PG&E Response to Request for Additional Information For Diablo Canyon Independent Spent Fuel Storage Installation (ISFSI) License Application

Chapter 1. Introduction and General Description

The staff had no comments regarding the general description of the proposed Diablo Canyon ISFSI.

Chapter 2. Site Characteristics

<u>*Question 2-1*</u>

Identify all sources of information used in the aircraft crash hazard analysis to support an evaluation of whether an aircraft crash is a credible hazard to the proposed facility.

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

<u>PG&E Response to Question 2-1</u>

The following are the sources of information for the aircraft crash hazards analysis:

Air Traffic Information	Source	Phone
On federal routes V-27	Terry Kristansen FAA Standards Office Operations	408-291-7681
At San Luis Obispo (SLO) Airport	Martin Pehi Airport Manager SLO Airport	805-781-5205
At Oceano Airport	Martin Pehi Airport Manager Oceano Airport	805-788-2319
Air travel routes and distances from DCPP	Los Angeles Sectional Aeronautical Chart circ. 09/2001	N/A
Military Traffic on VR-249	Controlling Agency, USMC GySgt Campos	858-577-7237
Ordinance on Military aircraft using VR-249	Naval Air Station - Lemoore Public Information Officer	805-998-3394

Question 2-2

Provide the calendar year for the flight statistics (for each flight corridor) used to support the evaluation of the aircraft crash hazard analysis.

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

PG&E Response to Question 2-2

The flight information was based on year-2001 information for federal corridors. VR-249 flight information was for the period of September 2001 to September 2002.

Question 2-3

Provide technical bases for the estimated effective area of the facility for all aircraft types, as given in the Diablo Canyon ISFSI Safety Analysis Report. The technical bases should be consistent with the established methodologies for estimating the effective area of a given facility for a given aircraft, for example, Section 3.5.1.6 of NUREG–0800 (NRC, 1987), or any other standards.

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

PG&E Response to Question 2-3

Refer to SAR Section 2.2.1.3, Amendment 1, for the bases for the estimated effective area of the facility for all aircraft types.

Question 2-4

Provide technical bases for the crash rate value (C), for each type of aircraft used in the Diablo Canyon ISFSI Safety Analysis Report. The technical bases should follow from an accepted methodology, such as the one documented in NUREG–0800 (NRC, 1987b).

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

PG&E Response to Question 2-4

Refer to SAR Section 2.2.1.3, Amendment 1, for the technical bases for the crash rate value for each type of aircraft used in the SAR.

Question 2-5

Provide reasonable estimates for future aircraft activities in the vicinity of the proposed ISFSI facility and an estimate of the cumulative crash hazard of all types of aircraft that may fly in the vicinity of the proposed site. These analyses should follow an established methodology, such as the one documented in NUREG–0800 (NRC, 1987).

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

PG&E Response to Question 2-5

PG&E estimates the projected growth of civilian flights based on Federal Aviation Administration (FAA) long-range forecast (FAA, 1999). Commercial aircraft operations include air carriers and commuter/air taxi takeoff and landings at all US towered and non-towered airports. Based on the FAA forecasts, the commercial aircraft operations are projected to increase from 28.6 million in 1998 to 47.6 million in 2025. That results in a projected increase of 66 percent by 2025.

In addition, the annual number of general aviation operations at all towered and non-towered airports in the US is projected by the FAA to increase from 87.4 million in 1998 to 99.2 million in 2025. That results in a projected increase of 14 percent by 2025.

Based on the above potential increases in traffic, the crash probability for local traffic on VR-27 would increase to 1.185×10^{-7} and for commercial traffic not landing locally to 1.3237×10^{-8} by the year 2025.

The FAA also predicts that the military traffic will not increase appreciably, if at all, in the foreseeable future. As a result the probability of a crash on VR 249 will remain at 5.6×10^{-8}.

Based on the FAA projections, the cumulative aircraft crash probabilities increases to 1.88×10^{-7} in 2025, which is still less than the threshold of 1×10^{-6} specified in DOE-STD-3014-96 as an acceptable frequency for impact into the facility from all types of aircraft.

Question 2-6

Provide information describing the (i) type of activities carried out by military aircraft in the vicinity of the proposed facility; (ii) possible ordnance carried by military aircraft, if any; and (iii) any potential hazard from the ordnance of these aircraft.

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

<u>PG&E Response to Question 2-6</u>

Refer to SAR Section 2.2.1.3, Amendment 1, for a description of the type of activities carried out by military aircraft in the vicinity of the proposed facility, possible ordinance carried out by military aircraft, and any potential hazard from the ordinance of these aircraft.

<u>Question 2-7</u>

Provide additional information to determine whether missile tests at Vandenberg Air Force Base could be a credible hazard to the proposed facility. This information should account for the number, type(s), and paths of missiles being tested in a year and describe the safety precautions to be implemented prior to and during tests.

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), and §72.94(c).

<u>PG&E Response to Question 2-7</u>

Mr. Ron Cortopassi, Vandenberg Air Force Base Chief Safety Engineer, indicated that there are 15 to 20 missiles fired per year and that currently, missions are flown in a range varying from due west to south easterly direction, depending upon launch site and mission. Vandenberg's Intercontinental ballistic missile tests launch from sites on north base, and typically fly due west. Vandenberg Air Force Base's spacelift missions typically launch from sites on the southern part of the base, and fly in a southerly direction. Polar orbit launches are in a southerly direction. There is a potential for missions in the future to fly in a north westerly direction, but Vandenberg Air Force Base will have safeguards in place to ensure there is no potential for the missile to impact on land outside of Vandenberg Air Force Base's boundary (same techniques used to protect the cities of Lompoc, Santa Barbara, etc.). Mr. Cortopassi also indicated that Vandenberg Air Force Base's most northerly missile launch site is approximately 25 miles south of the DCPP site and that Vandenberg Air Force Base is a designated alternate landing site for the space shuttles, but has not been used for that purpose to date.

The DCPP FSAR Update, Section 3.5.1.4 states that in the event that a launched missile deviates from the intended trajectory, it is destroyed. Discussions with representatives of Vandenberg Air Force Base indicate that very few missiles deviate from the planned flight plan. Missiles that deviate are destroyed before the debris path would exceed a narrow preplanned window. Consequently, the probability of missiles originating from this source striking safety-related structures or components on the site is extremely small.

<u>*Question 2-8*</u>

Provide information on potential accidents at nearby facilities and transportation routes, as described in NUREG–1567 (NRC, 2000). No information is given in the Safety Analysis Report as to why potential accidents at the Diablo Canyon Power Plant or on nearby transportation routes would not present a credible hazard to the proposed ISFSI.

This information is necessary to determine compliance with 10 CFR §72.94(a), §72.94(b), §72.94(c), and §72.98(a).

<u>PG&E Response to Question 2-8</u>

Diablo Canyon ISFSI SAR Section 2.2.1 describes offsite potential hazards. SAR Section 2.2.1.2 demonstrates that there is no hazard from offsite facilities and transportation. SAR Section 2.2.1.3 evaluates aircraft hazards and concludes that the total aircraft hazard probability meets NRC guidance. SAR Section 2.2.2 describes potential onsite hazards. Onsite hazards are evaluated in SAR Section 8.2 and are concluded as meeting NRC guidance. As summarized in these SAR sections, there are no credible accident scenarios involving any onsite or offsite industrial, transportation, or military facilities in the area around the DCPP site that will have any significant inverse impact on the ISFSI. This information includes the potential hazards at the DCPP facility as the transportation of the spent fuel to the ISFSI is initiated within the DCPP facility.

See also the response to RAI 2-10.

<u>*Question 2-9*</u>

Provide information and analysis to determine whether any sharing of utilities and services between the proposed ISFSI and the existing nuclear power plant increases the probability or consequences of an accident or possible malfunction of structures, systems, or components important to safety, or reduces the safety margin for any technical specification of either facility.

This information is necessary to determine compliance with 10 CFR §72.122(k)(4).

<u>PG&E Response to Question 2-9</u>

As indicated in the response RAI 2-11, there are no important-to-safety systems that are shared with the Diablo Canyon Power Plant.

Question 2-10

Provide information and analysis to ensure that the cumulative effects of the combined operations of the proposed ISFSI facility and existing nuclear power plant will not constitute an unreasonable risk to the health and safety of the public.

