detonation of a propane bottle transported past the ISFSI storage pad

(4) Detonation of an acetylene bottle 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 storage facility

(8) Detonation of acetylene bottles stored on the east side of the cold machine shop

Important to safety SSCs that are required to function after an explosion event include the storage casks, the transportation casks, the transporter, and the CTF. Regulatory Guide 1.91 (U.S. Nuclear Regulatory Commission, 1978) provides an acceptable methodology to estimate the minimum separation distance between an explosion source and a structure so that the peak positive incident overpressure would be less than 6.9 KPa [1 psi]. If the minimum separation distances calculated by following the suggested methodology of Regulatory Guide 1.91 are not sufficiently large to allow a conclusion that the peak positive incident overpressure would be less than 6.9 kPa [1 psi], an analysis of the frequency of hazardous materials shipment may be used to show the associated risk is sufficiently low. If the hazardous materials are shipped by more than one transportation mode, the frequency of exposure for the modes should be summed. Regulatory Guide 1.91 also states that potential explosion hazards can be screened out if, based on realistic or best estimate bases, an exposure rate less than 10^{-7} per year can be demonstrated. If conservative estimates are used, an exposure rate less than 10^{-6} per year is sufficiently low.

Regulatory Guide 1.91 sets 6.9 kPa [1 psi] as the peak positive incident overpressure below which no significant damage to the structures would be expected to result from an explosion. Explosion-induced ground motions are bounded by the earthquake criteria. Similarly, effects of explosion-generated missiles would be bounded by those associated with the air overpressure levels if the threshold air overpressure from any explosion source is kept below 6.9 kPa [1 psi], based on Regulatory Guide 1.91.

A potential explosion event can affect (1) canister transfer operation at the CTF, (2) storage casks placed on the pads, and (3) the transfer cask moved by the transporter from the FHB/AB to the proposed facility. Potential sources of explosive materials that may affect the storage casks and the canister transfer operation are (1) detonation of the transporter or onsite vehicle fuel tank, (2) detonation of a 3,028-L [800-gal] tanker truck while transporting gasoline past the ISFSI storage pads, (3) detonation of a propane bottle transported past the ISFSI storage pads, (4) detonation of an acetylene bottle transported past the ISFSI storage pads, (5) detonation of large stationary fuel tanks, and (6) an explosive decompression of a compressed gas cylinder. Other sources are far away from the proposed storage site and contain sufficiently small amounts of explosive materials such that they do not pose a credible hazard to the storage casks and canister transfer operations. A transfer cask loaded on a transporter could be affected by (1) detonation of the fuel tank of the transporter or an onsite vehicle (including the potential explosion of a parked vehicle fuel tank), (2) explosion of large stationary fuel tanks in the vicinity of the transport route, (3) explosion of the Bulk Hydrogen Storage Facility, and (4) explosion of acetylene bottles stored on the east side of the cold machine shop. Explosion of the mineral oil in the Unit 2 main bank transformers was determined to be a non-credible scenario.

Transporter and/or Onsite Vehicle Fuel Tanks

Potential sources of explosion considered for the Diablo Canyon ISFSI accident analyses include the fuel tanks of the onsite transporter or other onsite vehicles, including 3,028-L [800-gal] gasoline tanker trucks (Pacific Gas and Electric Company, 2003). The maximum capacity of the fuel tank of the onsite transporter is 189 L [50 gal] of diesel fuel. The average capacity of the fuel tank of any onsite vehicle is 76 L [20 gal](Pacific Gas and Electric Company, 2003c). A 3,028-L [800-gal] capacity gasoline tanker truck will use the onsite road near the storage pads on its way to and from the maintenance shop, located approximately 666 m [2,000 ft] northeast of the storage pads. PG&E will impose administrative controls to prevent a 15,142-L [4,000-gal] fuel truck from passing near the proposed storage facility at any time, and to also prevent it from entering the owner-controlled area at all while spent nuclear fuel is being transferred from the FHB/AB to the storage pads (Pacific Gas and Electric Company, 2003c).

Detonation of the fuel tank of a transporter and/or an onsite vehicle could potentially occur near the storage pads, CTF, and transport route. These events have been analyzed by PG&E, as they could potentially affect the storage cask, the transfer cask, or the structure of the CTF.

In its analyses, PG&E assumed that a minimum distance of 15m [50 ft] will be maintained between the source of explosion and the nearest storage cask because:

- No gasoline-powered vehicles will be allowed within the restricted area of the proposed facility; and

- A minimum distance will be maintained between the storage casks and the protected area fence at the north side of the proposed facility.

The flash point of diesel fuel is 51.7 °C [125 °F]. Based on the Fire Protection Association Handbook (National Fire Protection Association, 1997), the flash point of a liquid must be less than 37.8 °C [100 °F] to be classified as a flammable liquid. Therefore, diesel in the fuel tank of a transporter does not pose a credible explosion hazard.

Regulatory Guide 1.91 provides a methodology to estimate the exposure rate *r*:

$$r = n \cdot f \cdot s \qquad (15\text{-}1)$$

where,

n	–	explosion rate (per mile)
f	–	frequency of shipment (per year)
s	–	exposure distance (miles)

Based on data from the National Highway Traffic Safety Administration of the U.S. Department of Transportation, a total of 6,323,000 crashes involving all types of motor vehicles took place in 2001 (U.S. Department of Transportation, 2003a). Additionally, approximately 4,450,339 million km [2,781,462 million mi] were traveled in that year by all types of vehicles. Therefore, the vehicle involvement rate would be 227 per 160 million km [100 million mi] of travel. Based on 2001 crash statistics compiled by U.S. Department of Transportation, approximately 30 percent of all vehicle crashes constitute a single-vehicle crash. Additionally, approximately 30 percent of all single-vehicle crashes took place at a speed below 48 km/hr [30 mph]. Moreover, approximately 0.1 percent of all vehicle crashes resulted in a fire.

PG&E, through administrative controls, will prevent any vehicle from passing another within the setback distance of 52.5 m [175 ft] from the proposed facility (Pacific Gas and Electric Company, 2003c). Consequently, only a single-vehicle accident needs to be considered further. This setback distance was selected so that the resulting air overpressure from an exploding 76-L [20-gal] gasoline tank would be 6.9 kPa [1 psi]. Additionally, PG&E will use administrative controls to prevent any motor vehicles from exceeding the speed limit of 40 km/hr [25 mph] in the area of the proposed facility (Assumption 7). Therefore, the frequency of vehicle fire has been estimated by PG&E to be 3.26×10^{-10} per km [2.04×10^{-10} per mi]. Assuming conservatively that every vehicle fire leads to an explosion, the explosion rate of vehicle fire, *n*, would be 3.26×10^{-10} per km [2.04×10^{-10} per mi].

The exposure distance, *s*, is the distance along the road within the setback region of the proposed facility from which the storage casks would have the potential to receive an air overpressure greater than 6.9 kPa [1 psi]. This distance is estimated to be approximately 90 m [300 ft]. As stated by PG&E (Assumption 10), a maximum of 140 gasoline-powered vehicles would pass by the proposed facility in a day. Consequently, approximately 51,100 times in a year all items important to safety at the proposed facility would be exposed to the explosion hazard from passing gasoline-powered motor vehicles. Therefore, the annual frequency of exposure, *r*, is

$$r = 2.04 \times 10^{-10} \times 51100 \times \frac{300}{5280} = 5.92 \times 10^{-7} \text{ per year} \quad (15\text{-}2)$$

The staff concludes that the annual frequency of occurrence of a transporter and/or onsite vehicle fuel tank explosion was estimated in a conservative manner.

<u>Parked Vehicle Fuel Tanks</u>

PG&E used a probabilistic analysis to estimate the annual frequency of explosion of an on-site vehicle, parked in the power plant parking lots, that may have a potential to damage a transfer cask being hauled by the transporter on the transport route. Since the start of construction of DCPP 30 years ago, there has never been an explosion of a parked car, although one parked car caught fire. PG&E considers this an incredible scenario as, by administrative procedures, walk-downs of the parking lots would be performed looking for any explosion hazards, such as gasoline leaking from a vehicle, before a loaded transporter passes by. Additionally, administrative and physical controls would prevent movement of any vehicle within 52.5 m [175 ft] of the transporter.

PG&E conducted a search for industry information regarding the frequency of explosion of parked vehicles; however, no data have been found. Although administrative and physical controls would make an explosion of a parked car an incredible scenario; nevertheless, PG&E conducted an analysis to estimate the magnitude of the potential hazard. An analysis of gasoline-powered moving vehicles estimated the frequency of fire (and explosion) to be 3.26×10^{-10} per km [2.04×10^{-10} per mi], based on a single-vehicle crash. Since any cars parked within 52.5 m [175 ft] of the moving loaded transporter would not be allowed to move, reduction of one order of magnitude in the explosion rate to 3.26×10^{-11} per km [2.04×10^{-11} per mi] would be reasonable.

The transporter carrying a HI-TRAC Transfer Cask will make eight trips per year from the protected area of the power plant to the proposed storage facility. Therefore, frequency, *f,* would be 8/yr. The exposure distance, *s,* is estimated to be 333 m [1,000 ft]. Assuming a maximum of 200 vehicles would be within the setback distance of 52.5 m [175 ft] at any moment while the transporter is moving, the annual frequency of exposure, *r,* is

$$r = 2.04 \times 10^{-11} \times 200 \times 8 \times \frac{1{,}000}{5{,}280} = 6.18 \times 10^{-9} \text{ per year} \qquad (15\text{-}3)$$

The staff concludes that the annual frequency of occurrence of a parked vehicle fuel tank explosion was estimated in a conservative manner.

<u>3,028-L [800-Gal] Tanker Truck While Transporting Fuel Near the Storage Pad</u>

PG&E performed a probabilistic risk analysis (Pacific Gas and Electric Company, 2003c) to estimate the annual frequency of the potential explosion hazard from the 3,028-L- [800-gal] gasoline tanker truck while passing near the proposed storage pads. Based on the U.S. Department of Transportation (2003a,b) statistics for large trucks, 429,000 crashes took place in 2001 with approximately 334,721 million km [207,686 million mi] of travel. Therefore, the involvement rate for large trucks would be 207 per 161 million km [100 million mi].

Single-vehicle accident data compiled by the U.S. Department of Transportation show that a total of 96,000 of the crashes involved a single vehicle, which is approximately 22 percent of all large truck crashes. Additionally, approximately 31 percent of these crashes took place at a speed below 48 km/hr [30 mph]. Moreover, approximately 0.5 percent of all large truck crashes resulted in fires (U.S. Department of Transportation, 2003a).

PG&E committed to prevent any vehicle from passing the tanker truck within 180 m [600 ft] of the proposed facility when the tanker truck is in motion (Assumption 8), so that only single vehicle crashes need to be considered in the analysis. The setback distance is calculated using the methodology given in Regulatory Guide 1.91, so that the air overpressure experienced by any safety-related SSCs from an accidental explosion of the gasoline tanker truck would be a maximum of 6.9 kPa [1 psi]. Additionally, administrative controls would prevent any vehicle movement at a speed greater than 40 km/hr [25 mph] within the setback region from the proposed facility (Assumption 7).

Assuming that the gasoline tanker will explode if caught on fire, PG&E estimated that the frequency of tanker explosion would be

$$207 \times 0.22 \times \frac{0.31}{100 \times 10^{6}} \times 0.005 = 7.06 \times 10^{-10} \text{ per mile} \qquad (15\text{-}4)$$

The exposure distance, *s,* is estimated to be 690 m [2,300 ft] based on a 180-m [600-ft] exclusion area from the nearest cask in the proposed facility. Assumption 5 states that the tanker truck would pass by the proposed facility six times in each week. Therefore, the annual frequency of shipment, *f,* is 312. Using Regulatory Guide 1.91, the estimated exposure rate, *r,* is:

$$r = 7.06 \times 10^{-10} \times 312 \times \frac{2{,}300}{5{,}280} = 9.59 \times 10^{-8} \text{ per year} \qquad (15\text{-}5)$$

The staff concludes that the annual frequency of occurrence of an explosion of the 3,028-L [800-gal] gasoline tanker truck while using the transport route near the proposed storage pads was estimated in a conservative manner.

<u>Propane and Acetylene Bottles Transported Past the Storage Pad</u>

The maintenance facility east of the proposed ISFSI uses acetylene for the cutting torch and propane to run forklifts. One acetylene bottle is the maximum required in 1 year. The forklift uses a 25.5 L [7 gal] liquefied propane bottle which is replaced at a maximum frequency of once per week. Through the use of administrative controls, PG&E will ensure that all compressed gas bottles transported past the proposed ISFSI are appropriately secured in the transporting vehicle in the upright position (Pacific Gas and Electric Company, 2003c, Assumption 19).

In analyzing this explosion event, PG&E considered that the bottle containing 25.5 L [7 gal] of liquefied propane may rupture while being transported past the proposed ISFSI, releasing the compressed gas. The propane could subsequently mix with air and the resulting vapor cloud could detonate, which could generate an air overpressure that could be damaging to the storage casks. For this event, Holtec International (2001b) and PG&E (2003) assumed that the minimum distance between the point of explosion and the storage casks would be the distance between the storage pads and the ISFSI security fence, because no combustible materials would be permitted inside the proposed ISFSI. The detonation of 26.5 L [7 gal] of propane is equivalent to 4.7 kg [10.37 lb] of trinitrotolune (TNT). At a distance of 15 m [50 ft], the resulting air overpressure would be 16.9 kPa [2.45 psi] (Holtec International, 2001b). Similar calculations performed by Holtec International for transport of the acetylene bottles, which contain smaller quantities of compressed gas, resulted in an estimated overpressure of 8.2 kPa [1.19 psi]; therefore, the postulated explosion of a propane bottle is the bounding event. PG&E asserted that because the HI-STORM 100SA storage casks are designed to perform satisfactorily under 68.9 kPa [10 psi] of air overpressure for a duration of 1 second, accidental detonation of a propane or an acetylene tank while being transported past the proposed facility would not damage the storage casks placed on the pad (Pacific Gas and Electric Company, 2003; Holtec International, 2001b). However, this overpressure level is greater than the recommended air overpressure limit of 6.9 kPa [1 psi] of Regulatory Guide 1.91; therefore, PG&E conducted a probabilistic risk analysis (Pacific Gas and Electric Company, 2003c) to estimate the annual exposure frequency of SSCs important to safety to a higher air overpressure level.