This information is necessary to determine compliance with 10 CFR §72.122(e).

PG&E Response to Question 2-10

The Diablo Canyon ISFSI is co-located with the DCPP as discussed in SAR Section 2.1.1 and as shown on Figures 2.1-2. The design and analysis of the ISFSI considered the hazards to the ISFSI from plant operations and equipment including the transmission lines. SAR Section 2.2.2 discusses on-site potential hazards. SAR Sections 8.2.5, 8.2.6 and 8.2.16 analyzed accidents from onsite hazards.

An accident at DCPP involving radiological releases could temporarily require evacuation of personnel from the ISFSI. There are no active equipment or systems at the ISFSI which require personnel to be in attendance. The only surveillance required at the ISFSI is monitoring of the cask air vents once per 24 hours. Any evacuation of ISFSI personnel would be temporary. The simultaneous blockage of two of the four air vents on one cask coincident with a radiological accident at DCPP requiring evacuation of ISFSI personnel is not considered credible.

SAR Section 7.4 provides estimated exposures to onsite personnel from normal ISFSI fuel handling operations. SAR Sections 7.5, 8.2.7, and 8.2.11 provide estimated exposures from ISFSI accidents.

SAR Section 7.5.4 provides the total collective dose from combined ISFSI and DCPP operations.

Therefore the above Diablo Canyon ISFSI SAR sections demonstrate that there will be no undue risk to the public health and safety from combined ISFSI and DCPP operations.

Question 2-11

Provide information to show that any of the ISFSI structures, systems, and components important to safety that would be shared with the nuclear power plant will not impair the capability of either facility to perform its safety function, including the ability to return to a safe condition in the event of an accident.

This information is necessary to determine compliance with 10 CFR §72.122(d).

PG&E Response to Question 2-11

SAR Table 4.2-5 indicates that SAR Section 1.2 discusses the shared SSCs between Diablo Canyon ISFSI and DCPP and indicates that no safety-related services are shared. Refer to attached SAR Table 4.2-5, Amendment 1, for a revision that explicitly states that no important-to-safety SSCs are shared between the ISFSI and DCPP. Also, refer to attached SAR Section 1.2, Amendment 1, for a revision that contains a more explicit discussion that no important-to-safety equipment is shared between the ISFSI and DCPP.

Question 2-12

Provide clarification of the precipitation data presented in Subsections 2.3.1 and 2.3.2 of the Diablo Canyon ISFSI Safety Analysis Report.

Specifically address whether the maximum hourly amount of precipitation recorded in the Diablo Canyon area was 5.97 cm [2.35 in] or 8.33 cm [3.28 in]. Similarly, address whether the maximum amount of precipitation in a 24-hr period was 8.33 cm [3.28 in] or 15.19 cm [5.98 in]. Provide the average annual precipitation that is more appropriate for the ISFSI site, either the average annual precipitation of 40.64 cm [16 in] reported for the "area" or the 54.69 cm [21.53 in] reported for San Luis Obispo.

NUREG–1567 (Section 2.4.3.1) states that the applicant must provide precipitation extremes for the region.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.90(a), §72.90(b), §72.92(a), §72.92(b), §72.98(a), and §72.122(a).

PG&E Response to Question 2-12

SAR Section 2.3.1 contained an error. SAR Section 2.3.1 has been revised, and now states that the maximum recorded amount of precipitation in 24 hours in San Luis Obispo was 5.98 inches. SAR Section 2.3.2 has also been clarified and now states that the average annual precipitation at the DCPP site is approximately 16 inches. Refer to the ISFSI SAR, Amendment 1, for revised SAR Sections 2.3.1 and 2.3.2.

Question 2-13

Provide the data source for the precipitation data presented in Sections 2.3.1 and 2.3.2 of the Diablo Canyon ISFSI Safety Analysis Report.

NUREG–1567 (Section 2.4.3.1) states that the applicant should discuss data sources and reliability.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.90(a), §72.90(b), §72.92(a), §72.92(b), §72.98(a), and §72.122(a).Question 1

PG&E Response to Question 2-13

The precipitation data presented in ISFSI SAR Sections 2.3.1 and 2.3.2 was obtained from the DCPP Units 1 & 2 FSAR Update Section 2.3.1.3 and 2.3.2.2.4, respectively.

Question 2-14

Provide the data and analyses used to support the statement that a maximum tsunami would not cause any flooding at the ISFSI site.

NUREG–1567 (Section 2.4.4.6) states that the applicant should analyze the history of tsunami in the region. The analysis should include all potential tsunami generators, such as specific faults, fault zones, volcanoes, and potential landslide areas.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.90(a), §72.90(b), §72.92(a), §72.92(b), §72.98(a), and §72.122(a).

PG&E Response to Question 2-14

Introduction

The data and analysis used to support the statement that a maximum tsunami would not cause any flooding at the ISFSI site are from the DCPP FSAR Update (Reference 1). The maximum combined wave runup from a distantly generated tsunami is 30 ft (9.1 meters) (DCPP FSAR Update, Section 2.4.6.1.3), and the maximum combined wave runup for near shore tsunamis is 34.6 ft (10.5 meters) relative to a mean lower low water (MLLW) reference datum (DCPP FSAR Update, Section 2.4.6.1.4). This is significantly lower than the elevation of the Diablo Canyon ISFSI site at 310 ft (~94.5 meters) above mean sea level (MSL) (312.6 ft, 95.3 meters above MLLW) or the Transporter route at 80 ft (~24.4 meters) above MSL.

Little new offshore geologic or geophysical data for central coastal California has been gathered since the studies conducted in the 1970s by USGS/BLM for offshore oil lease sales (Reference 2) and in the 1980s by PG&E for the DCPP licensing (Reference 3). Over the last several years, however, more information about the occurrence and generation of tsunamis in other parts of California and the world has become available. This response reviews this new information and discusses these results in the context of the Diablo Canyon ISFSI licensing application. It should be noted that the information presented below does not include storm surge, storm waves or tides.

Worldwide Tsunami Data

Plafker (Reference 4) reviewed tsunami data for post-1943 earthquakes worldwide and developed empirical relationships to assess maximum runup heights for near source tsunamis. The results are illustrated in his Figure 1, which is reproduced herein (Figure RAI 2-14-1). The main conclusions of that review are:

- For the majority of tsunamigenic earthquakes, the associated tsunamis are generated by large-scale coseismic vertical displacements of the seafloor associated with thrust faulting. Maximum tsunami run-up scales with both the average fault slip and the vertical component of slip for tectonic tsunamis (not complicated by landslides, unusual bathymetry, or irregular configurations of the coast). Maximum runups range from about 1 meter for M 7.2 earthquakes to 15 meters for M 9.5 events (Figure RAI 2-14-1).

- The 1998 Aitape event (#37 in Figure RAI 2-14-1) produced a 15 meter tsunami, but it is considered by Plafker (Reference 4) to have unusual geology that allowed for a larger than usual landslide.

- Strike slip earthquakes produce predominately horizontal tectonic displacements and are inefficient generators of tsunamis. Only two strike slip tsunami earthquakes are shown in Figure RAI 2-14-1. Runups from tsunamis generated during the1999 Mw 7.1 Izmet, Turkey earthquake (not included in Figure RAI 2-14-1, maximum runup – 2.6 meters) were half the amount of horizontal fault displacement (4.2 meters). The 1906 Mw 7.8 San Francisco earthquake (not included in Figure RAI 2-14-1) produced small tsunamis of less than 1 meter near San Francisco (Reference 5).

- Tsunamis associated with those strike slip events in Figure RAI 2-14-1 that are comparable in size to the Hosgri Design Earthquake (#36 - 1994 Mindoro Is Mw 7.1; #29 - 2002 New Guinea Mw 7.6) have been primarily generated by earthquake triggered sub-marine landslides rather than tectonic displacements.

- Geologic factors that that may control the susceptibility of earthquake-triggered sub-marine landsliding include:

  (1) Steep sub-marine slope

  (2) Availability of thick sediment accumulation (e.g., deltas, glacial margins and offshore basins)

  (3) Earthquake size and duration (larger events exhibit a longer duration of shaking and higher peak accelerations which tend to cause landslides with larger displacements)

(4) Frequency of large earthquakes (frequent events appear to keep potential landslide slopes 'clean', so only some events trigger landslides).