In its analysis, PG&E postulated that the motive force required for a compressed-gas bottle to fail or explode would be from a vehicle crash. Because the crashes near the proposed ISFSI are assumed to be only single-vehicle incidents, PG&E used an explosion rate, *n*, of 7.06×10^{-10} per mile, estimated for large truck crashes. Additionally, the frequency of bottle shipment, *f*, is assumed to be four times a week or 208 times a year to be conservative. The exposure distance, *s*, is assumed to be 690 m [2,300 ft], the same as with the tanker truck crash. Therefore, the estimated exposure frequency, *r*, is

$$r = 7.06 \times 10^{-10} \times 208 \times \frac{2{,}300}{5{,}280} = 6.39 \times 10^{-8} \text{ per year} \qquad (15\text{-}6)$$

Although pressurized gas bottles may also fail along the welded seam, the bottles are required to meet the current industry standards. Therefore, this mode of failure of gas bottles was not considered credible.

The staff concludes that the annual frequency of occurrence of an explosion of the propane and acetylene bottles transported past the storage pads was estimated in a conservative manner.

Compressed Gas Cylinders

Cylinders containing compressed acetylene, air, argon, helium, nitrogen, oxygen, and propane gases are stored inside the reactor-controlled area. Internal pressure of the compressed gas cylinders can be in excess of 13.8 MPa [2,000 psi]. The potential energy of the stored cylinders at such high pressures could have significant effects during a rupture because this potential energy would be released as kinetic energy that could potentially damage SSCs important to safety. PG&E postulated that these compressed gas cylinders may be damaged in a way that the valve assembly at the top of the cylinders is broken. This failure would create a hole, approximately 5 cm [2 in] in diameter, at one end of the cylinder. Gases escaping through this hole would impart a large acceleration to the cylinder body and/or the valve assembly. The cylinders and/or the valve assemblies could accelerate toward the cask systems resulting in impacts (Holtec International, 2001b).

One function of both HI-TRAC 125 Transfer Cask and HI-STORM 100SA storage casks is to prevent any missiles (e.g., gas cylinder body and valve assembly) from affecting the MPC. Based on the calculations performing by Holtec International (2001b), any missile impacting the HI-TRAC 125 Transfer Cask must penetrate a minimum of 3.8 cm [1.5 in] of steel before impacting the confinement boundary of the MPC. Similarly, any missile has to penetrate at least 5 cm [2 in] of steel before impacting the MPC for the HI-STORM 100SA storage cask neglecting the presence of the concrete overpack. Holtec International (2001b) estimated the maximum velocity of all ruptured gas cylinders using the bounding discharge coefficient so that the estimated acceleration and the resulting force are maximum, and, therefore, the depth of penetration in a steel plate would be maximum.

The maximum depth of penetration by the gas cylinder body occurs with propane gas and is equal to 0.59 cm [0.232 in]. The valve assembly produces a penetration of 0.61 cm [0.241 in]. Therefore, the maximum depth of penetration for all types of cylinders and the valve assemblies is substantially less than the steel thickness available to resist penetration. Consequently, there is reasonable assurance that no SSCs important to safety will be damaged from accidental rupture of compressed gas cylinders.

Stationary Fuel Tanks Near the Transport Route

Three large stationary fuel tanks are located approximately 360 m [1,200 ft] from the transport route at the closest point to the proposed ISFSI. These tanks include a 946-L [250-gal] propane tank, a 7,571-L [2,000-gal] diesel fuel tank, and an 11,356-L [3,000-gal] gasoline tank. These three fuel tanks are located close enough to each other so that an explosion of one tank could cause potential rupture of the other two tanks. Diesel fuel does not present an explosion hazard because of its high flash point. While a rupture and subsequent detonation of either the propane tank or the gasoline tank could potentially rupture the diesel fuel tank, the spilled diesel fuel would burn without exploding. Consequently, the stored diesel fuel would not contribute to the explosion overpressure. Therefore, this event is limited to the near-simultaneous explosion of both the propane and gasoline tanks to generate any incident air overpressure. An explosion of these tanks may potentially affect the canister transfer operations at the CTF, the storage casks placed on pads, or the loaded transfer cask en route to the CTF.

Holtec International (2001b) estimated the air overpressure from a simultaneous explosion of 946 L [250 gal] of propane and 11,356 L [3,000 gal] of gasoline. These sources are equivalent to 53.27 kg [117.33 lb] of TNT, which generates an air overpressure of 5.79 kPa [0.84 psi] at a distance of 366 m [1,200 ft], the minimum distance between the stationary fuel tanks and the transport route (Pacific Gas and Electric Company, 2003). Based on Regulatory Guide 1.91 , an air overpressure of 5.79 kPa [0.84 psi] would not cause damage to any safety-related structures. The ISFSI security fence and the CTF are further away from the storage tanks than the closest point on the transport route. Therefore, it is expected that the air overpressure at these locations will be lower than 5.79 kPa [0.84 psi].

The stationary fuel tanks are more than 805 m [0.5 mi] from the proposed storage pad location and at an elevation of approximately 61 m [200 ft] below. These tanks are located southwest of the proposed facility with prevailing southeastern wind directions. Therefore, the winds would normally take the vapor cloud south of the proposed facility. Additionally, the vapor cloud generated at the fuel tank location needs to climb the 61-m [200-ft] hill to reach the proposed facility. Moreover, there is a major cut in the hillside directly above and east of the tanks. This cut would likely channel the vapor cloud away from the proposed facility. Therefore, there is reasonable assurance that any vapor cloud generated at these stationary tanks would not pose any undue hazard to the proposed facility.

The stationary fuel tanks will be periodically filled by standard fuel tankers with a capacity between 11,356 to 15,142 L [3,000 to 4,000 gal]. During any spent fuel transfer operation, the filling of these tanks would be suspended and all vehicle movements will be administratively controlled in accordance with the Cask Transportation Evaluation Program in the Diablo Canyon ISFSI Technical Specifications. Additionally, Section 8.2.6 of the SAR states that administrative controls will be used to ensure that the air overpressure received by any safety-related structures from an explosion of a tanker truck would be less than the 6.9-kPa [1-psi] limit.

Bulk Hydrogen Storage Facility

A bulk hydrogen facility is located approximately 4.5 m [15 ft] from the transport route from where the loaded transfer casks enter and leave the FHB/AB of Unit 1 of the DCPP. This facility contains 6 hydrogen tanks with a total capacity of approximately 8,495 L [300 ft^3]. These tanks are refilled approximately twice a month and are kept in a seismic-qualified rack enclosed in a seismic-qualified vault. The vault has a 0.3- [12-in] diameter top vent to ensure that no leaked gas builds up. The vault only opens toward the FHB/AB. The hydrogen facility is designed against excessive flow, overpressurization, and vehicle damage during refilling. Therefore, it is extremely difficult to accumulate significant quantities of loaded gas leading to an explosion.

The Electric Power Research Institute Fire Events database considers hydrogen fire to be a credible event and provides a frequency of 3.2×10^{-3} per year (Pacific Gas and Electric Company, 2003c). Therefore, the hourly frequency of fire at the bulk hydrogen facility is estimated to be $3.2 \times 10^{-3}/8760$, or 3.7×10^{-7}. Because the design of the facility prevents accumulation of leaked hydrogen gas in confined spaces, it is extremely difficult to have an explosion even in the case of a hydrogen fire. PG&E assumed that in 10 percent of the cases, a hydrogen fire would lead to an explosion in the bulk hydrogen facility and, therefore, the estimated hourly frequency of hydrogen explosion would be $3.7 \times 10^{-7} \times 0.1$, or 3.7×10^{-8}.

PG&E states that the loaded cask transporter would be in the vicinity of the hydrogen tanks for less than 1 hour during each spent fuel transfer from the FHB/AB to the storage pad (Assumption 14), and there will be eight spent fuel transfers each year (Assumption 1). To add further conservatism, PG&E assumed a yearly exposure of 10 hours. Therefore, the annual exposure frequency of the transfer cask to a potential hydrogen tank explosion would be

$$3.7 \times 10^{-8} \times 10 = 3.7 \times 10^{-7} \text{ per year} \tag{15-7}$$

The staff concludes that the annual frequency of occurrence of an explosion of the bulk hydrogen storage facility having an impact on a loaded transfer cask was estimated in a conservative manner.

Acetylene Bottles Stored on the East Side of the Cold Machine Shop

A maximum of 10 acetylene bottles are stored on the east side of the cold machine shop near the DCPP. This facility is more than 7.5 m [25 ft] from the transporter route and is protected by concrete block walls on two sides. The third side is protected by a building. Administrative procedures ensure that these bottles are restrained in an upright position because of seismic considerations. This restraint ensures that no potential missiles, originated from an exploding bottle, would be aimed at the transporter route. Furthermore, the cold machine shop facility location allows limited access of vehicles. Additionally, administrative procedures will control any vehicle movement within 52.5 m [175 ft] of the transporter route when the transporter is hauling a loaded transfer cask. Therefore, there would be no motive force available to initiate damage to the gas bottles leading to an explosion at those times. Consequently, PG&E concluded that accidental detonation of acetylene bottles stored on the east side of the cold machine shop would not be a credible hazard to any safety-related SSC for the proposed ISFSI.

Mineral Oil from Diablo Canyon Power Plant Unit 2 Main Bank Transformers

There are six transformers on the Unit 2 side of the DCPP: three single-phase 500-kV, two three-phase 25-kV, and one three-phase 12-kV. Additionally, two spare transformers are stored adjacent to the active transformers. The three single-phase 500-kV transformers are located approximately 240 feet from the closest point to the transport route. The other transformers are mostly shielded from the transport route by these 500-kV transformers because of the layout with respect to the transport route. Each active transformer has a fire-suppression system that will activate in case of a fire.

The mineral oil in the transformers acts as a coolant. It has a flash point of 135 °C [275 °F]. Therefore, an explosion of mineral oil does not pose a significant hazard (Holtec International, 2001b) because this is not a flammable liquid. To be classified as a flammable liquid, the flash point of the liquid should be less than 37.8 °C [100 °F] (National Fire Protection Association, 1997). Although an electrical fault may occur within one of the transformers, the resulting rupture of the transformer case may ignite and burn the mineral oil, but the mineral oil would not explode. Therefore, a potential explosion of the mineral oil at Unit 2 of DCPP was not considered a credible hazard for ISFSI operations.

Summary of Review

The potential explosion hazards that may affect the storage casks or the cask or canister transfer operations are: (1) detonation of the transporter or onsite vehicle fuel tank, (2) detonation of 3,028-L [800-gal] tanker truck while transporting gasoline past the ISFSI storage pads, (3) detonation of a propane bottle transported past the ISFSI storage pads, (4) detonation of an acetylene bottle transported past the ISFSI storage pads, (5) detonation of large stationary fuel tanks, and (6) an explosive decompression of a compressed gas cylinder. Other sources are far away from the proposed storage site and contain sufficiently small amounts of explosive materials to not pose a credible hazard to the storage casks and cask and canister transfer operations. A transfer cask loaded on a transporter could be affected by: (1) detonation of the fuel tank of a transporter or an onsite vehicle fuel tank (including the potential explosion of a parked vehicle), (2) explosion of large stationary fuel tanks in the vicinity of the transport route, (3) explosion of the Bulk Hydrogen Storage Facility, and (4) explosion of acetylene bottles stored on the east side of the cold machine shop. The Diablo Canyon ISFSI Technical Specifications will include requirements for a Cask Transportation Evaluation Program, which will specify administrative controls to prevent movement of the tanker truck and any onsite vehicles during transporter operation. Similarly, no acetylene or propane bottles will be transported during transporter operations. Decompression of compressed gas cylinders does not pose an air overpressure hazard; missiles generated by the decompression of the cylinders are the primary concern in this situation.

PG&E conducted a probabilistic risk analysis (Pacific Gas and Electric Company, 2003c) of the remaining explosion hazards that have a potential to cause damage to safety-related structures at the proposed facility. Based on the previous discussion, the annual frequency of exposure to explosion hazards of the storage casks placed on the storage pads at the ISFSI and the canister transfer operation at the CTF is:

$$P_1 = P_{onsite\,vehicle} + P_{propane/acetylene} + P_{tanker\,truck} + P_{stationary\,tanks}$$
$$or,\ P_1 = 5.92 \times 10^{-7} + 6.39 \times 10^{-8} + 9.59 \times 10^{-8} + 0 = 7.52 \times 10^{-7}\ \text{per year} \qquad (15\text{-}8)$$

Similarly, the annual frequency of exposure to explosion hazards of the transfer cask while being transported by the transporter is:

$$P_2 = P_{onsite\,vehicle} + P_{parked\,car} + P_{\text{stationary tanks}} + P_{hydrogen} + P_{acetylene}$$
$$or,\ P_2 = 0 + 6.18 \times 10^{-9} + 0 + 3.7 \times 10^{-7} + 0 = 3.76 \times 10^{-7}\ per\ year. \quad (15\text{-}9)$$

Regulatory Guide 1.91 provides an acceptable methodology to evaluate the potential hazards by an explosion on safety-related SSCs. Regulatory Guide 1.91 also states that potential explosion hazards can be screened out if the annual exposure frequency is less than 10^{-6} and conservative estimates are used. PG&E made conservative estimates of the potential explosion hazards, so an annual frequency limit of 10^{-6} is applicable here. Therefore, the staff concludes, based on the review of information and analyses presented by PG&E, that no safety-related SSCs at the proposed facility will be subjected to explosion overpressures that exceed the 6.9 kPa [1 psi] threshold.

The staff reviewed the information provided by the applicant regarding potential hazards from an accidental onsite explosion at the proposed facility. The staff found the analysis acceptable because the applicant:

- Appropriately identified the potential sources of hazard;

- Used the Regulatory Guide 1.91 value of 6.9 kPa [1 psi] as the limiting air overpressure for all safety-related structures;

- Developed a probabilistic hazard analysis to estimate the annual frequency of exposure of safety-related structures from each potential source of explosion for those situations that do not meet stand-off zone criteria based on the 6.9-kPa [1-psi] air overpressure limit;

- Summed the annual frequency of explosion hazard from each individual source to estimate the total hazard to the proposed facility, as recommended in Regulatory Guide 1.91; and

- Used conservative assumptions to estimate the annual frequency of exposure from each source of the explosion hazard.