(5) Occurrence of zones of structural weakness in the bedrock below moderate to steep sub-marine slopes

(6) Presence of high fluid pressure in unconsolidated sedimentary strata. This can be caused by accumulation of clathrates and gas, or sandy materials that can liquefy during earthquakes.

Estimates of Tsunamis Offshore of California

TIME (Tsunami Inundation Mapping Efforts) maps

- Current systematic coastal mapping by the California Governor's Office of Emergency Services (OES) as part of the National Tsunami Hazard Mitigation Program is based on potential earthquake sources and hypothetical extreme undersea, near shore landslide events (Reference 13).
- See http://www.pmel.noaa.gov/tsunami/time/ca/index.shtml for current status of mapping efforts. No maps are currently available for the central coast of California.
- Maximum runup to a specific contour (9.8 m (32 ft) in the Santa Barbara area and 12.8 m (42 ft) in the San Francisco, Los Angeles, and San Diego areas was determined by OES to be a reasonable representation of the "worst case scenario" based on limited historic records and estimates of landslide hazards. These maps are to be used for evacuation proposes only and are not to be considered official State maps for land use planning.

Central Coastal California

Historic Tsunamis - The area offshore of central California in the vicinity of DCPP contains both strike slip and thrust type faulting and has experienced one locally generated tsunami in historic time (1927 M_w 7.0 Lompoc earthquake). This thrust event, located 40 km west of Point Conception (References 10 and 11) produced local runups at Surf and Port San Luis that ranged from 4 to 6 ft (1.2 to 1.8 meters) (Reference 5).

Subaerial Landslides – The coast of central California near Diablo Canyon between Point Arguello, 75 km to the south of the DCPP, and north of San Simeon, 65 km to the north of the DCPP, is not a potential source to generate large subaerial landslides because the coast is bordered by wide terraces and alluvial filled valleys and does not have steep slopes adjacent to the sea. Moreover the detailed geomorphic analysis of the coast done for the PG&E Long Term Seismic Program (Reference 3) did not discover any large landslides. The steep coast at Big Sur has the potential for large rockslides to fall directly into the ocean, but these would be far enough away (> 65 km) that any tsunami would attenuate and not be significant in the Diablo Canyon area.

Sub-marine Landslides – Sub-marine landslides could form in deltas or other areas of sediment accumulation on the continental shelf or the continental slope.

Continental Shelf - Between north of San Simeon and Point Arguello the continental shelf is 55 kilometers wide and generally flat, with an average dip of less than 1 degree. Local relief on the shelf is spatially limited and hence is not a credible source for large, catastrophic landslides. Several small, possible landslides have been mapped. These are discussed below:

McCulloch et al. (Reference 2) map three areas as sub-marine landslides along the eastern side of the Santa Maria basin (SW of Pt. San Luis). These slides cover areas of approximately 125 km^2, 40 km^2 and 8.5 km^2 and are described as being "... composed of discreet blocks of sediment that have been rotated downward at their up-slope edges along a slip surface. The slip surface merges downward with unbroken seismic reflectors that parallel the general slope of the seafloor. The slide geometry suggests progressive slumping along a buried failure zone or surface." These features appear as a series of many, small imbricated slumps (rather than a large single slump) on seismic reflection profiles.

The mapped landslide zones in McCulloch et al. (Reference 2) occur within an area of muddy sediment (mixture of silt and clay) (Reference 14) that is associated with continuous gas-charged reflectors. These gas-charged reflectors are generally shallow (greater than 30 m) and lie at, or near, the base of unconsolidated Quaternary sediments. McCulloch et al. (Reference 2) and others suggest that gas within the sediments may be a contributing factor to sediment instability. The presence of gas in sediments can lead to liquefaction type failure in response to earthquake ground shaking.

Our analysis of the seismic records collected offshore DCPP indicates that these 'slides' have neither a clearly defined head scarp nor an accumulation of sediments at the toe. Ship tracklines in this area are typically 3 to 5 km apart, and are sufficiently close to identify any major topographic or bathymetric feature on the sea floor. Comparison of available marine geophysical data offshore DCPP with similar features observed elsewhere along coastal California is useful for inferring the genesis and significance of these bathymetric features. 3.5 kHz seismic reflection profiles do show ridge and swale topography along the continental slope and gully-type topography near the head of the mapped slide zone that is similar to those seen in studies of the Humboldt slide in the offshore Eel River basin (References 6 and 7). The Humboldt slide, which had originally been interpreted as a shallow sediment failure along rotated blocks (e.g. sub-marine landslide) by Field et al. (Reference 12) and Gardner et al. (Reference 6) has been recently reinterpreted as a series of sediment waves caused by turbidity currents (Reference 7) or internal tidal waves (Reference 8).

Deltaic Deposits - There are no areas of thick sediment accumulation in the Diablo Canyon area. No sub-marine deltas are evident at the mouths of the three largest rivers- the Santa Ynez, the Santa Maria, and the Arroyo Grande or the smaller streams – Pismo Creek and San Luis Obispo Creek. These rivers and streams discharge to the sea after depositing most of their sediments into basins that trap the sediments before reaching the coast. Hence, any sediment accumulations are not potential sources for significant tsunamis at Diablo Canyon.

Continental Slope - The continental slope is more than 55 km from the coast and has a shallow slope that averages about 6 degrees. No large landslides are known in the Diablo Canyon area. Potential tsunamis from landslides originating on the continental slope are estimated to be less than or equal to the DCPP design-basis tsunami.

Summary

- The maximum combined wave runup from a distantly generated tsunami is 30 ft (9.1 meters) (DCPP FSAR Update, Section 2.4.6.1.3), and the maximum combined wave runup for near shore tsunamis is 34.6 ft (10.5 meters) relative to MLLW reference datum (DCPP FSAR Update, Section 2.4.6.1.4). These runup heights are significantly lower than the elevation of the Diablo Canyon ISFSI site at 310 ft (~94.5 meters) above MSL (312.6 ft, 95.2 meters above MLLW) or the transporter route at 80 ft (~24.4 meters).

- Global comparison of earthquake related tsunamis indicate near shore runups due to tectonic displacement of less than a meter for a strike slip event comparable to a M 7.2 earthquake on the Hosgri fault. Modeling the Hosgri fault as an oblique slip event (DCPP FSAR Update, Section 2.4.6.1.2 and Reference 9) indicates that the maximum tsunami generated runup would be less than 3 meters.

- Coastal inundation mapping by the state of California along the coasts of southern California, San Francisco and Monterey Bay defines maximum runup zones between 9.8 and 12.8 meters. The central coast at Diablo Canyon has not been mapped at this time.

- No large subaerial landslides or high steep slopes that could generate landslides are evident along the coast for 65 km along either side of the DCPP. Therefore, no significant tsunamis can be generated by this mechanism.

- Earthquake triggered landslides can create larger than normal runups given the right conditions (e.g., steep slopes, and large sediment accumulations) as shown by worldwide data. In general, larger earthquakes produce larger landslides that produce larger tsunamis. For earthquakes in the magnitude range M_w 7 to 7.5, local landslide generated runups have generally been less than 5 to 10 meters (see Figure RAI 2-14-1).

- The continental slope offshore DCPP is not a likely area to generate large sub-marine landslides. No thick sequences of sediments, such as a delta, occur along this part of the coast. The existing mapped landslides most likely are not actual landslide features, but are similar to features that have been studied in detail offshore Eureka, CA. These features are interpreted to be a series of sediment waves caused by turbidity currents (Reference 7) or internal tidal waves (Reference 8). Similar types of features, which are present on the continental slope offshore DCPP, do not pose a tsunami threat to the DCPP.

- Regardless of the mechanism for producing the sub-marine topography offshore the DCPP, the overall potential for large landslides to be generated from the continental shelf is considered to be low. Even if these features are related to shallow slides, the movements are controlled and limited by the number and distribution of shear surfaces on a relatively shallow slope. Maximum vertical displacements are judged to be on the order of a few meters and maximum horizontal displacements may be a few hundred meters. It is judged that any associated tsunami caused by a near shore earthquake, or a landslide induced from a near shore earthquake would have runups less than the DCPP design basis tsunami described in DCPP FSAR Update, Section 2.4.6.1.