Based on the foregoing evaluation, the staff finds that the Diablo Canyon ISFSI SSCs will be able to maintain subcriticality, confinement, and sufficient shielding of the stored fuel for all postulated onsite explosion events.

15.1.2.5 Electrical Accident

Section 8.2.8 of the SAR evaluates the potential consequences of lightning strikes and a 500-kV transmission line drop on the HI-STORM 100SA storage casks and the HI-TRAC 125 Transfer Cask. Of the different 500-kV transmission line drop scenarios that were considered, the worst-case condition is defined by a line drop of a single conductor of one phase, which causes a single line-to-ground fault current and a voltage-induced arc at the point of contact.

Both electrical events (i.e., lightning strike and 500-kV transmission line drop) manifest themselves as electrical discharges that travel along the least resistive path through the cask to ground. Because these events originate from sources that are outside the confines of the cask, the path of least electrical resistance for the HI-STORM 100SA storage cask is the overpack, and for the HI-TRAC 125 Transfer Cask, the enclosure shell. As a result, the MPC will not be susceptible to any electrically induced damage in either case.

In the case of a lightning strike, it was satisfactorily demonstrated that the temperature increase of the HI-STORM 100SA storage cask overpack and HI-TRAC 125 Transfer Cask enclosure shell will be less than 0.6 °C [1 °F].

For the case of the 500-kV transmission line drop, it was determined that holes would be created in both the HI-STORM 100SA storage cask and HI-TRAC 125 Transfer Cask outer shells by way of material sublimation. Behind the steel outer shell of the HI-STORM 100SA storage cask is a thick concrete layer that would exhibit only localized spalling and crystallization in the immediate region where the steel outer shell sublimation occurred. The staff determined that the resulting effects on the HI-STORM 100SA storage cask decay heat removal and radiation shielding capabilities would be minimal. A hole created in the HI-TRAC 125 Transfer Cask outer shell could cause a loss of the water jacket designed to provide neutron shielding and facilitate removal of the spent nuclear fuel decay heat. As discussed in Section 8.2.11 of the SAR, a loss of the water jacket does not cause the accident radiation dose to offsite individuals to exceed the limits of 10 CFR §72.106, and the increase in fuel cladding and component material temperatures will not exceed their short-term accident temperature limits. Moreover, the MPC internal pressure will remain below the accident design limit gauge pressure of 1.38 MPa [200 psi]. Additionally, these events are even less likely to impact a loaded transfer cask, as cask transfer activities are of relatively short duration, and will generally not be conducted under the adverse conditions most likely to result in a lightning strike or transmission line drop.

15.1.2.6 Earthquake

The staff has reviewed the information presented in the following SAR sections: 8.2.1, “Earthquake”; 2.6, “Geology and Seismology”; and 3.2.3, “Seismic Design.” Section 4.5 of the SAR classifies the SSCs important to safety based on the Quality Assurance (QA) Program described in Chapter 11 of the SAR. The importance to safety for each of these SSCs is further refined into three QA classification categories (i.e., Categories A, B, and C) based on the guidance contained in NUREG/CR–6407 (McConnell, et al., 1996). The Category A SSCs important to safety include the: (1) MPC; (2) fuel basket; (3) damaged fuel container; (4) transfer cask; (5) MPC lift cleats and downloader slings; (6) transfer cask impact limiters and lift links; (7) HI-STORM 100 System lifting brackets, mating device bolts, and shielding frame, and lift links; (8) cask transporter; and (9) lateral restraints (HI-TRAC 125 Transfer Cask and transporter at the CTF). The classification of Category B SSCs important to safety include the: (1) HI-STORM 100SA storage cask overpack; (2) storage pads; (3) overpack anchorage hardware; (4) CTF; (5) transfer cask horizontal lift rig and lift slings; (6) upper and lower fuel spacer columns and end plates; (7) transporter connector pins; and (8) helium fill gas. The classification of Category C SSCs important to safety includes the HI-STORM 100 System cask mating devices (except bolts and shielding frame).

A seismic event can occur at any time during any stage of a transfer or storage operation involving a cask or a canister. At a specific site, earthquake potential is often described by the annual probability of exceeding certain ground motion levels or seismic hazard curves. The design earthquake, double-design earthquake, Hosgri earthquake (HE), and long term seismic program (LTSP) earthquakes form the seismic licensing basis for the DCPP. The applicant indicated that, because both DCPP and the ISFSI sites are classified as rock and they have similar ranges of shear-wave velocities within the rock classification, and because the distance to the controlling seismic source is essentially the same, the DCPP ground motions are judged to be applicable to the ISFSI design. Section 2.1.6 of this SER provides additional information about the seismic ground motion hazard and the staff's review of the information.

In conducting analyses of transporter stability, slope stability, and ISFSI storage pad sliding, the applicant developed the ISFSI long-period (ILP) earthquake spectra. The ILP are 84th percentile spectra at damping values of 2, 4, 5, and 7 percent for the horizontal and vertical components that extended out 10s and that include near-fault effects of directivity and fling. The applicant indicates that the ILP spectra envelop the double-design earthquake spectra at 2- and 5-percent damping; the HE spectra at 4-, 5-, and 7-percent damping; and the long term seismic program earthquake spectra at 5-percent damping. The applicant further indicates that the use of ILP earthquake spectra for transporter stability, slope stability, and ISFSI storage pad sliding would provide an extra design margin by considering long-period energy. Five sets of ILP spectra-compatible time histories generated from large-magnitude earthquakes ($M > 6.7$) recorded at short distances {< 15 km [9.3 mi] from the fault) were used as input for the analyses. Based on the statements provided in the SAR, the staff concluded that the use of ILP spectra-compatible time histories to assess transporter stability, slope stability, and ISFSI storage pad sliding potential is acceptable.

<u>Seismic Analysis of Cask Transportation on Transport Route</u>

The transport route from the FHB/AB at the DCPP to the ISFSI storage pad is approximately 1.93-km [1.2-mi] long. Approximately one-third of the route is on bedrock, and the rest is on surficial deposits over bedrock. The route is made up of slopes with an 8.5-percent nominal grade decline and a 6-percent nominal grade incline and a 2-percent grade perpendicular to the roadway with a decline toward the hill side. The minimum roadway width is 7.92 m [26 ft]. The cask transporter carries a HI-TRAC 125 Transfer Cask in a horizontal position from the FHB/AB to the CTF for MPC transfer operation. After the MPC transfer operation is executed, the cask transporter carries the loaded overpack in a vertical orientation to the final position on the ISFSI storage pad. The cask transporter is 5.37-m [17.625-ft] wide and 7.47-m [24.5-ft] long. The applicant states that the maximum acceptable sliding movement along the roadway is limited to the cask transporter track length to ensure that the transporter will remain on the roadway after exiting a turn in the roadway. Assuming that the cask transporter travels along the middle of the roadway, the allowable lateral sliding distance is the distance between the edge of the transporter and the edge of the roadway, which is approximately 1.28 m [4.19 ft].

During transport to the ISFSI storage pad, the cask transporter protects the MPC from the effects of earthquake ground motions. The transporter stability assessment discussed in the SAR was analyzed three dimensionally. The cask transporter, the HI-STORM 100SA storage cask, the HI-TRAC 125 Transfer Cask, the MPC (including the fuel basket, fuel, and lid), and the cask lids were modeled as rigid bodies. The mass of the MPC and the contained spent nuclear fuel is lumped in a free-standing rigid cylinder. Three cases of roadway conditions were modeled: flat surface, 6-percent grade, and 8.5-percent grade. For all cases, the ground surface was treated as a nondeformable boundary. The SAR states that a transporter stability analysis was performed for a potential transporter overturning or sliding off the roadway using only the bedrock ground acceleration associated with the ILP earthquake time histories. The maximum sliding along the roadway axis of approximately 0.77 m [2.52 ft] occurred on the portion of 8.5-percent grade roadway, and the maximum sliding transverse to the roadway axis of approximately 0.27 m [0.89 ft] occurred on the portion of the roadway with a 6-percent grade. These sliding distances are small compared to the corresponding allowable sliding distance. The analysis also demonstrated that overturning is not credible under the ILP seismic events.

The applicant indicates that peak ground accelerations at certain points along the surface of surficial deposits over bedrock of the transport route can be 1.5 to 2.0 times the amplitude of the peak ground acceleration on bedrock. PG&E did not specifically analyze the potential for overturning and sliding of the transporter on surficial deposits. The SAR points out that a significant safety margin exists to prevent a transporter from overturning or sliding off the roadway while traveling on the surficial deposits even through the ground acceleration would be amplified.

PG&E provided two analyses to address the potential accident scenario, in which an earthquake occurs while the cask is being transported on a portion of the roadway underlain by soil to the CTF or ISFSI pad. The first is a risk assessment to show that this scenario is not credible. The second is a calculation to show that transporter and cask will remain stable during an earthquake. The staff's review of these two analyses is discussed in detail in the following paragraphs. In summary, the staff agrees with the PG&E assessment that this is not a credible scenario. The staff concludes that the regulatory requirements of 10 CFR §72.90, §72.90(a), §72.98, §72.102, and §72.122 have been satisfied.

PG&E conducted a probabilistic risk assessment calculation and concluded that the annual probability of damage to the transporter while transporting spent fuel from the power plant to the CTF is 2.1×10^{-10}, which is substantially less than the 1×10^{-6} threshold criterion recommended for credible events. The PG&E probabilistic risk assessment calculation includes the 1.4×10^{-3} annual exposure probability for transport casks on the transport route (12 hr/yr) and the 1.2×10^{-7} annual exceedence probability for two times the ILP earthquake ground motions.

The staff reviewed the PG&E probabilistic risk calculation and agrees with their conclusion. Specifically, the annual exceedence probability for earthquake-induced damage of the transfer cask while in transit from the power plant to the CTF is less than 1×10^{-6} and is, therefore, not a credible hazard. The use, however, of the annual exceedence probability associated with twice the ILP earthquake ground motions is not considered to be appropriate. Twice the ILP earthquake ground motions was used by PG&E to account for possible site response amplification on those portions of the transport route underlain by soil, not as an added factor in the probability calculation. For this reason, the annual probabilities of the ILP earthquake ground motions, not the annual probabilities for twice the ILP earthquake ground motions, should be used in the probabilistic risk calculation.

The staff independently estimated the upper bound annual exceedence probability for earthquake-induced damage of the casks while in transit from the power plant to the CTF. The estimated probability would be no more than 1.4×10^{-7} per year. The calculation performed by the staff assumed a maximum annual probability for the ILP earthquake ground motions to be less than 1×10^{-4}. When combined with the 1.4×10^{-3} probability of annual exposure of the transfer casks being in transit, an upper bound value of 1.4×10^{-7} probability of annual exposure is calculated. The exact probability depends on a number of factors, including the spectral frequency of interest and the statistical measure used (mean, median, or 84th percentile). Based on this calculation, the staff concludes, with reasonable assurance, that earthquake-induced damage of the loaded transfer cask while in transit from the power plant to the CTF is not a credible hazard.

Seismic Analysis of the Cask Transfer Facility

The staff reviewed Section 4.2.1.2 of the SAR and found that the structural analysis of the CTF demonstrates that it is designed to mitigate the effects of seismic loading as documented in Section 5.1.4.4 of this SER.

The steel structures of the CTF were analyzed to demonstrate compliance with the material allowables (Holtec International, 2001c). This analysis addressed the following major structural elements: main shell, lifting jacks, jack support platform, CTF base support block, and lifting platform. The appropriate spectral values are used to account for possible amplification of the horizontal accelerations of the stacked components. The applicant demonstrated that the factors of safety for all components and all load conditions are greater than 1.0. The adequacy of the structures has been demonstrated by the analysis results given in the SAR, as designed to satisfy the requirements of ASME Section III, Subsection NF (ASME International, 1995a).

Loads from the Holtec International structural evaluation were also used in the calculation of the necessary thickness and reinforcement for the CTF concrete (ENERCON Services Inc., 2001a). The analysis determined the required size and general reinforcing requirements to resist the loads applied to the concrete structure. The concrete structure is designed to withstand loads from both the CTF and the transporter. Using the controlling load combinations, an analysis identified shear and axial forces and moments in the reinforced concrete structural elements of the CTF. Steel reinforcement size and placement for the pad and wall were established based on these demands. The design of the concrete structure and its reinforcement are based on the requirements in American Concrete Institute (ACI) 349-97 (American Concrete Institute, 1998). Results of the analysis indicate that the available design strength of the CTF exceeds that required for the factored design loads.

Seismic Analysis of the HI-STORM 100SA Overpack Anchored on the ISFSI Storage Pad

Structural analyses of the anchored HI-STORM 100SA overpack are provided in the HI-STORM 100 System FSAR (Holtec International, 2002). The staff's evaluation of the HI-STORM 100 System FSAR is documented in the NRC HI-STORM 100 System SER (U.S. Nuclear Regulatory Commission, 2002b). The Diablo Canyon ISFSI SAR Section 4.2.3 provides a summary of the analyses performed in the HI-STORM 100 System FSAR. The loading conditions at the Diablo Canyon ISFSI are enveloped by the loading conditions considered in the HI-STORM 100 System FSAR (Holtec International, 2002). As documented in the HI-STORM 100 System SER, the structural analysis shows that the structural integrity of the HI-STORM 100 System cask system is maintained during all credible loads. Based on the results presented in the HI-STORM 100 System FSAR, the stresses in the overpack structures during the most critical load combinations are less than the allowable stresses of ASME Boiler and Pressure Vessel Code, Section III (ASME International, 1995b) for the structures materials.