- The continental slope is more than 55 km from the coast and has a slope of about 6 degrees. No large landslides are known, but runups from any potential landslide-related tsunamis origination on the continental slope are estimated to be less than or equal to the DCPP design-basis tsunami.

Conclusion

Based on analysis of tsunami runups from the world-wide data, estimates of potential runups for southern California and the San Francisco Bay area, and our preliminary assessment of tectonic and landslide generated tsunamis for the central California coast at Diablo Canyon, it is judged that a runup from an earthquake on the Hosgri fault, runup from a distantly generated tsunami, and from an offshore landslide induced by an earthquake would be less than or equal to the DCPP design-basis tsunami and significantly below the elevation of the Diablo Canyon ISFSI site at 310 ft (~94.5 meters) above MSL and the transporter route at a minimum elevation of 80 ft (~24.4 meters).

References

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3. PG&E, Final report of the Diablo Canyon Long Term Seismic Program, 1988.

4. G. Plafker, Evaluation of the Tsunami Hazard at the Diablo Canyon Power Plant Site Based on Empirical Data from Tsunamigenic Earthquakes, report to PG&E Geosciences, 2002.

5. J. F. Lander, and P. A. Lockridge, United States Tsunamis (including United States Possessions) 1690-1988, US Dept of Commerce, Publication 41-2, Boulder CO, 1989.

6. J. V. Gardner, D. B. Prior, and M. E. Field, Humboldt Slide – A Large Shear-Dominated Retrogressive Slope Failure, Marine Geology, 154, 323-338, 1999.

7. H. J. Lee, J. P. M. Syvitki, G. Parker, D. Orange, J. Locat, W. E. H. Hutton, and J. Imran, Distinguishing Sediment Waves from Slope Failure Deposits: Field Examples, Including the 'Humboldt Slide' and Modeling Results, Marine Geology, in press, 2002.

8. D. A. Cacchione, L. F. Pratson, and A. S. Ogston, The Shaping of Continental Slopes by Internal Tides, Science, 296, 724-727, 2002.

9. L-S Hwang, A. F. H. Yuen, and M. Brandsma, Earthquake Generated Water Waves at the Diablo Canyon Power Plant (Part Two), Tetra Tech report No. TC-443-B, 1975.

10. D. V. Helmberger, P. G. Somerville and E. Garnero, , The Location and Source Parameters of the Lompoc, California Earthquake of 4 November 1927, Bull. Seismological Society of America, 82, 1678-1709, 1992.

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12. M. E. Field, S. H. Clark, Jr., and M. E. White, Geology and Geologic Hazards of the Offshore Eel River Basin, Northern California Continental Margin, U.S. Geological Survey Open File Report 80-1080, 1980.

13. TIME (Center for Tsunami Inundation Mapping Efforts), 2002, see http://www.pmel.noaa.gov/tsunami/time/ca/index.shtml, website visited on 10/11/2002.

14. E. E. Welday, and J. W. Williams, Offshore Surficial Geology of California, California Division of Mines and Geology Map Sheet 26, scale 1:500,000, 1975.

Question 2-15

Provide analysis to demonstrate the potential effects of a tsunami (either from an offshore earthquake or an earthquake-induced submarine landslide) on the stability of the Patton Cove landslide area. Resulting wave erosion could exacerbate slide potential at Patton Cove.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.90(a), §72.90(b), §72.92(a), §72.92(b), §72.98(a), and §72.122(a).

PG&E Response to Question 2-15

The Patton Cove landslide is described in SAR Section 2.6.1.12.1 and shown in SAR Figures 2.6-36 and 2.6-17a. It is further discussed in the response to RAI 2-17 and illustrated in more detail in Figures RAI 2-17-1, 2-17-2 and 2-17-3. As shown in these figures, the base of the slide is constrained by the wave-cut platform on Tertiary bedrock of claystone and siltstone that is at elevation 15 ft where it is exposed above Patton Cove (the SAR Figure 2.6-17a is approximate, Figures RAI 2-17-2 and 2-17-3 provide a more accurate depiction of the landslide). Large storm waves off shore typically reach heights of 21 to 22 ft, but in some years reach heights of 30 ft. Within Patton Cove these waves have eroded the toe of the slide somewhat since the slide was reactivated in early 1970. However, this wave erosion has caused only limited enlargement of the slide (discussed in RAI 2-17).

As discussed in SAR Section 8.2.3.1 and in DCPP FSAR Update Section 2.4.6.1, the maximum combined tsunami runup is 34.6 ft. Such waves, if they occur, will probably erode the toe of the slide, but this erosion is expected to be similar to that caused by storm waves. This erosion may cause reactivation of the slide and advancement of the slide headward toward Shore Cliff Road. Although splash run-up at the head of the cove might supply some water into the middle of the slide), the tsunami would not reach the top of the slide, which is at an elevation of about 100 ft and thus would not cause massive infiltration of water into ground cracks in the slide that would lead to major reactivation of the slide. Tsunami wave drawdown below sea level would not cause reactivation of the slide because the base of the slide is above sea level.

See RAI 2-14 for updated information on tsunami hazards.

<u>Question 2-16</u>

Provide analysis to demonstrate that the subsurface materials at the proposed storage-pad site are sufficiently competent to withstand the storage-pad foundation loading during a design-basis earthquake.

The analysis provided in Section 2.6.4 of the Diablo Canyon ISFSI Safety Analysis Report is not adequate because (i) the effects of preexisting structural features (such as joints, bedding planes, and clay beds) on potential failure modes of the subsurface materials were not adequately considered in the analysis; and (ii) the potential stress distributions that may control the behavior of the subsurface materials during an earthquake were not adequately considered in the analysis. The stress distributions arise from (i) initial stresses in the subsurface materials, (ii) gravitational loads from the pads and casks, (iii) seismic loading of the subsurface materials from the free-field ground motion, and (iv) seismic loading associated with the inertia of the pads and casks.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(d), §72.90, §72.92, §72.102(d), and 10 CFR §72.122(b)(2).

<u>PG&E Response to Question 2-16</u>

Regarding part (i) of the RAI, the effects of preexisting structural features beneath the proposed pad site were considered in various analyses related to pad stability. The structural features are characterized in Section 2.6.4 of the SAR as tight, with no open fractures. These observations are supported by Calculation GEO.DCPP.01.21 (submitted in PG&E Letter DIL-01-004 dated December 21, 2001), which refers to boring and televiewer (Data Report E, submitted in PG&E Letter DIL-01-005 dated December 21, 2001) logs at the pad site and concludes (on pages 56 and 74) that "joints are typically tight and partly bonded throughout the borings" and indicates that rock mass properties at the CTF site are consistent with those underlying the pad site.

These observations, along with demonstrable evidence of significant removal of overburden at the site (Calculation GEO.DCPP.01.21, page 37), lead directly to the conclusion stated in SAR Section 2.6.4.4 that no settlement, differential, or otherwise, is expected due to pad loads. This is especially true as the zone of stress relief in the upper approximately 4 ft of rock occasioned by the 1971 borrow site excavation (Calculation GEO.DCPP.01.21, page 55) will be removed during excavation for the pads.

Geosciences also considered the effect of structural features in Calculation GEO.DCPP.01.03 and GEO.DCPP.01.04 (submitted as PG&E Calculations 52.27.100.713 and 714, respectively, in PG&E Letter DIL-02-005 dated May 16, 2002). In these cases, structural features were either specifically accounted for by conservative assumptions in the analysis (as in the bearing capacity analysis) or modeled (as in the sliding analysis).

For the determination of bearing capacity beneath the pad site, the spacing and character of the discontinuities were considered in the selection of appropriate methods of analysis. When discontinuities are very frequent and spacings are small relative to the foundation size, the rock mass behaves like a dense sand or gravel (ASCE, 1996, page 41). The frequent spacing of discontinuities is confirmed in Data Report F (submitted in PG&E Letter DIL-01-005 dated December 21, 2001), which states (page F-5) that "joints are pervasive and common throughout the ISFSI study area," and (page F-6) that "discontinuity spacing averages between 1 and 3 feet." Accordingly, use of a bearing capacity analysis modeling the rock mass as a dense sand was considered.

Another estimate of bearing capacity on jointed rock was made using a correlation of allowable bearing pressure with RQD (Peck and others, 1974, page 362). This correlation is appropriate "if the joints are tight or are not wider than a fraction of an inch (Peck and others, 1974, page 361)." Based on values of RQD determined from the borings at the pad site, a lower value of bearing capacity was obtained.

Accordingly, the lesser value of allowable bearing stress was used in Calculation PGE-009-CALC-003 (submitted in PG&E Letter DIL-01-004 dated December 21, 2001) to compare with calculated static and dynamic stresses obtained from the analysis. The comparison found the calculated stresses beneath the pad to be substantially less than either the static or dynamic allowable stresses (page 67). Appendix MD-3 of Calculation PGE-009-CALC-003 also demonstrated (page 2) that the size of the rock mass analyzed was sufficiently large relative to the pad imparting the loads such that stresses calculated were not significantly affected by boundary conditions.

In a similar manner and because of the consistency of rock types and characteristics, the lateral bearing capacity at the CTF site was calculated by assuming a similar dense sand and modeling the lateral capacity as uniform with depth, except for the upper 3 ft where the capacity is reduced to zero at the surface. Refer to Calculation 52.27.100.716 (Attachment 2-1).

In the pad sliding analysis, the potential for sliding beneath the pad was modeled assuming a horizontal clay-coated bedding plane directly beneath the pad conservatively sized at half the area of a pad, and no embedment of the pad along its edges. These assumptions ensure a conservatively calculated sliding resistance that is also utilized in pad stability analyses as described in SAR Section 8.2.1.2.3.2.

The potential for sliding along clay beds assumed to extend beneath the pad sites and adjacent areas (as distinct from clay-coated bedding planes) has also been assessed in an approximate but conservative manner. Although clay beds have been shown to be less frequent and continuous in the sandstone beneath the pad sites (Calculation

GEO.DCPP.01.21, page 46), the clay bed identified approximately 50 ft below the site and depicted in SAR figure 2.6-10 was conservatively assumed to project continuously to the canyon wall located over 500 ft from the pad site. The clay bed strength used in analyses of slope stability above the site (Calculation GEO.DCPP.01.24, submitted in PG&E Letter DIL-01-004 dated December 21, 2001) was assigned to this clay bed, a pseudostatic horizontal acceleration of 1/2 the peak ground acceleration of 0.84g was selected, and a pseudostatic analysis of the stability of the rock mass overlying the clay bed was performed. Results of this assessment indicate that the sliding safety factor is greater than 1.0, indicating that this mode of sliding failure is unlikely.

Regarding part (ii) of the RAI, the effect of potential stress distributions on behavior of subsurface materials was considered. Specifically, as indicated above, Calculation PGE-009-CALC-003 was performed of stress and strain distributions within the pad and underlying rock materials as discussed on pages 8.2-16 and 8.2-17 (Section 8.2.1.2.3.2) of the SAR. Rock elastic properties for the analyses were obtained from Calculations GEO.DCPP.01.01 and GEO.DCPP.01.15 (submitted as PG&E Calculations 52.27.100.711 and 725, respectively, in PG&E Letter DIL-02-005 dated May 16, 2002). These properties are stress-strain dependent; that is, they are appropriate only for the range of stresses and strains for which they are determined.

A check was made of the Calculation PGE-009-CALC-003 results to verify that stresses and strains calculated in the underlying rock mass were within the range for which use of the rock properties is appropriate. It was determined that the average values of shear and compressive strain calculated within a volume of rock approximately 35 ft deep beneath an ISFSI pad are comparable to the range of strains for which the rock elastic properties were determined. Therefore, the elastic properties are appropriate for use in pad load-displacement analyses.

<u>*Question 2-17*</u>

Provide data to show that the proposed transport route roadway is sufficiently far from the Patton Cove landslide such that an encroachment of the slide into the transport route can be considered unlikely.

The information provided in Section 2.6.5 of the Diablo Canyon ISFSI Safety Analysis Report does not include an adequate description of the subsurface materials and interfaces in the area between the transport route and the existing slide.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(d), §72.90, §72.92, and §72.122(b)(2).

PG&E Response to Question 2-17

The Patton Cove landslide was described in SAR Section 2.6.1.12.1 and shown in Figures 2.6-7 and 2.6-17a (the discussion and figures are the same as in Revision 2 of Calculation GEO.DCPP.01.21 (PG&E Calculation 52.27.100.731) page 61 and Figures 21-3, and 21-19a, respectively. To address RAI 2-17, PG&E has prepared Figures RAI 2-17-1, 2-17-2, and 2-17-3 to illustrate the landslide in more detail.

As stated in the SAR, the Patton Cove landslide is a deep-seated rotational slump adjacent to Shore Cliff Road. PG&E's evaluation of the slide indicates that the slide has two parts: a lower slump that was mapped and investigated by Harding Miller Lawson & Associates in 1970 (Attachment 2-2) and an upper incipient slide that extends beneath Shore Cliff Road and is marked by a zone of tensional ground cracks that initiated during the wet winter of 1996/97 (Attachment 2-3).

The lower landslide and the southern part of the upper landslide appear to be a reactivation of an older landslide. A geologic map made in 1966 prior to road construction shows a crescent-shaped scarp noted as a "marine terrace riser" whose northern extent was the 112-ft contour (placing the scarp beneath Shore Cliff Road). Given our current understanding of the subsurface geology, this previously mapped geomorphic feature appears to be the eroded and subdued headscarp of a preexisting landslide in the sea cliff at the head of Patton Cove.

The preexisting 1966 landslide was approximately 180 ft long and 250 ft wide. In the winter of 1969/70 much of the slide was reactivated; the reactivated part of the landslide in 1970 was approximately 150 ft long, 200 ft wide, and 50 ft deep (Figures RAI 2-17-1, 2-17-2, and 2-17-3). In 1970, the head scarp of the slide was approximately 15 ft south of the toe of the fill for Shore Cliff Road and the slide below had many feet of displacement localized on several slumps. Harding Miller Lawson & Associates attributed the cause of the 1970 landslide to the weak alluvial fan deposits, groundwater in the marine terrace gravels above bedrock at the base of the fan deposits, erosion of the seacliff by waves that created the steep slope, and the erosion of a deep gully by a culvert that drained into the slope. The slide was not associated with heavy rainfall, but did occur following particularly heavy rains from the El Nino of the 1968/1969 and 1969/1970 winters. In the early 1970 the drainage from the culvert was diverted around the slide to reduce the slide movements. Nonetheless, in the 32 years since slide movement was first documented in 1970, the lower slide mass has been episodically reactivated by heavy rains and continued wave erosion at the toe of the slide along the base of the sea cliff. However, headward encroachment or migration of the lower landslide has remained limited and the slide has not reached the fill prism that supports Shore Cliff Road.

The upper landslide moved during the wet winter of 1996/1997 when numerous, en echelon cracks in the asphalt roadway and walkway along Shore Cliff Road occurred (Figure RAI 2-17-1). In the winter of 1999/2000, a raw water line for fire suppression separated beneath the paved roadway in the vicinity of the cracks and was subsequently repaired. The zone of tensional cracking marks the incipient headscarp area and uphill limit of the reactivated upper landslide. It is approximately 100 ft long (above the lower slide), 350 ft wide, and 50 ft deep. The cracks in the pavement range from 1/16-inch to 1/4-inch wide. One crack near the firewater break has a vertical offset of up to 1/2-inch, down toward Patton Cove; this crack is less than 2 ft long. Since cracks were initially observed along Shore Cliff Road in 1996/97 they have progressively enlarged. The post-1966 downslope movement of the upper slide mass has been small, interpreted to be less than a few inches and significantly less than the reactivated movement of the lower slide mass.