<u>Seismic Analysis of the ISFSI Storage Pad</u>

SAR Section 8.2.1.2.3.1, "Cask and Anchorage Seismic Analysis," summarizes seismic analyses of the cask and anchorage system performed by Holtec International. The staff's review of this analysis is summarized in Section 5.1.3.4 of this SER. Although the Diablo Canyon site-specific seismic zero period accelerations for all events are lower than those identified in Appendix B of the Holtec HI-STORM 100 Certificate of Compliance (U.S. Nuclear Regulatory Commission, 2002a), Holtec International performed a specific analysis of the cask anchoring system to be used at Diablo Canyon ISFSI (Holtec International, 2001d). The primary reason for this analysis was the difference in the number of anchor rods identified for the Diablo Canyon ISFSI anchoring system with respect to the design basis given for the HI-STORM 100SA System (Holtec International, 2002). The results indicate that the casks do not develop body decelerations that exceed the cask design basis of 45 g. The seismic events postulated for the Diablo Canyon ISFSI do not induce stresses in the preloaded anchor studs, cask flange, and shell that exceed the design-basis ASME Code limits. The interface loads transferred to the ISFSI pad embedment were established using acceptable methods.

SAR Section 8.2.1.2.3.2, "Storage Pad Seismic Analyses," identifies the analysis performed to ensure that the reinforced concrete pads and the anchored casks remain functional during all seismic conditions. Two analyses are covered in this section, a static analysis (ENERCON Services Inc., 2001b) and a nonlinear pad sliding analysis (Pacific Gas and Electric, 2001a). The static analysis was performed to determine the storage pad size and thickness required to resist the loads resulting from seismic accelerations applied to the pad and resultant loads from the cask dynamic analysis (Holtec International, 2001d). In addition to the cask loads, an inertial force was applied to the pad with reference to the zero period acceleration of the seismic event. The pad and cask vertical displacements are small and within acceptable limits. These maximum tensile stresses in the concrete are less than the tensile stress that will cause cracking in the 34.5-MPa [5,000-psi] concrete. The maximum compressive stress is significantly less that the 34.5-MPa [5,000-psi] design value. Sections throughout the pad were isolated for the HE seismic event calculations and the internal forces acting upon them were computed. The resulting internal forces for design purposes are given in Table 11 of the ENERCON calculation package (ENERCON Services Inc., 2001b). The results of the analysis were used in Calculation No. PGE–009–CALC–007 (ENERCON Services Inc., 2003a) to evaluate the concrete per the design codes and to determine the size of the steel reinforcement needed for compliance with the requirements of ACI 349-97 (American Concrete Institute, 1998). The staff has reviewed this calculation and finds that it demonstrates compliance with the requirements of ACI 349-97.

The anchorage system was designed to meet the ductile anchorage provision of the proposed Draft Appendix B for ACI 349-97. To satisfy the requirements of Appendix B of ACI 349-97, the diagonal tension shear capacity must exceed the anchor bar ductile design strength of 1.05 MN [235.63 kips]. The applicant has provided sufficient reinforcing steel to ensure the failure cone for concrete pullout intersects sufficient rebar to prevent brittle failure (ENERCON Services Inc., 2003a). The reinforcing steel in the storage pad (ENERCON Services Inc., 2003b) has been sized in accordance with the requirements of ACI 349-97.

15.1.2.7 Loss of Shielding

Section 8.2.11 of the SAR (Pacific Gas and Electric Company, 2003) evaluates the potential consequences of a loss-of-neutron shielding for the HI-TRAC 125 Transfer Cask. The potential consequences of this postulated accident were determined by assuming a loss of the water jacket and Holtite-A solid neutron shielding. The staff previously determined that the methodology used to assess this postulated accident is acceptable and the short-term fuel cladding and other component temperature limits, the MPC accident internal pressure, and the accident dose limits defined by 10 CFR §72.106 are not exceeded, so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are adhered to. The staff has confirmed that appropriate limits have been incorporated into the proposed Diablo Canyon ISFSI Technical Specifications.

Section 8.2.6.3 of the SAR specifies that the consequences of postulated explosion events analyzed for the Diablo Canyon ISFSI are enveloped by the design-basis accident conditions in the HI-STORM 100 System FSAR (Holtec International, 2002). Additionally, there is no effect on shielding, criticality, thermal, or confinement capabilities of the HI-STORM 100 System as a result of the explosion pressure load. Based on the structural and radiological evaluations presented in Chapters 3 and 11 of the HI-STORM 100 System FSAR, the applicant concludes that the MPC confinement boundary will remain intact and the shielding effectiveness of the storage and transfer casks will not be significantly affected by any potential onsite explosion.

Considering the results of the onsite explosion accident analysis evaluation presented in Section 15.1.2.4, "Fire and Explosion," of this SER, the staff finds that the maximum reduction in ISFSI radiation shielding thickness, material shielding effectiveness, or loss of temporary shielding in all possible shielding areas caused by postulated onsite explosion events, has been adequately evaluated by the applicant. Therefore, the information and analyses presented by the applicant provide reasonable assurance that the accident dose to any individual beyond the owner-controlled area will not exceed the limits specified in 10 CFR §72.106(b), and the occupational exposures from accident recovery operations will not exceed the limits specified in 10 CFR Part 20.

15.1.2.8 Adiabatic Heatup

The staff has previously determined that the methodology used to estimate the time required to reach the short-term, fuel-cladding temperature limit of spent nuclear fuel stored in the HI-STORM 100 System storage cask under adiabatic conditions is acceptable (U.S. Nuclear Regulatory Commission, 2002a,b). The HI-STORM 100 System FSAR (Holtec International, 2002, Figure 11.2.6) indicates that a total cask decay heat load of 30 kW [102,360 BTU/hr], which bounds the cask decay heat load specified for the Diablo Canyon ISFSI, will not cause the short-term cladding temperature limit for the spent nuclear fuel to be exceeded for 45 hours under adiabatic conditions. Moreover, the internal pressure limit for the MPC is not exceeded within the 45-hour timeframe for this condition.

In the event that the HI-STORM 100 System storage cask is subjected to conditions that thermally insulate its exterior (e.g., encased within soil as the result of a landslide), the previously reviewed and accepted recovery operation procedures will be implemented (U.S. Nuclear Regulatory Commission, 2002a,b).

15.1.2.9 Full Blockage of Air Inlets and Outlets

The staff previously determined that the methodology used to estimate the time required to reach the short-term, fuel-cladding temperature limit of spent nuclear fuel stored in the HI-STORM 100SA storage cask subjected to 100-percent blockage of the air inlet ducts is acceptable (U.S. Nuclear Regulatory Commission, 2002a,b). For the bounding values of decay heat load of 30 kW [102,360 BTU/hr] and insolation of 834 w/m^2 [800 g-cal/cm^2] per day {387 W/m^2 [123 BTU/hr-ft^2]}, the short-term cladding temperature limit for the spent nuclear fuel will not be exceeded for 72 hr when the HI-STORM 100SA storage cask air inlet ducts are 100-percent blocked. Moreover, the internal pressure limit for the MPC is not exceeded within the 72-hour timeframe for this condition. Furthermore, the HI-STORM 100 System 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). In the event that the HI-STORM 100SA storage cask air inlet ducts are found to be partially obstructed or blocked, the previously reviewed and accepted recovery operation procedures will be implemented (U.S. Nuclear Regulatory Commission, 2002a,b).

15.1.2.10 Tornadoes and Missiles Generated by Natural Phenomena

The staff reviewed the information presented in the Diablo Canyon ISFSI SAR Sections 3.2.8, “Tornado and Wind Loadings;” 3.3.2.3.3, “Maximum Permissible Tornado Wind and Missile Load;” 4.2.3.3.2.6, “Tornado Winds and Missiles;” and 8.2.2, “Tornado.” The staff also reviewed responses to requests for additional information (Pacific Gas and Electric Company, 2002; RAIs 4-3, 15-18, 15-19, 15-20, and 15-21), including the report, “Design Basis Wind and Tornado Evaluation for DCPP”, (Holtec International, 2001e, Attachment 4-1) and Section 3.3, “Wind and Tornado Loadings,” of the FSAR for DCPP, Units 1 and 2 (Pacific Gas and Electric Company, 2001b). This evaluation assumed that site personnel would not have any prior warning before the ISFSI SSCs are impacted by a potential design-basis tornado or a tornado missile.

The annual mean number of days with tornadoes is zero for the ISFSI site. Characteristics of the design-basis tornado and tornado missile are given in Section 3.2.1 of the ISFSI SAR. The SAR developed the characteristics of the design-basis tornado in accordance with the DCPP licensing-basis wind speed of 89 m/s [200 mph]. The proposed site is located in Region II as defined in Regulatory Guide 1.76 (U.S. Nuclear Regulatory Commission, 1974). The characteristics of the design-basis tornado for the proposed ISFSI are defined as a tornado with a maximum wind speed of 89 m/s [200 mph], a rotational speed of 70 m/s [157 mph], a translational speed of 19 m/s [43 mph], and a 5.9-kPa [0.86-psi] pressure drop at a rate of 2.5 KPa/s [0.36 psi/s].

The design-basis tornado missiles considered in the Diablo Canyon ISFSI SAR are based on Spectrum II missiles of Section 3.5.1.4, “Missiles Generated by Natural Phenomena,” of NUREG–0800 (U.S. Nuclear Regulatory Commission, 1981a), the Diablo Canyon FSAR Update (Revision 14, Pacific Gas and Electric Company, 2001b), and the three 500-kV tower missiles specific to the ISFSI (Pacific Gas and Electric Company, 2003). These objects are postulated to be picked up and transported by the winds of a design-basis tornado. A list of these missiles is provided in Table 15.1.

Table 15-1. Tornado missiles considered in Diablo Canyon Independent Spent Fuel Storage Installation (ISFSI)

Missile	Mass kg [lb]	Velocity Considered m/s [mph]	
		Diablo Canyon ISFSI Safety Analysis Report	Holtec International (Region I)
Automobile	1,800 to 1,814 [3,968 to 4,000]	56 [126]	56 [126]
Utility Pole	510 [1,124] 33 cm- [13.5 in-] diameter, 10.7 m [35 ft] long, density of 688.8 kg/m^3 [43 lb/ft^3] in Diablo Canyon Power Plant Units 1 & 2 (DCPP)	16 [35]	48 [107.4]
30 cm- [12 in-] diameter Schedule 40 pipe	340 [744] 4.5 m [15 ft] long, density of 7,849 kg/m^3 [490 lb/ft^3] in DCPP	2.2 [5]	28 [62.6]
15 cm- [6 in-] diameter Schedule 40 pipe	130 [285] 4.5 m [15 ft] long, density of 7,849 kg/m^3 [490 lb/ft^3] in DCPP	3 [7]	42 [93.9]
20-cm- [8-in-] diameter solid steel cylinder	125 [276]	56 [126]	56 [126]
10 cm × 30 cm × 3.05 m [4 in × 12 in × 10 ft] board	49 [108] In DCPP Units 1 & 2, 91 kg [200 lb], density of 801 kg/m^3 [50 lb/ft^3]	89 [200]	Not Applicable
7.5 cm- [3 in] diameter, 3.05 m [10 ft-] long Schedule 40 pipe	34.5 [76] In DCPP, 4.5 m [15 ft-] long pipe with density of 7,849 kg/m^3 [490 lb/ft^3]	29.8 [66.7]	Not Applicable
500-kV insulator string	344.7 [760]	70 [157]	Not Applicable
5 cm × 5 cm × 0.32 cm [2 in × 2 in × 1/8 in] steel angle {1.5 m [5 ft] long}	3.9 [8.6]	70 [157]	Not Applicable
2.5 cm- [1in-] diameter steel rod	4 [8] 0.9 m [3 ft-] long, density of 7,849 kg/m^3 [490 lb/ft^3] in DCPP	2.2 [5]	40 [89.5]
2.5-cm- [1-in-] diameter solid steel sphere	0.22 [0.5]	56 [126]	56 [126]

Important to safety SSCs that may be affected by design-basis tornado missiles are: (1) the CTF, (2) site transporters, (3) the transfer cask, and (4) the storage casks. These SSCs are required to function during this design-basis event.

Based on the resulting kinetic energy, PG&E's analysis assumed that an automobile at 203 km/hr [126 mph], a 500-kV insulator string at 253 km/hr [157 mph], and a 2.5 cm-[1 in-] diameter steel rod at 144 km/hr [89.5 mph] are the bounding missiles for the large, intermediate, and small missiles categories. PG&E assumed that the impact velocity of an automobile is consistent with that suggested in NUREG–0800. PG&E developed an equation to estimate the maximum horizontal missile velocity for a 322-km/h [200-mph] tornado from a 386-km/h [240-mph] Type III tornado curve using Figure 16.3.1 of Simiu and Scanlan (1986). However, the basis for the equation is not clear. This formula will produce a different result for the correlation power factor if tornados other than Type III are used.

The staff's confirmatory calculation indicated that energy imparted by the automobile is significantly larger than that of a utility pole. Therefore, any impact of a utility pole would be bounded by the automobile impact for assessing transporter stability. Holtec International (2001e) studied the effects of transporter stability while transporting a loaded transfer cask to the storage area at the proposed facility. This analysis included a large missile represented by a 1,800-kg [4,000-lb] car traveling at a speed of 56 m/s [126 mph]. The impact analysis result indicates that a loaded transporter would be displaced laterally by a distance of only 1.65 cm [0.65 in]. The transporter remains stable and does not tipover as a result of this impact.

The staff reviewed the information provided by the applicant, evaluated the analyses of potential hazards from design-basis tornadoes and tornado missiles at the proposed facility, and conducted a confirmatory analysis. The staff concludes that a tornado or tornado-generated missile would not impair the ability of the SSCs to maintain subcriticality, confinement, and sufficient shielding of the spent fuel during transfer or storage.

15.1.2.11 Accidents at Nearby Sites—Aircraft Crash Hazards

The staff reviewed the information presented in the Diablo Canyon ISFSI SAR, Section 2.2 (Pacific Gas and Electric Company, 2003). In addition, the staff reviewed information presented by PG&E in response to staff questions regarding aircraft crash hazards (Pacific Gas and Electric Company, 2003d). The purpose of this review is to ensure that the risk to the proposed facility caused by aircraft hazards has been appropriately estimated and is acceptable.