Both the upper and lower landslide masses are completely within Quaternary alluvial and near-shore marine deposits that overlie two marine wave-cut platforms (Figures RAI 2-17-2 and 2-17-3. A buried bedrock sea cliff separates the two wave-cut platforms. Borings were drilled in 1970 (HML-1 to HML-4), 1996 (WLA 96-1 and 96-3) and 2000 (PC-1) to evaluate the deposits. The logs of the borings (Attachments 2-2, 2-3 and 2-7) indicate that the fan deposits are composed generally of sandy clay, and silt and clay with some sand and rock clasts (CH, CL, ML and SL), and silty sand with rock clasts (SM). These deposits are typically stiff to very stiff, but in places are soft. Locally, the thin marine deposits consisting of sands (SM, SP) with some gravel, are found separating the fan deposits and underlying bedrock wave-cut platform. For the analysis of the Patton Cove landslide the top of bedrock is interpreted at the top of the weathered rock in the borings: 35 ft deep in HLA-1, 32 ft in HLA-2, 21 ft in HLA-3, 10 ft in HLA-4, 11 ft in PC-1, 18 ft in WLA 96-1, and 16 ft in WLA 96-3.

The buried wavecut platforms and seacliff separating the two wave-cut platforms appears to control the slide geometry, extent, and behavior of each slide mass. The base of each slide is constrained by bedrock below the wave-cut platform (i.e., the slide is confined to the alluvial and marine deposits above the platform and does not extend into solid bedrock). The wave-cut platforms are developed on claystone and siltstone bedrock of the Tertiary Obispo Formation (Figures RAI 2-17-2 and 2-17-3). The base of the slide and the slide plane may incorporate the upper highly weathered, saprolitic bedrock that is locally up to several feet thick on top of the wave-cut platform. The 1970 slide is above the lower platform. This platform has a shoreline angle at 35 ft elevation (above mean sea level, MSL) and slopes gently seaward to an elevation of 15 ft where the base of the slide daylights above Patton Cove. The head of the lower landslide is constrained by the buried sea cliff above the 35-ft shoreline angle as shown in Figures RAI 2-17-2 and 2-17-3. The depth of the upper slide is constrained by the higher wavecut platform that is at elevation about 75 ft. The shoreline angle corresponding to this platform lies at an elevation of about 105 ft and is located below the steep hills along Reservoir Road as shown on SAR Figure 2.6-17a. The lateral extent of the upper landslide is marked by the ground cracks in Shore Cliff and Reservoir roads.

Groundwater at the landslide occurs as perched water on both wavecut platforms. The seeps on top of bedrock in Patton Cove mapped by Harding Miller Lawson mark the top of the lower wavecut platform. Groundwater was measured in the 1996 borings in Parking Lot 7 (e.g., Boring WLA 96-1) on top of the upper platform.

An inclinometer was installed on the road shoulder within the upper slide and close to the lower slide in November 2000 to monitor the depth and rate of future movements, if any, of the landslide. The inclinometer is 130 ft deep terminating close to mean sea level. As of September 2002, the inclinometer shows no measurable offsets indicating the absence of any differential movements of slide planes across the borehole, including the contacts at the base of fill and at the top of bedrock (Figure RAI 2-17-4). The inclinometer shows an overall apparent displacement of about 0.45 inches (Figure RAI 2-17-5) at the surface that is distributed from the bottom of the hole. This displacement may indicate some small overall movement in the Patton Cove landslide, or it may be settlement and adjustment of the casing since it was installed.

Evaluation

(1) Continued movement of the lower Patton Cove landslide will not impact the proposed transport route because the landslide's headward migration is limited by the buried sea cliff that is 220 ft south of the edge of the proposed transport route.

(2) Significant movement of the upper Patton Cove landslide, if it occurs, will not impact the proposed transport route because its headward migration is limited by the depth of the slide, which is controlled by the elevation of the higher wavecut platform. The geometry of the landslide is such that it is unlikely to extend much farther landward because it would require either (a) an extremely low slide plane angle in the alluvial fan deposits or (b) a deeper slide plane that cuts through the bedrock materials. These scenarios are both considered to be very unlikely. The current head of the upper slide is located 110 ft from the edge of the proposed transport route. Continued movement of the lower slide, however, will probably continue to destabilize the upper slide and cause additional movements and increased cracking in Shore Cliff Road.

(3) The slide is being monitored periodically by measuring the ground cracks and by measuring the inclinometer. If significant movements occur, the landslide will be reassessed.

(4) As discussed in SAR Section 2.2.2.3, a Cask Transportation Program will be developed and implemented to require a walkdown of the transportation route prior to any movement of the transporter. This walkdown will ensure that no hazards are present from the Patton Cove landslide as evidenced by severe cracking of the roadway surface. In addition, Shore Cliff Road is the main plant access, so any road hazards from landsliding would be readily identifiable in the road prior to cask transport.

Question 2-18

Provide an assessment of the stability of the natural slope above and below the proposed storage-pad site during a design-basis earthquake.

The analysis provided in the Diablo Canyon ISFSI Safety Analysis Report is not adequate because (i) an assessment of the potential effects of a design-basis earthquake on the stability of the slope is not provided; and (ii) estimates of seismically induced displacements of potentially unstable masses were calculated using the Newmark sliding block analysis method, but the uncertainties of using the Newmark method for the ground-motion magnitudes associated with the design-basis earthquake were not evaluated.

This information is necessary to determine compliance with 10 CFR §72.24, §72.90, §72.92, and §72.122(b)(2).

PG&E Response to Question 2-18

Slope Above the Proposed Site:

Regarding part (i) of the request, potential displacements estimated as a result of analyses are presented in Section 2.6.5.1.3.5 of the Diablo Canyon ISFSI SAR. It is noted that planned mitigation measures are discussed in SAR Section 4.2.1.1.9. Potential effects described in this section include:

- cut slope rock blocks potentially prone to failure during seismic loading (to be mitigated by rock bolts and shotcrete);
- rocks dislodged on the natural slope above the site (to be mitigated by a rockfall barrier above the ISFSI site);
- rock offset along clay beds daylighting in the cutslope (to be mitigated by benches in the cutslope above the ISFSI site and setback of the storage pads from the toe of the cut slope); and
- displacements along clay beds beneath the pads (no mitigation required: displacements are expected to propagate around the heavily reinforced concrete pads).

Regarding part (ii) of the request, the Newmark method is particularly well suited to analysis of the native slope above the site, as the potential movement of rigid rock blocks on discrete clay beds is very similar to the analytical model presented by Newmark (Reference 29 in SAR Section 2.6.6). In fact, the appropriateness of the methodology in this case is demonstrated by comparison of the magnitudes of displacements calculated simply by assuming the slide masses are rigid with those calculated after modeling the slide masses as non-rigid bodies. The comparison of the displacements as presented in Tables 1 and 2 of Calculation GEO.DCPP.01.26 (submitted in PG&E Letter DIL-01-004 dated December 21, 2001) indicates that magnitudes calculated by these two different methods are nearly identical. Uncertainties associated with the magnitude of potential displacements were dealt with primarily by performing analyses with a suite of ground motions with varying characteristics (SAR Section 2.6.2.5) and by verifying that none of the inputs to the displacement analyses were unconservative (SAR Section 2.6.5.1.2.2).

The methodology used, as described in SAR Section 2.6.5.1.3, is consistent with regulatory guidelines found on pages 2-9 through 2-11 of NUREG-1620 (Revision 1). Specifically, two types of analyses are recognized in these pages: (a) a pseudostatic analysis (paragraph (d) on page 2-10) which is acceptable if the design seismic coefficient is less than 0.20 g; and (b) a dynamic analyses (paragraph (g) on page 2-10) which is recommended if the design seismic coefficient is greater than 0.20 g. A pseudostatic analysis of the slope above the site was not performed, and would not be appropriate in any case as the maximum seismic coefficient calculated is well above 0.20 g. Instead, a dynamic analysis with finite element modeling (as described in GEO.DCPP.01.25, which was submitted in PG&E Letter DIL-01-004 dated December 21, 2001) was performed in accordance with NUREG-1620 recommendations.

The methodology used is also consistent with the recommendations of Kramer (Reference 1). Specifically, Kramer states (page 446):

The effects of slope response on the inertial force acting on a potential failure mass can be computed using dynamic stress-deformation analyses (Reference 2). Using a dynamic finite-element analysis, the horizontal components of the dynamic stresses acting on a potential failure surface are integrated over the failure surface to produce the time-varying resultant force that acts on the potential failure surface. This resultant force can then be divided by the mass of the soil above the potential failure surface to produce the average acceleration of the potential failure mass. Although the procedure was developed originally for dams, the basic concept can be applied to any type of slope. The average acceleration time history, which may be of greater or smaller amplitude than the base acceleration time history (depending on the input motions and the amplification characteristics of the slope), provides the most realistic input motion for a sliding block analysis of the potential failure mass.