The staff reviewed the aircraft crash hazard analysis in accordance with NUREG–0800, Section 3.5.1.6, "Aircraft Hazards." The staff accepts the methodology in NUREG–0800, as applicable, for reviewing the aircraft crash probability for the proposed ISFSI. Section 3.5.1.6 of NUREG–0800, provides three screening criteria that must be satisfied to conclude, by inspection, that the aircraft hazards at a nuclear power plant are less than 1×10^{-7} per year for accidents that could result in radiological consequences greater than 10 CFR Part 100 exposure guidelines. The staff's review indicates the proposed facility site does not satisfy screening Criterion II.1(a), which states, "The plant-to-airport distance, *D* is between 5 and 10 statute miles, and the projected annual number of operations is less than 500 D^2, or the plant-to-airport distance, *D,* is greater than 10 statute miles, and the projected annual number of operations is less than 1000 D^2." Based on the information given in the SAR, and the air traffic increase projected in the next 25 years by the Federal Aviation Administration (FAA), the projected annual number of operations may not satisfy Criterion II.1(a). Additionally, screening Criterion II.1(c) states, "The plant is at least 2 statute miles beyond the nearest edge of a federal airway, holding pattern, or approach pattern." As stated by the applicant in Section 2.2.1.1 of the SAR, air traffic to San Luis Obispo County Regional Airport passes the proposed site at a distance of 1.6 km [1 mi]. Therefore, screening Criterion II.1.(c) is also not satisfied, and in accordance with NUREG–0800 review guidance, a detailed review is needed to assess the aircraft crash hazards for the proposed site. PG&E provided its detailed analysis to estimate the annual frequency of a potential aircraft crash at the proposed ISFSI (Pacific Gas and Electric Company, 2003d). Additionally, the staff conducted its own confirmatory analysis. These analyses are discussed in the following sections.

Estimating the total probability of an aircraft crash onto the proposed ISFSI requires an evaluation of crash probabilities from several sources:

- Aircraft taking off and landing at San Luis Obispo County Regional Airport;

- Aircraft taking off and landing at other municipal airports located close to the site, such as Oceano County Airport, Camp San Luis Obispo Heliport, and Vandenberg Air Force Base;

- Aircraft flying the low-altitude flight corridor V–27 (commercial airway) and either landing at or departing from San Luis Obispo County Regional Airport, or not landing at or departing from San Luis Obispo County Regional Airport; and

- Aircraft flying military training route VR–249.

<u>Aircraft Taking Off and Landing at San Luis Obispo County Regional Airport</u>

San Luis Obispo County Regional Airport is approximately 19.3 km [12 mi] east of the proposed site. This airport has four runways. Only Runway 11 is equipped for instrument landing approach. The other three runways are used for visual landing. Some aircraft use Airway V–27 to align for instrument landing at the airport. Some of these aircraft come within approximately 1.6 km [1 mi] of the proposed ISFSI site at an elevation of 914 m [3,000 ft]. Based on NUREG–0800, any aircraft flying Airway V–27 for instrument landing at San Luis Obispo County Regional Airport will be in an in-flight mode. Their contribution to the overall crash hazard has been accounted for in the analysis of V-27. The commonly used approach route for visual landing at San Luis Obispo County Regional Airport passes approximately 12.8 km [8 mi] from the proposed site.

In Section 2.2.1.3 of the ISFSI SAR, "Hazards from Air Crashes," PG&E states that approximately 92,330 operations (take offs or landings) occur annually at San Luis Obispo Regional County Airport. However, while discussing local traffic on Airway V–27, PG&E stated approximately 16,000 takeoffs and landings occur annually at San Luis Obispo County Regional Airport, based on an average of data from 1998–2001, by commercial or air-taxi aircraft. Primarily turboprop aircraft with a gross weight of not more than 13,608 kg [30,000 lb] are used in these commercial flights. Additionally, private aircraft (i.e., general aviation aircraft) landed at or took off from San Luis Obispo County Regional Airport approximately 7,560 times monthly, based on the average of data from 1998–2001. These aircraft have gross weight of less than 5,670 kg [12,500 lb]. Consequently, at least a total of approximately 106,720 landings and departures took place annually at the San Luis Obispo County Regional Airport without counting the operations by military aircraft.

PG&E concluded that no analysis would be necessary as the number of annual operations at San Luis Obispo County Regional Airport is below the number needed to have an annual crash frequency of 10^{-7} based on Criterion II.1(a) of NUREG–0800.

The staff independently verified the number of annual operations at this airport from the FAA database at <http://www.gcr1.com/5010WEB/default.htm> and another source at <http://www.airnav.com>. Based on this information, approximately 72,000 annual operations take place at the San Luis Obispo County Regional Airport, out of which approximately 16,500 operations are by commuter aircraft and approximately 55,000 operations are by general aviation aircraft, in addition to approximately 900 operations by military aircraft. Because the number of annual operations given by PG&E (i.e., 106,720 with 900 additional operations by military aircraft) is bounding, the staff used that value for further review.

The staff reviewed the information and the analysis provided by the applicant with respect to the potential hazards of aircraft taking off and landing at San Luis Obispo County Regional Airport. The staff found the hazards acceptable because adequate information has been presented to describe the potential hazards and an acceptable methodology has been used to screen the potential hazards. As the airport is approximately 19.3 km [12 mi] away from the proposed ISFSI site, the estimated annual frequency of crash onto the proposed ISFSI is insignificant using the methodology given in NUREG–0800 to analyze the crash potential of aircraft landing at or taking off from an airport. Based on the this information, the staff has concluded that aircraft taking off and landing at San Luis Obispo County Regional Airport would not pose any undue hazard to the proposed ISFSI.

Aircraft Taking Off and Landing at Oceano County Airport, Camp San Luis Obispo Heliport, and Vandenberg Air Force Base

There are several smaller municipal airports in the vicinity of the proposed site. Oceano County Airport is located 24 km [15 mi] away from the proposed site. Only general aviation aircraft with weight not more than 5,670 kg [12,500 lb] use this airport. In the Diablo Canyon ISFSI SAR, PG&E estimated annual traffic at this airport to be no more than 26,400. Both the FAA database at <http://www.gcr1.com/5010WEB/default.htm> and another source at <http://www.airnav.com> give the estimated annual number of flight operations at this airport to be approximately 10,000. Therefore, the estimated number for annual flights used in the SAR is conservative. Again, PG&E concluded that no analysis would be necessary, based on Criterion II.1(a) of NUREG–0800, as the number of annual operations at Oceano County Airport equates to an annual crash frequency of 10^{-7}, or lower. Based on the analysis methodology given in NUREG–0800, the staff estimates that the frequency of aircraft crashing onto the proposed ISFSI while taking off or landing at Oceano County Airport is insignificant.

Camp San Luis Obispo airfield, located approximately 13 km [8 mi] northeast of the proposed ISFSI site, is a heliport owned by the U.S. Army. The staff concludes that landings and takeoffs by helicopters at this heliport do not pose a credible hazard to the proposed ISFSI because of the type of aircraft and the long distance from the ISFSI, based on the U.S. Department of

Energy (DOE) Standard, “Accident Analysis for Aircraft Crash Into Hazardous Facilities.” (DOE–STD–3014–96, U.S. Department of Energy, 1996).

Vandenberg Air Force Base is 56 km [35 mi] away from the proposed site. At this distance, the number of takeoffs or landings per day will not exceed the NUREG-0800 criterion that would require further analysis. Therefore, any landing or takeoff operations at Vandenberg Air Force Base will pose a negligible hazard to the proposed Diablo Canyon ISFSI.

Aircraft Flying Low-Altitude Airway Victor 27 (V-27)

A low-altitude Airway Victor 27 (V–27) passes approximately 8 km [5 mi] east of the proposed facility. Aircraft use this airway to fly between the Santa Barbara area and the Big Sur area. Aircraft using V–27 can either land at San Luis Obispo County Regional Airport or fly through to their destination without landing. The majority of the aircraft using airway V-27 fly at an en route altitude of 3,333 m [10,000 ft] above mean sea level (MSL). Occasionally, V-27 is also used by traffic approaching San Luis Obispo County Regional Airport from the south for instrument landings on Runway 11, or for instrument departures to the south from Runway 11. Some landings on Runway 29, and instrument departures to the south from Runway 29 also use V-27. Some aircraft using this approach or departure pattern pass as close as 1.6 km [1 mi] from the proposed ISFSI site at an elevation of 914 m [3,000 ft].

Aircraft Landing or Departing San Luis Obispo County Regional Airport Using V-27

PG&E used the FAA database <http://www.apo.data.faa.gov/faaatadsall.htm> to obtain information about commercial or air taxi (AT) and general aviation operations at San Luis Obispo County Regional Airport. An average of 16,000 AT operations (i.e., takeoffs or landings) took place annually during 1998–2001. Additionally, an average of 1,781 AT landings took place annually at this airport under instrument meteorological conditions.

Based on the scheduled airline flight information at San Luis Obispo County Regional Airport, PG&E estimated approximately 65 percent of the commercial traffic is departing to or approaching from the south. Therefore, approximately 1,781 × 0.65, or, 1,157 instrument landings may use the V–27 airway annually. Assuming a similar number of takeoffs using instrument conditions, approximately 2,314 flights will use Airway V–27 annually, and this number was considered in the aircraft hazards analysis for the proposed ISFSI.

The FAA database shows that approximately 7,560 landings and takeoffs by general aviation aircraft took place monthly at San Luis Obispo County Regional Airport over the 4-year period of 1998–2001. During the same period, an average of 1,430 flights, which includes local and itinerant general aviation and military flights, landed at San Luis Obispo County Regional Airport annually under instrument conditions. PG&E again assumed that approximately 65 percent of the general aviation traffic is departing to or approaching from the south. Therefore, PG&E considered that approximately 2 × (1,430 × 0.65), or 1,860 operations (takeoffs and landings) took place annually under instrument conditions.

The nearest major airway intersections (CREPE and CADAB) are approximately 18 km [11 mi] and 34 km [21 mi] from the proposed ISFSI site. Holding patterns at both of these intersections would place the aircraft even further away from the proposed ISFSI site, thus they are not considered to contribute to the overall aircraft hazard.

Since the Morro Bay Very-High Frequency Omnidirectional Range Navigation System is used for missed approaches to San Luis Obispo County Regional Airport, PG&E estimated that 5 percent of all instrument landing approaches are missed, and each aircraft remains in the holding pattern for 10 passes. Therefore, for purposes of this analysis, commercial aircraft traffic is assumed to increase by an additional 579 (2,314/2 × 0.05 × 10) annual flights and general aviation aircraft traffic by 465 [1,860/2 × 0.05 × 10] additional annual flights. In its response to additional staff questions, PG&E stated that the assumption that 5 percent of all instrument landing approaches are missed is conservative based on discussions with the personnel at the control tower of San Luis Obispo County Regional Airport regarding the specific approaches available to the airport. Additionally, discussions with pilots of commercial and private aircraft support this conclusion. San Luis Obispo County Regional Airport has limited landing facilities. Most instrument approaches are near minimum weather requirements for using the visual flying rule and result in a visual landing under an instrument flying rule approach. Essentially, zero landing misses take place under this type of approach to the airport. Runway 11 is the only runway available with a precision instrument landing system. If wind and fog results in downwind landing on Runway 11, commercial aircraft will not depart San Luis Obispo County Regional Airport.

PG&E states that aircraft approaching from the south and not during weather classified as instrument meteorological conditions will fly to the CADAB intersection and will land on Runway 29 under visual control. These aircraft do not generally use Airway V–27 while landing at San Luis Obispo County Regional Airport. However, when San Luis Obispo County Regional Airport is under instrument meteorological conditions, all aircraft arriving from the south will use Runway 11 approach, if the ceiling is below 270 to 330 m [900 to 1,100 ft], depending on the aircraft type. This approach uses V-27. However, if the ceiling is above 270 to 330 m [900 to 1,100 ft], the pilot may also use the Runway 29 approach, which does not use V–27. Consequently, a major portion of the aircraft approaching San Luis Obispo County Regional Airport from the south (PG&E has estimated it to be approximately 65 percent) do not use V–27 to land; however, PG&E has conservatively assumed that all aircraft approaching from the south use Airway V–27. The V–27 airway has a width of 12.8 km [8 statute mi] with a center approximately 8 km [5 mi] from the proposed ISFSI site. Consequently, the proposed ISFSI site is 1.6 km [1 statute mi] from the edge of V–27 airway, and an effective width equal to 16 km [10 statute mi] is used in accordance with NUREG-0800 to estimate the probability of air crashes from traffic using this airway at the ISFSI site.

PG&E assumed that the wingspan of commercial aircraft is 29.9 m [98 ft] with a skid distance of 213 m [700 ft] and cotangent of the impact angle, cot φ, equal to 10.2. Using length, width, and height of the facility as 152, 32, and 6.1 m [500, 105, and 20 ft], PG&E estimated the effective area of the facility to be 0.0580 km^2 [0.0224 mi^2] for commercial aircraft, using the formula given in DOE Standard DOE–STD–3014–96. Using a wingspan of 22.3 m [73 ft], skid distance of 213 m [700 ft], and cot φ of 10.2, PG&E estimated the effective area of the facility to be 0.0554 km^2 [0.0214 mi^2] for general aviation aircraft.

Use of 213 m [700 ft] as the skid distance by PG&E is based on the layout of the proposed facility. The proposed facility is surrounded by hills on three sides, which limits the potential skid distance by a crashing aircraft to reach to the SSCs important to safety. The fourth side is protected by a drop in the terrain with a slope greater than 1:1 (PG&E SAR, 2003, Figure 2.2-1).

PG&E assumed a crash rate of 2.5 $\times 10^{-10}$ per km [4 $\times 10^{-10}$ per mi] for commercial aircraft and 0.97 $\times 10^{-7}$ per km [1.55 $\times 10^{-7}$ per mi] for general aviation aircraft flying in this corridor. The crash rate for commercial aircraft is based on the suggested value in Section 3.5.1.6 of NUREG–0800. Additionally, PG&E used Kimura, et. al (1996) to select the crash rate for general aviation aircraft.

Based on the above parameters and using the formula given in NUREG–0800, Section 3.5.1.6, PG&E estimated the annual crash frequency onto the proposed ISFSI by commercial aircraft to be 2.59 $\times 10^{-9}$. Similarly, the annual crash frequency of general aviation aircraft is estimated by PG&E to be 7.7 $\times 10^{-7}$. Therefore, the total crash frequency by aircraft flying airway V-27 is 7.73 $\times 10^{-7}$ per year.

The staff consulted the FAA database <http://www.apo.data.faa.gov/faaatadsall.htm> to independently verify the number of annual flights by both commercial and general aviation aircraft approaching San Luis Obispo County Regional Airport during instrument meteorological conditions. The staff confirmed that the 4-year (1998–2001) average of flights during instrument meteorological conditions for both types of aircraft are acceptable. Additionally, inclusion of 2002 data would somewhat decrease the annual average for both commercial and general aviation aircraft. Therefore, the applicant's consideration of information from 1998–2001 is appropriate.

Commercial Aviation

San Luis Obispo County Regional Airport is served primarily by turboprop or smaller aircraft for the commercial or air taxi traffic. The maximum capacity of these aircraft is 41 people with a maximum gross weight of 13,608 kg [30,000 lb]. Although PG&E used the crash rate of commercial aircraft equal to 4 $\times 10^{-10}$ per mile, as suggested in Section 3.5.1.6 of NUREG–0800, the staff used a crash rate of 9.28 $\times 10^{-10}$ per km [5.801 $\times 10^{-10}$ per mi], as given in Table 2.13 of Kimura, et al. (1996) for off-airport crashes with destroyed aircraft or aircraft that sustained substantial damage to the airframe as a result of the crash. Staff considers this crash rate to be more appropriate for the type of aircraft under consideration. A search of the website <http://www.sloairport.com/flightinfo.html> shows that certified air carriers operate at this airport. A certified air carrier is an air carrier possessing a Certificate of Public Convenience and Necessity issued by the U.S. Department of Transportation in accordance with 14 CFR Part 121 to operate scheduled air services (Kimura et al., 1996). The information obtained by the staff independently from the websites <http://airnav.com> and <http://www.gcr1.com/5010WEB/default.htm> indicates that the traffic at San Luis Obispo County Regional Airport does not have any air-taxi operations, rather it has commercial operations. Therefore, the staff used the crash rate of 9.28 $\times 10^{-10}$ per km [5.801 $\times 10^{-10}$ per mi] as the crash rate appropriate for commercial aircraft operating at San Luis Obispo County Regional Airport.

Although PG&E stated that San Luis Obispo County Regional Airport is primarily serviced by turboprop or smaller aircraft for commercial traffic, PG&E used a wingspan of 29.4 m [98 ft], as suggested for air carriers in commercial aviation in Table B–16 of DOE Standard DOE–STD–3014–96. This table suggests that the wingspan for turboprop aircraft, classified as general aviation aircraft, is 22.3 m [73 ft]. Therefore, use of a higher value for wingspan will produce a larger estimate of the effective area, and therefore, it is conservative. The staff used a wingspan of 29.9 m [98 ft] for commercial aviation. Additionally, the staff considered all general aviation aircraft to be the turboprop type, which has the largest wingspan of all general aviation aircraft types.

Table B–17 of the DOE standard provides the suggested values for the mean of the cotangent of the impact angle (cot φ). For commercial aviation aircraft, the suggested value is 10.2. DOE (1996) recommends cot φ equal to 8.2 for general aviation aircraft. Mean skid distances for commercial and general aviation aircraft are 439 and 18 m [1,440 and 60 ft], as per Table B–18 of the DOE Standard. PG&E asserted that a commercial aircraft would not have enough space to skid for a distance of 439 m [1,440 ft] because of the topography surrounding the proposed ISFSI. The staff agrees with this conclusion and has used a skid distance of 213 m [700 ft] as an appropriate skid distance for commercial aircraft in the calculation. Nevertheless, the staff also used 439 m [1,440 ft] in the calculation to test the sensitivity of the skid distance parameter.

Using a wingspan of 29.9 m [98 ft], cot φ of 10.2, and a skid distance of 213 m [700 ft], the staff estimates the effective area of the proposed facility to be 0.058 km^2 [0.0224 mi^2]. Using a skid distance of 439 m [1,440 ft], however, the estimated area increases to 0.0997 km^2 [0.0385 mi^2] for commercial aircraft. Using a wingspan of 22.3 m [73 ft], cot φ of 8.2, and skid distance of 18 m [60 ft], the effective area is 0.01844 km^2 [0.00712 mi^2]. As discussed before, the effective width of the airway is 16 km [10 mi]. Based on this information, the staff estimates that the annual frequency of a crash of a commercial aircraft onto the proposed facility, using the formula given in NUREG–0800 Section 3.5.1.6, is approximately 3.8×10^{-9}, for a skid distance of 213 m [700 ft]. Assuming a skid distance of 439 m [1,440 ft], (which is not considered realistic given the topography surrounding the proposed ISFSI), the probability of a commercial aircraft crash increases to approximately 6.5×10^{-9} per year.

<u>General Aviation</u>

PG&E stated that the general aviation aircraft using the airport and airways near the proposed ISFSI include small single- and dual-engine aircraft, and small corporate aircraft powered by either propeller or jet. These aircraft with an average gross weight of less than 5,670 kg [12,500 lb] have a maximum capacity of eight people. Kimura, et al. (1996) provide crash rates per flight mile for single- and multi-engine reciprocating, turboprop and turbojet, rotary wing with either reciprocating or turbine engine aircraft. Because the proportion of these aircraft is not known, the staff considers the use of a crash rate of 2.48×10^{-7} per km [1.550×10^{-7} per mi] for all powered aircraft appropriate. As a part of the sensitivity analysis, the staff also used the crash rates equal to 2.416×10^{-7} per km [1.510×10^{-7} per mi] for all fixed-wing (single- and multi-engine reciprocating, turboprop and turbojet) aircraft and 5.669×10^{-7} per km [3.543×10^{-7} per mile] for all rotary-wing (reciprocating or turbine engine) aircraft. Additionally, a wingspan of 22.3 m [73 ft] has been used. As discussed before, this is a conservative estimate of the actual wingspan as the typical wingspan of a general aviation aircraft is given as 15.2 m [50 ft], except for a turboprop aircraft, which has a wingspan of 22.3 m [73 ft] (U.S. Department of Energy, 1996). Additionally, a skid distance of 18 m [60 ft] and cot φ of 8.2 have been used to estimate the effective area of the proposed facility. The effective area of the proposed facility has been estimated to be 0.01844 km^2 [0.00712 mi^2]. Therefore, the staff estimates that the annual frequency of crash of a general aviation aircraft onto the proposed ISFSI, using the formula given in NUREG–0800, Section 3.5.1.6, is approximately 2.6×10^{-7} assuming the crash rate for total powered general aviation aircraft. Assuming the crash rates for all fixed-wing and all rotary-wing aircraft, the estimated annual frequencies of crash of a general aviation aircraft onto the proposed ISFSI are approximately 2.5×10^{-7} and 5.9×10^{-7} per year, respectively.

The staff reviewed the information and analysis presented by the applicant with respect to potential hazards of aircraft flying airway V-27 to land at or depart from San Luis Obispo County Regional Airport. The staff found them acceptable because:

- Adequate information has been presented to describe the potential hazards;
- appropriate bases has been provided for the assumed crash rates for both commercial and general aviation aircraft;
- appropriate bases have been provided for the assumed number of flights of each type of aircraft in the vicinity of the proposed ISFSI using this flying corridor; and
- conservative values of crash parameters have been used to estimate the annual crash frequencies for different types of aircraft.

Aircraft Not Landing or Departing San Luis Obispo County Regional Airport Using V-27

As discussed before, V–27 is a federal airway also used by aircraft flying between the Santa Barbara and Big Sur areas. These aircraft do not land at San Luis Obispo County Regional Airport. The majority of the aircraft in V–27 fly at an altitude of 3,333 m [10,000 ft] above MSL; however, some smaller aircraft may fly at elevations as low as 1,050 m [3,500 ft]. Based on information from the FAA, PG&E estimates that mostly commercial aircraft fly in this airway at a rate of approximately 20 per day or, 7,300 flights per year. Using a crash rate of 6.4×10^{-10} per flight km [4.0×10^{-10} per flight mi] and an effective area of 0.058 km^2 [0.0224 mi^2], PG&E estimated the annual frequency of aircraft flying in this part of V–27 crashing onto the proposed facility would be 6.53×10^{-9}.

The staff estimated the annual crash frequency of aircraft in this category, assuming a skid distance of 213 m [700 ft], and a crash rate of 9.282×10^{-10} per flight km [5.801×10^{-10} per flight mi], as the contribution of this activity to the overall crash frequency is relatively minor. Using the methodology given in NUREG–0800, the staff estimated the crash frequency at the ISFSI for this category of aircraft to be approximately 9.5×10^{-9} per year. The staff reviewed the information and analysis presented by the applicant with respect to potential hazards of aircraft using Airway V–27 to transit between the Santa Barbara and Big Sur areas. The staff found the applicant's analysis acceptable because:

- Information presented to describe the potential hazards is adequate;
- an appropriate basis has been provided for the assumed crash rate, and
- an appropriate basis has been provided for the assumed number of flights of each type of aircraft in the vicinity of the proposed ISFSI.

Aircraft Flying in Military Training Route VR–249

VR–249 is a military training route. Aircraft can fly at any elevation up to 3,333 m [10,000 ft]. Flight through this route requires at least 8 km [5 mi] of visibility with a ceiling at 900 m [3,000 ft]. Aircraft using this route usually remain offshore. The ISFSI SAR indicates that these aircraft do not fly directly over the proposed ISFSI or DCPP.

A majority of the aircraft that flew through VR–249 in the period of September 2001 to September 2002 were F-18 military jets. Additionally, a limited number of F-16s, C-130s, and EA6B aircraft and some helicopters used this route. Based on the information obtained by PG&E from the Naval Air Station at Lemoore, bombs are not carried onboard a majority of the aircraft that fly VR–249, although air-to-air missiles and cannon/machine guns may be carried. The amount of explosive charges in these armaments is considered to be too small to pose a hazard to the proposed ISFSI.

The route VR–249 is used by military aircraft infrequently; approximately 50 flights annually. Additionally, aircraft fly near the proposed ISFSI area in normal flight mode, not in high-stress maneuvers. To be conservative, PG&E assumed that approximately 75 flights use this route in a year. PG&E assumed a wingspan of 33.5 m [110 ft] for an F-18 aircraft. Additionally, a skid distance of 213 m [700 ft] and cot φ of 10.2 have been assumed by PG&E. The calculated effective area of the proposed facility is 0.059 km^2 [0.0228 mi^2].

PG&E was not able to obtain specific crash information for F-18 aircraft to develop a crash rate in normal inflight mode. As a result, PG&E assumed a crash rate of 4.378×10^{-8} per km [2.736×10^{-8} per mi] for all types of aircraft flying in this corridor, based on the crash rates for F-16s developed for a separate ISFSI license application for the Private Fuel Storage Facility (Private Fuel Storage Limited Liability Company, 2002). PG&E assumed that the crash rate for F-16 aircraft could be applied to F-18 aircraft. The centerline of the route VR–249 is approximately 3.2 km [2 mi] offshore. PG&E assumed the width of the route for estimating the crash hazard as 1.6 km [1 mi]. The resulting crash hazard has been estimated to be 4.68×10^{-8} per year.

The majority of the aircraft flying through the route VR–249 are F-18s. The staff used the information given in Tables B–16 through B–18 of the DOE Standard (U.S. Department of Energy, 1996) to estimate the effective area of the proposed ISFSI, assuming all aircraft are either F–16s, F–18s, C–130, or EA–6B. Both F–16s and F–18s are high-performance small aircraft with wingspans of 10.0 m [32 ft 10 in] and 13.62 m [45 ft], respectively. The suggested value for cot φ is 10.4 and the skid distance is 136 m [447 ft] for both of these aircraft (U.S. Department of Energy, 1996). It should be noted that C–130s are transport aircraft and should be categorized as large military aircraft. The EA–6B is a twin-engine aircraft used for electronic countermeasures and is based on the airframe of A-6 aircraft. It has been categorized as a small military aircraft for estimating the effective area of the proposed ISFSI. C–130s have a wingspan of 40.4 m [132 ft 7 in]. EA–6Bs have a wingspan of 16.2 m [53 ft]. A skid distance of 112 m [368 ft] and cot φ of 9.7 have been used for C–130 aircraft. Similarly, a skid distance of 136 m [447 ft] and a cot φ of 10.4 have been used for EA–6B aircraft (U.S. Department of Energy, 1996). The estimated effective area of the proposed ISFSI is 0.0386 km^2 [0.0149 mi^2] for F–16s, 0.0396 km^2 [0.0153 mi^2] for F–18s, 0.0401 km^2 [0.0155 mi^2] for EA–6Bs, and 0.0409 km^2 [0.0158 mi^2] for C–130s. Therefore, a value of 0.0396 km^2 [0.0153 mi^2], appropriate for F–18s, has been used by the staff. Use of the effective area for any other aircraft would make an insignificant difference in the estimated annual frequency of aircraft crash onto the proposed ISFSI.

The staff searched the website <http://www.chinfo.navy.mil/navpalib/factfile/aircraft/air-fa18.html> of the U.S. Navy and found that the F–18 is a twin-engine aircraft. It is expected that the crash rate of a twin-engine, high-performance aircraft would be less than a single-engine aircraft, such as an F–16. The crash rate given in Table 4.8 of Kimura, et al. (1996) for F–16s and F–15s (a twin-engine aircraft) indicates that the F–15 has a lower crash rate than F–16. Similarly, it is expected that the crash rate for an F–18 would be less than or equal to that for an F–16 aircraft. Therefore, in the absence of specific information, assuming an F-16 crash rate of 4.378×10^{-8} per km [2.736×10^{-8} per mi] for an F-18 is acceptable. This assumption is also considered valid because the potential crash of a military aircraft traversing route VR–249 would produce a small contribution to the overall aircraft crash hazard at the Diablo Canyon ISFSI.

Although the centerline of the route VR–249 is approximately 3.2 km [2 mi] offshore, PG&E assumed the width of the route for estimating the crash hazard as 1.6 km [1 mi]. This assumption is conservative because it places all 75 flights in a 1.6-km- [1-mi-] wide corridor centered over the proposed ISFSI site for crash hazard estimation purpose. In reality, some of the aircraft would fly further away from the proposed ISFSI site. The staff also used a width of the route equal to 1.6 km [1 mi]. Using these parameters, the estimated crash hazard of aircraft flying route VR–249 is approximately 3.1×10^{-8} per year.