To further review the appropriateness of the methodology used in analyzing potential displacements of the slope above the proposed storage pad site, a short historical background discussion is provided, following, to assist in clearly distinguishing between the various methods of analyses available.

Pseudostatic Analysis

The traditional pseudostatic analysis involves modeling the ground motion as a single static horizontal load, or "seismic coefficient," imposed on the slide mass, and calculating the resulting slide mass safety factor against sliding. Generally, the amplitude of the seismic coefficient is selected as some fraction of the peak horizontal acceleration of the acceleration time history. In 1979, Prof. H. B. Seed pointed out that earthquake-related slide mass displacements could occur even when a pseudostatic analysis produces a factor of safety above unity, although in his experience these displacements (up to about 3 feet) would be acceptable if the calculated safety factor was greater than about 1.15 for a design seismic coefficient of about 0.15 (Reference 3). Alternatively, Prof. Seed recommended estimating slide mass displacements directly using the procedure described by Prof. Newmark in 1965 (Reference 4).

Newmark Sliding Block Analysis

In 1963 (Reference 5), Prof. N.M. Newmark first proposed the concept that the effects of an earthquake on embankment stability could be assessed in terms of the deformations they produced. Newmark presented a method of analysis based on this concept in his paper presented at the Rankine Lecture (Reference 4). In this paper Newmark presented the analogy between the potential sliding mass of an embankment dam and that of a rigid block sliding on top of a wedge. The input ground motion was represented as a simple square acceleration pulse. Based on these assumptions and using basic law of physics, he developed simple equations and charts to estimate upper bound movements of slide masses during earthquakes. This concept is commonly referred to as a Newmark analysis.

Newmark-Type Sliding Block Analysis

Subsequent to the introduction of the Newmark analysis, a number of studies were undertaken to estimate permanent displacements of slide masses using actual earthquake recordings while employing the sliding block concept (e.g. References 6, 7, 8, and 9). The studies estimated the slide mass time history, or "seismic coefficient time history," in a separate analysis, then double integrated those portions of the seismic coefficient time history exceeding the slide mass yield acceleration to estimate cumulative displacements of the slide mass. This type of decoupled analysis is generally referred to as a Newmark-type analysis (such as stated in NUREG 1620, Reference 10).

In SAR Section 2.6.5.1.3, distinctions between a Newmark and Newmark-type analysis were not explicitly stated. The analysis of the slope above the proposed storage pad site is a decoupled Newmark-type analysis.

Finite Element Analysis of ISFSI Slope

For results of a Newmark-type analysis to be reasonable, the seismic coefficient time histories must be reasonably developed. As described in SAR Section 2.6.5.1.3, the seismic coefficient time histories were developed using the finite element method. The thin clay beds, which could potentially damp out high frequency motions, were not incorporated in the finite element mesh. By not modeling the clay beds in the finite element analysis, the computed seismic coefficient time histories are considered conservatively high.

The rock mass constituting the slope above the proposed storage pad site has shear wave velocities in excess of 3,500 ft/sec. Because these high velocities are indicative of a very stiff material, it is appropriate to use an equivalent linear approach to estimate seismic coefficient time histories in these materials.

Coupled Versus Decoupled Analyses

Marcuson and others (Reference 11) summarize the current state of practice for seismic slope stability and permanent deformation analysis and state that a decoupled Newmark type sliding block analysis is appropriate for slopes that are statically quite stable. On the other hand, a fully non-linear, fully coupled analysis is more appropriate for slopes that are marginally stable statically. For the slope above the proposed pad site, the computed factors of safety under static loading conditions are sufficiently high that post-earthquake movements of potential slide masses under gravity loads alone are unlikely. Thus, the assessment of the stability of the slope using a decoupled Newmark-type sliding block analysis is consistent with recommendations of Marcuson and others (Reference 11).

In a recent project for the seismic retrofit of PG&E's Butt Valley Dam, both a Newmark type sliding block analysis and fully non-linear finite element analysis were used to assess the potential for dam displacements. The two types of analysis were separately performed by two independent consulting firms. The Newmark-type analysis estimated potential movement of the critical slide mass at about 2.5 ft (Reference 12) while the fully nonlinear analysis estimated movements between 1.9 to 2.8 ft (Reference 13). The similarity of these results provided increased confidence in the reasonableness of both analysis methods.

Gazetas and Uddin (Reference 14) compared the results of a decoupled Newmark-type analysis with a fully coupled nonlinear analysis incorporating interface sliding elements. The results indicate that the decoupled analysis usually yields higher computed displacements than the coupled analysis, especially if the predominant period of the motion is close to the site period, which is the case for the slope above the proposed site for the storage pads.

Fully Coupled Nonlinear Analysis for the Slope Above the Proposed Site

To assess the reasonableness of the displacements calculated using the decoupled Newmark-type approach, a separate fully coupled nonlinear assessment was performed for the slope above the proposed storage pad site. A separate finite element mesh was prepared similar to that presented in SAR Figure 2.6-56, but with all potential sliding planes modeled as interface elements. The two-dimensional program FLAC was used, which calculates seismically induced displacements of the potential slide masses along the modeled clay beds directly as part of the response analysis. Material properties for the rock mass and clay beds were developed consistent with the laboratory test results and previous analyses. The FLAC assessment was performed for the critical case involving ground motion Set 1 and slide mass 1b, with displacement estimated at 3.1 ft (SAR Table 2.6-5), and using the same bi-linear undrained strength envelope for the clay beds as presented in SAR Figure 2.6-50. Calculated displacement along the slide plane from the FLAC assessment is about 3 ft and is consistent with the value calculated using the decoupled Newmark type analysis. This consistency provides high confidence that displacements calculated for other slide masses within the slope using the Newmark-type analysis are reasonable as well.

Slope Below the Proposed Site:

The slope (consisting of the Diablo Canyon wall) below the proposed site is discussed in SAR Section 2.6.1.12.2. The discussion concludes, in part, that "no deep-seated bedrock slides have occurred since formation of the 430,000 year-old terrace, and the ridge is interpreted to be stable. Some shallow debris-flow failure and slumps were identified in surficial soil on the outermost 3 to 4 ft. of weathered rock in the steep (45 to 65 degrees) slope below the raw water reservoir (SAR Figure 2.6-7). These failures are shallow, and do not pose a stability hazard to the ISFSI or CTF sites, which are set more than 180 ft back from the top of the slope." Much of these debris-flow features are attributed to a water tank spill which occurred in 1992, rather than to natural causes. In addition, removal of significant amounts of overburden from the site (as shown in SAR Figure 2.6-18) improves stability of the slope.

Conclusions

(1) Use of Newmark-type displacement analysis for the slope above the proposed site is appropriate, and reasonableness of results has been confirmed using a fully nonlinear FLAC assessment.

(2) The slope below the site is stable with significant setback for the proposed site.

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14. G. Gazetas, N. and Uddin, "Permanent Deformation on Preexisting Sliding Surface in Dams", Journal of Geotechnical Engineering, ASCE, Vol. 120, No. 11, 1994.

Question 2-19

Provide site-response assessment of the vibratory ground motions for the proposed transport route roadway between the nuclear power plant and the Diablo Canyon ISFSI pad; or provide sufficient justification of why a seismic event that may cause cask drop, overturn of the transporter, or sliding of the transporter off the transport route is not credible (as described in Section 8.2.1.2.1 of the Diablo Canyon ISFSI Safety Analysis Report).

Unlike the power plant and the storage-pad locations, which are founded on bedrock, the proposed transport route is underlain by soils and manmade fill. The site response of these soils and manmade fill could change the amplitude and spectral frequency content of the input vibratory ground motions used in seismic design analyses of the transporter and casks. The conclusion provided by the Applicant in Section 8.2.1.2.1 of the Diablo Canyon ISFSI Safety Analysis Report is that the limited exposure time of the radioactive material during transportation from the power plant to the Cask Transfer Facility (12 hr per year, which is equal to a yearly probability of 1.37×10^{-3}), makes this a noncredible accident scenario. This conclusion requires further justification.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(d), §72.90, §72.92, §72.102(b), §72.122, §100.20, and §100.23.