The staff reviewed the data and analysis presented by the applicant with respect to the potential hazards of aircraft flights in military training route VR–249. The staff found them to be acceptable because:

- Adequate information has been presented to describe the potential hazard;
- an acceptable methodology has been used to estimate the crash potential; and
- PG&E conservatively used the crash rate of a single-engine aircraft, the F–16, which is expected to have a higher crash rate than the twin-engine F–18, which is the aircraft primarily used on this route. In addition, PG&E conducted a sensitivity analysis by doubling and tripling the crash rate used to show that the crash rate for this route has only a minor effect on the cumulative aircraft crash hazard for the proposed ISFSI.

Probability Acceptance Criterion for Aircraft Crash Hazards for the Diablo Canyon Independent Spent Fuel Storage Facility

NUREG–0800 Section 3.5.1.6, "Aircraft Hazards" provides the methodology to estimate the annual frequency of a crash of an aircraft onto a nuclear power plant. An operating nuclear power plant requires active systems to control the dynamic nuclear and thermal processes that occur in the conversion of nuclear energy into thermal power. In the event of a mishap, large amounts of thermal energy within the reactor core can be affected. Emergency cooling systems are provided as part of a reactor facility design to avoid core damage or meltdown and the release of radioactive material into the environment.

Compared to a nuclear reactor facility, an ISFSI is a passive system that does not have complex control requirements and that has contents with relatively low thermal energy. Therefore, potential fuel damage and the associated radioactive source terms from a potential accident are significantly less than those expected from a potential accident at a nuclear reactor facility. As a result, the estimated consequences from a potential accident at an ISFSI are less severe than from a potential accident at a nuclear reactor facility. Therefore, the staff concludes that a frequency of 1×10^{-6} crashes per year is an appropriate acceptance criterion for evaluating aircraft crash hazards at the proposed Diablo Canyon ISFSI.

Summary of Review and Discussion

PG&E examined past and present activities in connection with potential hazards from the crash of both civilian and military aircraft flying in the vicinity of the proposed Diablo Canyon ISFSI. The activities examined include aircraft taking off and landing at San Luis Obispo County Regional Airport, Oceano County Airport, Camp San Luis Obispo Heliport, and Vandenberg Air Force Base; aircraft flying Airway V–27; and military aircraft flying in route VR–249. The applicant provided sufficient information and used acceptable methods to evaluate the potential hazard to the proposed ISFSI from an aircraft crash. The staff reviewed the scenarios, data, information, and analyses presented by PG&E in connection with the proposed facility and also carried out independent confirmatory analyses in selected cases, as presented in the previous section of this SER. The confirmatory analyses relied on some different assumptions from those applied by PG&E.

Summarizing the staff review, the crash frequencies for aircraft are given in Table 15-2. As indicated in the discussion of aircraft hazards within this section, these frequencies are estimated on the basis of several elements that determine the overall likelihood that each specific type of aircraft operation may lead to an impact at the proposed facility. Typically, these elements include measures that reflect traffic density (e.g., flights per year), a crash rate (e.g., crashes per mile), effective target area, as well as width of the flying corridor. Other factors, such as human errors in aircraft design, fabrication, or maintenance, also influence the estimated probabilities but have not been addressed explicitly since their effects are inherently taken into account through the use of historically established crash rate data.

Table 15-2. Estimated Annual Frequency of Aircraft Crashes at the Diablo Canyon Independent Spent Fuel Storage Installation

Source	Estimated Annual Frequency (Crashes/Year)	
	PG&E	**U.S. NRC**
Aircraft taking off and landing at San Luis Obispo County Regional Airport (SLOC Airport)	0	~0
Aircraft taking off and landing at other nearby airports	0	~0
Aircraft flying Airway V–27 using SLOC Airport •Commercial Aviation •General Aviation	 2.59×10^{-9} 7.7×10^{-7}	 3.8×10^{-9} 2.5×10^{-7} to 5.9×10^{-7}
Aircraft flying Airway V–27 not using SLOC Airport	6.53×10^{-9}	9.5×10^{-9}
Aircraft flying military training route VR–249	4.68×10^{-8}	3.1×10^{-8}
Cumulative Aircraft Crash Hazard	8.25×10^{-7}	2.9×10^{-7} to 6.3×10^{-7}

The estimated crash frequency values determined by the staff, as listed in Table 15-2, may be different from those determined by PG&E because of the sensitivity or confirmatory calculations performed by the staff. PG&E has used more conservative values than suggested in the DOE

Standard (U.S. Department of Energy, 1996) for skid distance of a crashing general aviation aircraft. Consequently, the calculated effective area and, in turn, the estimated annual crash frequency are higher and more conservative. The values determined by PG&E have been accepted by the staff as reasonable. Based on the information presented in Table 15-2, which demonstrates that the conservative estimates of aircraft crash probabilities are below the threshold probability criterion of 1×10^{-6} crashes per year for facilities of this type, the staff concludes that the analysis of aircraft crash hazards for civilian and military aircraft and ordnance for the proposed Diablo Canyon ISFSI is acceptable.

Future Developments

PG&E estimated the projected growth of civilian flights based on the FAA long-range forecast (Federal Aviation Administration, 1999). Commercial aircraft operations include air carrier and commuter/air taxi takeoffs and landings at all United States towered and nontowered airports. Based on the FAA forecasts, the commercial aircraft operations are projected to increase from 28.6 million in 1998, to 36.6 million in 2010, and to 47.6 million in 2025. Therefore, commercial aviation operations in the United States are projected to increase by 66 percent by 2025.

The annual general aviation operations (takeoffs and landings) at all towered and nontowered airports in the United States are projected to increase from 87.4 million in 1998 to 92.8 million in 2010 and to 99.2 million in 2025 (Federal Aviation Administration, 1999). Therefore, the FAA projects an increase of general aviation traffic by 14 percent by 2025.

PG&E has discussed the long-term trend of military aviation to project the estimated aircraft crash probability for the proposed ISFSI. The FAA predicts that the military air traffic would not increase appreciably, if at all, in the foreseeable future. Based on the projections of the FAA, the number of military aircraft handled by the FAA en route to traffic control centers will remain constant at 4.2 million from 1998 through 2025.

Based on the estimated annual frequencies listed in Table 15-2 and the increase in commercial and general aviation traffic projected by the FAA, the annual frequency of aircraft crash onto the proposed ISFSI would increase to 9.40×10^{-7} by 2025, as calculated by PG&E. Applying these same growth factors to the estimated crash probability of commercial and general aviation aircraft, the staff estimates that the crash frequency will increase to 3.4×10^{-7} to 7.2×10^{-7} per year by 2025, from the range of 2.9×10^{-7} to 6.3×10^{-7} shown in Table 15-2.

Conclusion

Based on the information and analysis provided by PG&E, the staff concludes that the cumulative probability of a civilian or military aircraft crashing at or affecting the proposed ISFSI is below the threshold probability criterion of 10^{-6} per year determined to be acceptable for these types of facilities. Therefore, there is reasonable assurance that civilian or military air crashes will not pose a hazard to the proposed Diablo Canyon ISFSI.

15.1.2.12 Accidents at Nearby Sites—Missile Testing at Vandenberg Air Force Base

In its responses to staff questions, PG&E provided information regarding operations at the Vandenberg Air Force Base (Pacific Gas and Electric Company, 2003d). The base is located approximately 56 km [35 mi] south-southeast of the proposed Diablo Canyon ISFSI.

Approximately 15 to 20 missiles are tested each year at this base. Missiles are fired in directions ranging from due west to southeast. Therefore, the flight paths of these missiles do not come near the proposed ISFSI. Additionally, intercontinental ballistic missiles are tested at Vandenberg Air Force Base. They are launched from sites at the northern part of the base and typically fly due west. Typical launches for spacelift missions are carried out at sites on the southern part of the base and fly in a southerly direction. Polar orbit launches at this base are also carried out in a southerly direction. Based on the information from the Base Chief Safety Officer, the most northerly missile launch site is approximately 40 km [25 mi] south of the proposed ISFSI. Vandenberg Air Force Base is also a designated alternate landing site for space shuttles, although the base has not been used yet for that purpose. The landing approach is west to east and does not bring the shuttle within 48 km [30 mi] of the proposed ISFSI. Therefore, the planned flight paths for missile tests and space shuttles to and from Vandenberg Air Force Base are always in a direction away from the proposed Diablo Canyon ISFSI site.

Only a small fraction of the missiles tested deviate from the intended trajectories. If a missile after launch deviates from its planned flight path, the missile is destroyed before the debris path exceeds a narrow preplanned window. Therefore, the probability of missiles launched from Vandenberg Air Force Base striking any safety-related SSCs is negligibly small.

The staff reviewed the information with respect to potential hazards of missile testing at Vandenberg Air Force Base. The staff found the information acceptable because:

- Verifiable information from the U.S. Air Force was used to determine the number of missile tests carried out annually and their intended flight paths;

- intended flights paths are always away from the proposed ISFSI site; and

- The U.S. Air Force uses avoidance as one of the primary safety measures to protect facilities.

Based on the foregoing information, there is reasonable assurance that different missile tests and potential space shuttle landings at Vandenberg Air Force Base will not pose a hazard to the proposed ISFSI because (1) the selected flight paths are away from the proposed ISFSI site and (2) several low-probability events would need to occur before a missile or the space shuttle would hit the proposed ISFSI.

15.1.2.13 Leakage Through Confinement Boundary

Section 8.2.7 of the ISFSI SAR evaluates the potential consequences of leakage resulting from a confinement boundary accident. The potential consequences of this postulated accident are determined by assuming that 100 percent of the cladding for the fuel rods have ruptured and the MPC pressure boundary has been breached. The staff has previously determined that the methodology used to assess this postulated accident is acceptable and that there are no consequences that affect the public health and safety so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The Diablo Canyon ISFSI Technical Specifications will impose similar conditions and limits on spent fuel storage so that the staff’s previous conclusions are applicable in this case. Moreover, NUREG–1536 (U.S. Nuclear Regulatory

Commission, 1997, Chapter 7, Section V.2) indicates that casks closed entirely by welding do not require seal monitoring. The MPC, which is the confinement system for the HI-STORM 100 System, is closed using a welded seal. As a result, the staff finds the applicant proposal not to provide monitoring of the confinement barrier for the HI-STORM 100 System acceptable because the casks will be loaded, welded, inspected, and tested in accordance with appropriate procedures. The NRC staff of the Spent Fuel Project Office has issued Interim Staff Guidance document ISG-18, which also addresses welded steel canisters, including the Holtec HI-STORM 100 MPCs. In ISG-18, the staff concludes that there is reasonable assurance that no credible leakage would occur from final closure welds of austenitic stainless steel canisters.

15.1.2.14 Loading of an Unauthorized Fuel Assembly

Section 8.2.9 of the ISFSI SAR indicates that loading of an unauthorized fuel assembly into the MPC will not occur because of the Technical Specifications and administrative procedures that will be implemented during loading operations. The Technical Specifications and administrative procedures are discussed in Chapters 10 and 16 of this SER.

15.1.2.15 Partial Blockage of Multi-Purpose Canister Vent Holes

Section 8.2.13 of the SAR evaluates the potential consequences of the partial blockage of the MPC vent holes. The potential consequences of this postulated accident were determined by assuming that only the minimum semicircular area of the vents are credited in the thermal models. The staff previously determined that the methodology used to assess this postulated accident is acceptable and partial blockage of the MPC vent holes has no effect on the structural, confinement, and thermal analyses of the MPC so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI.

15.1.2.16 100-Percent Fuel Rod Rupture

Section 8.2.14 of the ISFSI SAR evaluates the potential consequences of 100-percent fuel rod rupture within the MPC. The potential consequences of this postulated accident were determined by assuming that the fission-product gases and fill gas are released from the fuel rods into the MPC cavity. The staff has previously determined that the methodology used to assess this postulated accident is acceptable and 100-percent fuel rod rupture within the MPC has no effect on the shielding, criticality, and thermal analyses of the MPC so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI.

15.1.2.17 Transmission Tower Collapse

Section 8.2.16 of the ISFSI SAR addresses the potential collapse of two 500-kV transmission towers that are in the vicinity of the ISFSI storage area and the CTF. The transporter will be designed to protect the transfer cask from the direct impact of a collapsing tower. As a result, an analysis of a transmission tower collapsing on the loaded HI-TRAC 125 Transfer Cask is not necessary.

Two tower-collapse scenarios were evaluated (Holtec International, 2001f). The first scenario was a tower collapse onto the CTF, with the tower directly impacting the lid of an MPC, which has been lowered into the HI-STORM 100 System storage overpack located within the confines of the CTF shell. The second scenario was a tower collapse onto a HI-STORM 100SA storage cask anchored to the ISFSI storage area pad.

Using an explicit finite element modeling method, PG&E determined that the maximum impact force on the MPC lid was 1.9 MN [427 kips], and for the anchored HI-STORM 100SA storage cask, 2.4 MN [534 kips]. In the case of the MPC lid, this impact force is bounded by previously evaluated tornado missile impact loads, as approved by the staff for the HI-STORM 100 system (U.S. Nuclear Regulatory Commission, 2002a,b). For the anchored HI-STORM 100SA storage cask, the impact force is predominantly oriented in the vertical direction. The horizontal component of the tower collapse impact force on the anchored HI-STORM 100SA storage cask, 0.4 MN [93 kips], is bounded by previously evaluated tornado missile impact loads approved by the staff for the HI-STORM 100 system. The vertical component of the tower collapse impact force on the anchored HI-STORM 100 SA storage cask, when converted into an equivalent gravity load, is also bounded by the previously reviewed and accepted equivalent gravity load for a cask drop (i.e., 45 g).

Even though an analysis of a collapsing tower impact with the HI-TRAC 125 Transfer Cask was not performed, the potential impact forces would be similar to those calculated for the MPC and anchored HI-STORM 100SA storage cask. Because these impact loads are bounded by previously reviewed and accepted loading conditions for the HI-STORM 100 system, the staff has determined that a separate analysis is not needed.

15.1.2.18 Nonstructural Failure of a Cask Transfer Facility Lift Jack

Section 8.2.17 of the ISFSI SAR evaluates a postulated failure of a CTF lift jack. The CTF lifting mechanism is configured with three lifting jacks, and the postulated lift jack failure evaluation assumes that only one of these will fail at any given time. If the failed mechanism cannot be repaired within 22 hours, (which corresponds to the time determined by analysis for the short-term fuel cladding temperature limits to be reached due to the diminished convective cooling efficiency of the HI-STORM 100SA storage cask when located within the CTF), the MPC will be returned to the HI-TRAC 125 Transfer Cask and the storage cask removed from the CTF so the necessary repairs can be made. This will be a requirement of the Diablo Canyon ISFSI Technical Specifications.

The design of the CTF lifting mechanism is such that the three lifting jack power screws are always loaded in tension. Because of this tension loading-only design feature, buckling failure of the lifting jack power screws, either singly or in combination, is unlikely.

15.1.2.19 Accidents Associated with Pool Facilities

The proposed ISFSI will use dry storage technology only; there will be no pool at the proposed ISFSI. Therefore, accidents associated with pool facilities are not applicable for the Diablo Canyon ISFSI.

15.1.2.20 Building Structural Failure and Collapse onto Structures, Systems, and Components

Section 4.4.5 of the ISFSI SAR evaluates the CTF for response to the design criteria identified in Chapter 3, "Principal Design Criteria" of the SAR. The CTF is designed to survive these events. (See also SER Section 15.2.2.18, "Transmission Tower Collapse"). Therefore, an accident involving structural failure of the facility is not applicable.

15.1.2.21 Hypothetical Failure of the Confinement Boundary

The HI-STORM 100 System MPC is a seal-welded pressure vessel, designed, fabricated, and tested in accordance with ASME Code requirements and acceptable alternative methods, as described in the ISFSI SAR. The MPCs have redundant welds to ensure that radioactive fuel is confined. The ISFSI SAR and HI-STORM 100 System FSAR have demonstrated that the MPC would maintain its integrity and the fuel would be adequately protected under site-specific and generic design-basis normal, off-normal, and accident conditions. As discussed in Chapter 9 of this SER, the dose (at the owner-controlled area boundary) calculated from a hypothetical failure of the confinement boundary is below the dose limit specified in 10 CFR §72.106(b).

15.2 Evaluation Findings

The applicant has provided acceptable analyses of the design and performance of SSCs important to safety under credible off-normal events and accident scenarios. The following summarizes the findings of the staff that pertain to the off-normal event and accident review.

<u>Off-Normal Events</u>

PG&E has committed to design the cask transporter so it will have redundant drop protection features and will conform to the requirements of NUREG–0612 (U.S. Nuclear Regulatory Commission, 1980), American National Standards Institute (ANSI) N14.6 (American National Standards Institute, 1993), and ASME B30.9-1996 (ASME International, 1996). The staff previously determined that a specific limit on cask lift height during transfers between the FHB/AB, CTF, and the storage pads is not necessary if these cask transporter design requirements are met (U.S. Nuclear Regulatory Commission, 2002a). As a result, an evaluation of a cask drop less than the design allowable height is not required.

The staff has previously determined that the HI-STORM 100 System storage cask provides adequate heat removal capacity under partial vent blockage conditions so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,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 staff finds that the Diablo Canyon ISFSI Technical Specifications will impose appropriate limits and that the environmental characteristics of the ISFSI site are within the corresponding design criteria, such that the staff's previous conclusions for the Holtec HI-STORM 100 system are also applicable to the Diablo Canyon ISFSI. In addition, the Diablo Canyon ISFSI Technical Specifications include 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). In the event that the HI-STORM 100SA storage cask air inlet ducts are found to be partially blocked, the blockage will be removed within one operating shift.

The staff finds that there is reasonable assurance that important to safety functions will not be affected for the proposed cask system or the proposed ISFSI due to failure of instrumentation.

The staff finds that potential vehicular impact will not impair the ability of the SSCs to maintain subcriticality, confinement, and sufficient shielding of the stored fuel.

The staff finds that the applicant's evaluation of loss of electrical power as an off-normal event is acceptable and concludes that there is reasonable assurance that Diablo Canyon ISFSI operations can be conducted without endangering the health and safety of the public.

The staff finds that the applicant's assessment of cask transporter off-normal operation is acceptable and concludes that there is reasonable assurance that Diablo Canyon ISFSI operations can be conducted without endangering the health and safety of the public.

The staff previously determined that the HI-STORM 100SA storage and HI-TRAC 125 Transfer Casks provide adequate heat removal capacity during off-normal ambient temperature conditions so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI.

The staff previously determined that the methodology used to assess off-normal pressure within the MPC is acceptable and that there are no consequences that affect the public health and safety so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI.

Accidents

The staff has previously determined that cask tip-over events need not be considered if the storage cask anchorage system and the storage pad are sufficiently designed to preclude such an event (U.S. Nuclear Regulatory Commission, 2002a,b). The staff finds that the design of the storage pads and cask anchorage system for the Diablo Canyon ISFSI is acceptable, and is sufficient to prevent a cask tip-over accident for the spectrum of seismic events evaluated for the site. The staff's structural evaluation of the pad and cask anchorage system can be found in Section 5.1.3 of this SER.

PG&E has committed to design the cask transporter such that it will have redundant drop protection features and conform to the criteria of NUREG–0612 (U.S. Nuclear Regulatory Commission, 1980), ANSI N14.6 (American National Standards Institute, 1993), and ASME B30.9-1996 (ASME International, 1996). The staff previously determined that a specific limit on cask lift height during transfers between the FHB/AB, CTF, and the storage pads is not necessary if these cask transporter design requirements are met (U.S. Nuclear Regulatory Commission, 2002a). As a result, an evaluation of a cask drop is not required.

The staff finds that the information provided by the applicant is sufficient to characterize flooding as a noncredible accident at the Diablo Canyon ISFSI. As discussed in Section 2.1.4, "Surface Hydrology," of this SER, PG&E has adequately demonstrated that local natural and man-made drainage systems are sufficient to prevent flooding of the ISFSI pad site and CTF.

The staff reviewed the information provided by the applicant regarding potential fire and explosion hazards at the proposed facility. The staff finds that the design basis parameters for all credible on-site fire and explosion hazards will not be exceeded and that the SSCs will meet all subcriticality, confinement, and shielding requirements for the stored fuel.

The staff concludes that earthquake-induced damage of the spent fuel while in transit from the power plant to the CTF is not a credible hazard, based on the low probability of the event and the limited frequency and duration of the transfers.

The staff finds that the design of the CTF concrete structure and its reinforcement satisfies the applicable codes and standards for all design basis accident loads.

The staff finds that the design basis loading conditions for the Diablo Canyon ISFSI are enveloped by the loading conditions considered in the HI-STORM 100 System FSAR (Holtec International, 2002). As documented in the HI-STORM 100 System SER, the structural analysis shows that the structural integrity of the HI-STORM 100 System is maintained during all credible loads. Based on the results presented in the HI-STORM 100 System FSAR, the stresses in the storage cask and anchorage structures during the most critical load combinations are less than the allowable stresses of ASME Boiler and Pressure Vessel Code, Section III (ASME International, 1995b) for the materials to be used.

The staff finds that the Diablo Canyon ISFSI storage cask anchorage system was designed to meet the ductile anchorage provision of the proposed Draft Appendix B for ACI 349-97 for the most critical load combinations.

The staff previously determined that the methodology used to assess the loss of neutron shielding accident is acceptable and the short-term fuel cladding and other component temperature limits, the MPC accident internal pressure, and the accident dose limits defined by 10 CFR §72.106 are not exceeded so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusions for the Holtec HI-STORM 100 system are applicable to the Diablo Canyon ISFSI. In the event that the HI-TRAC 125 Transfer Cask loses its neutron shielding, appropriate recovery operation procedures will be implemented.

The staff finds that the maximum reduction in ISFSI radiation shielding thickness, material shielding effectiveness, or loss of temporary shielding in all possible shielding areas caused by postulated on-site explosion events has been adequately evaluated by the applicant. Therefore, the information and analysis presented by the applicant provide reasonable assurance that the dose to any individual beyond the owner-controlled area will not exceed the limits specified in 10 CFR §72.106(b) and the occupational exposures from accident recovery operations will not exceed the limits specified in 10 CFR Part 20.

The HI-STORM 100 System FSAR (Holtec International, 2002, Figure 11.2.6) indicates that a total cask decay heat load of 30 kW [102,360 BTU/hr], which bounds the cask decay heat load specified for the Diablo Canyon ISFSI, will not cause the short-term cladding temperature limit for the spent nuclear fuel to be exceeded for 45 hours under adiabatic conditions. Moreover, the internal pressure limit for the MPC is not exceeded within the 45-hour timeframe for this condition. In the event that a HI-STORM 100 System storage cask is subjected to conditions that thermally insulate its exterior (e.g., encased within soil as the result of a landslide), appropriate recovery operation procedures will be implemented.

The staff previously determined that the methodology used to estimate the time required to reach the short-term, fuel-cladding temperature limit of spent nuclear fuel stored in the HI-STORM 100SA storage cask subjected to 100-percent blockage of the air inlet ducts is acceptable (U.S. Nuclear Regulatory Commission, 2002a,b). For the bounding values of decay heat load of 30 kW [102,360 BTU/hr] and insolation of 834 w/m^2 [800 $g\text{-}cal/cm^2$] per day {387 W/m^2 [123 $BTU/hr\text{-}ft^2$]}, the short-term cladding temperature limit for the spent nuclear fuel will not be exceeded for 72 hr when the HI-STORM 100SA storage cask air inlet ducts are 100-percent blocked. Moreover, the internal pressure limit for the MPC is not exceeded within the 72-hour time frame for this condition. Furthermore, the Diablo Canyon ISFSI Technical Specifications 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). In the event that the HI-STORM 100SA storage cask air inlet ducts are found to be 100-percent blocked, appropriate recovery operation procedures will be implemented.

The staff reviewed the information provided by the applicant, evaluated the analyses of potential hazards from design-basis tornadoes and tornado missiles at the proposed facility, and conducted a confirmatory analysis. The staff concludes that a tornado or tornado-generated missile would not impair the ability of the SSCs to maintain subcriticality, confinement, and sufficient shielding of the stored fuel.

The staff finds that the applicant has adequately demonstrated that the cumulative probability of occurrence of civilian and military aircraft crashes, and ordnance accidents is below the threshold probability criterion of 1×10^{-6} crashes per year. As a result, the staff concludes that civilian and military aircraft crashes, and ordnance accidents at the Diablo Canyon ISFSI are not credible events and require no further evaluation.

The staff finds with reasonable assurance that different missile tests and potential space shuttle landings at Vandenberg Air Force Base will not pose a hazard to the proposed facility because: (1) the selected flight paths are away from the proposed ISFSI site, and (2) several low-probability events would need to occur before a missile or the space shuttle would hit the proposed ISFSI.

The staff has previously determined that the methodology used to assess leakage through the confinement boundary is acceptable and that there are no consequences that affect the public health and safety so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI. Moreover, NUREG–1536 (U.S.

Nuclear Regulatory Commission, 1997, Chapter 7, Section V.2) indicates that casks closed entirely by welding do not require seal monitoring. The MPC, which is the confinement system for the HI-STORM 100 System, is closed using a welded seal. As a result, the staff finds the applicant's proposal not to provide monitoring of the confinement barrier for the HI-STORM 100 System acceptable because the casks will be loaded, welded, inspected, and tested in accordance with appropriate procedures.

Section 8.2.9 of the SAR (Pacific Gas and Electric Company, 2003) indicates that an unauthorized fuel assembly will not be loaded into the MPC because of the technical specifications and administrative procedures that will be implemented during loading operations. These technical specifications and administrative procedures are discussed in Chapters 10 and 16 of this SER.

The staff previously determined that the methodology used to assess partial blockage of the MPC vent holes is acceptable and this postulated accident has no effect on the structural, confinement, and thermal analyses of the MPC so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI.

The staff previously determined that the methodology used to assess the potential consequences of a 100-percent fuel rod rupture within the MPC is acceptable and this postulated accident has no effect on the shielding, criticality, and thermal analyses of the MPC so long as the fuel specifications and loading conditions as defined in the HI-STORM 100 System CoC and SER (U.S. Nuclear Regulatory Commission, 2002a,b) are met. The staff finds that the Diablo Canyon ISFSI Technical Specifications will impose similar and appropriate limits and conditions so that the staff's previous conclusion for the Holtec HI-STORM 100 system is applicable to the Diablo Canyon ISFSI.

The staff finds that the impact loads associated with the two postulated tower-collapse scenarios are bounded by previously reviewed and accepted loading conditions (U.S. Nuclear Regulatory Commission, 2002a,b).

The design of the CTF lifting mechanism is such that the three lifting jack power screws are always loaded in tension. Because of this tension loading-only design feature, the staff find that a buckling failure of the lifting jack power screws, either singly or in combination, would not occur.

The staff finds, based on information provided by the applicant, that an accident involving structural failure of the facility is not applicable.

Based on the information provided, the staff finds that a postulated failure of the confinement boundary would result in offsite accident doses below the dose limits specified in 10 CFR §72.106(b) because the HI-STORM 100 System MPC is a seal-welded pressure vessel, designed, fabricated, and tested in accordance with the applicable codes and standards.

In summary, the PG&E analyses of off-normal and accident events demonstrate that the proposed Diablo Canyon ISFSI will be sited, designed, constructed, and operated so that during all credible off-normal and accident events, public health and safety will be adequately protected. Based on analyses submitted by the applicant and independent confirmatory analyses performed by the staff, the staff finds that the proposed ISFSI will maintain subcriticality, maintain confinement, and provide sufficient shielding for all credible off-normal events and accident scenarios consistent with the requirements of 10 CFR §72.92, §72.94, §72.98(a), §72.98(b), §72.98(c) §72.102(f), §72.106(b), §72.122(b), §72.122(c), §72.122(h), §72.122(i), §72.122(l), §72.124(a), and §72.128(a)(2).

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