PG&E Response to Question 2-19

SAR Section 8.2.1.2.1 describes the seismic evaluations performed for the cask transporter. SAR Section 2.6.2.6 describes the transport route design basis ground motions. SAR Section 8.2.1.2.1 indicates that the cask transporter stability analysis was performed using bedrock ground acceleration associated with the ISFSI long-period (ILP) earthquake. SAR Section 2.6.2.6 states that where crosses surficial deposits over bedrock (approximately two-thirds of the route) peak ground accelerations at certain points along the surface of the transport can be 1.5 to 2.0 times the amplitude of the peak bedrock acceleration.

PG&E has further evaluated the effects of the surficial deposits and has concluded that the ILP spectra used for evaluation of transporter stability on the transport route over bedrock is also applicable for the portions of the route over surficial deposits as described in a letter from Norm Abrahamson to Rich Klimczak, dated September 13, 2002 (Attachment 2-4). Therefore the seismic stability analysis of the transporter described in SAR Section 8.2.1.2.1 along the portions of the transport route over bedrock, which demonstrates that the cask transporter will not overturn during a seismic event and will not leave the road, is also applicable to the portions over surficial deposits. Refer to Diablo Canyon ISFSI SAR, Amendment 1, Sections 2.6.2.6 and 8.2.1.2.1.

PG&E also performed a seismic evaluation of the cask transporter under ground accelerations twice those of the ILP earthquake accelerations. This evaluation is documented in PG&E Calculation OQE-14 (Attachment 2-5) and demonstrates that even under these hypothetical conditions, the cask transporter would remain stable and would not overturn or leave the roadway.

PG&E evaluated the risk of an earthquake causing ground accelerations twice those of the ILP occurring simultaneously with cask transport activities (12 hours per year) and concluded that the risk is not credible (less than 10^{-7}) as described in PG&E Calculation PRA 02-10 (Attachment 2-6).

In summary, the transporter will remain stable under seismic conditions while the transporter is traversing the portions of the route over bedrock and the surficial deposits over bedrock. In addition, PG&E analyses for ground accelerations twice those of the ILP demonstrate that the transporter will remain stable and the risk of such a ground acceleration occurring during cask transport is not credible (less than 10^{-7}).

Chapter 3. Operational Systems

<u>*Question 3-1*</u>

Provide a complete operational description of the cask transporter during the following operations:

(a) Loading of the cask transport frame onto the cask transporter

(b) Transport to the Cask Transfer Facility (for example, what allowances are made for transverse slope of the road outside the Fuel Handling Building and operational controls of the transporter)

(c) Upending and downending of cask transport frame at the Cask Transfer Facility (for example, what defense-in-depth design features or operational controls prevent tipover during upending and prevent motion past vertical)

(d) Transfer of multi-purpose canisters to the storage cask (for example, what are the steps to attach the restraints for the transporter and controls to ensure that the multi-purpose canister does not bind during transfer)

(e) Transport of loaded storage cask to the storage-pad

(f) Placement of storage cask on the storage-pad (e.g., alignment process and torque sequence for bolts)

This information is necessary to allow the reviewers to assess the ability of the transporter to perform its tasks. This should include discussion of the design features, *operator controls, and administrative controls. Section 5.1.1.3 of the Diablo Canyon ISFSI Safety Analysis Report contains only a brief narrative description that is supported in part by Figure 5.1.1 of the Diablo Canyon ISFSI Safety Analysis Report.*

This information is necessary to determine compliance with 10 CFR §72.24(b) and §72.128(a).

PG&E Response to Question 3-1

In addition to the operational description cited in Diablo Canyon ISFSI SAR Section 5.1.1.3, the operation of the cask transporter is discussed in SAR Section 4.3.2.1. These sections provide an adequate level of detail on the operation of the cask transporter for the SAR. Additional information is provided for the specific items in this RAI and cross-references to the applicable SAR Section(s) are provided below.

(a) Loading of the cask transport frame onto the cask transporter.

The loaded transfer cask, in the cask transport frame, is downended in the fuel handling building/auxiliary building (FHB/AB). The cask and transport frame are supported by removable transport frame rollers (SAR Figure 4.2-12). SAR Figures 4.3-4 through 4.3-6 show the transfer cask in the cask transport frame being upended prior to fuel loading. Downending would be performed in the reverse order from that shown in these upending figures, except that the removable rollers would be installed under the long end of the cask transport frame. Once in the horizontal position, the cask transport frame and attached transfer cask are moved outside the FHB/AB on the transport frame rollers using a suitably designed pulling device.

Outside the FHB/AB, the transfer cask lift slings (sized to ensure a level lift) are fed underneath the transfer cask at each end adjacent to the cask transport frame supports. The sling ends are then temporarily draped over the top of the horizontal transfer cask. The cask transporter is then moved into position over the transfer cask with the transfer cask horizontal lift rig already attached to the lift points of the cask transporter (SAR Figure 4.3-1). Finally, the sling ends are attached to the attachment points on the horizontal lift rig and the transfer cask and cask transport frame are lifted off the ground for the trip to the cask transfer facility (CTF). Note that the cask transport frame is used solely for upending and downending operations and does not support the transfer cask while suspended by the horizontal lift rig.

(b) Transport to the CTF (for example, what allowances are made for transverse slope of the road outside the FHB/AB and operational controls of the transporter).

The transfer cask is transported to the CTF in the horizontal configuration by the cask transporter, as depicted in SAR Figure 4.3-1.

The transport route has a 2 percent transverse slope into the hill from the southeast entry outside the Protected Area and south along Plant View Road up to where the road joins the main plant access road (Shore Cliff Road). The main plant road has a 2 percent crown for 50-100 ft. until it meets the Patton Cove Bypass Road. The Patton Cove Bypass Road has up to a 2 percent maximum transverse slope toward its radius until it joins Reservoir Road at which the transverse slope is 2 percent into the hill. Overall, the transport route includes an approximate 6 percent uphill grade to the CTF. The Diablo Canyon ISFSI SAR was revised accordingly. Refer to the Diablo Canyon ISFSI SAR, Amendment 1, Section 4.3.3.

The design of the cask transporter requires positive action by the operator for movement. That is, the operator needs to hold a joystick in position to move the vehicle. The joystick cannot be locked in the drive position. When the joystick is released, the transmission pump is stopped, which stops the hydraulic motor that drives the vehicle. For defense in depth, a crew of personnel will also be escorting the cask transporter when it is moving a loaded transfer cask to the CTF. Certain personnel will have the responsibility of maintaining visual contact with the operator at all times during movement of the transporter and will control the directionality of the vehicle through communications to the operator. Lastly, the cask transporter design will include an emergency stop switch in the operator's cab and another two on the outside of the vehicle at each end for the escort crew to use in case the operator cannot stop the vehicle for any reason. The administrative controls for cask transporter operation will be included in a procedure and will be part of the training and qualification program for ISFSI operations personnel.

(c) Upending and downending of cask transport frame at the CTF (for example, what defense-in-depth design features or operational controls prevent tipover during upending and prevent motion past vertical).

Downending and upending of the loaded transfer cask and cask transport frame is conducted inside the 10 CFR 50 facility and at the CTF, respectively, before and after the transfer cask is moved to the CTF. All handling of the transfer cask will be governed by the DCPP Control of Heavy Loads Program.

Control of the downending operation inside the 10 CFR 50 facility is summarized in SAR Sections 4.4.1.3.1 and 5.1.1.2. The transfer cask and cask transport frame are downended to the horizontal position using the FHB/AB crane main hoist. The crane lift yoke supports the transfer cask by the lifting trunnion for the entire time downending is taking place. The cask transport frame design includes downending/upending rockers (SAR Figure 4.2-12) that provide a smooth pivot point and allow the evolution to proceed in a slow, deliberate manner to avoid dynamically loading the lift yoke and preventing "slapdown" of the cask.

Control of the upending operation at the CTF is summarized in SAR Section 5.1.1.3. Upending of the loaded transfer cask and cask transport frame at the CTF is accomplished using the cask transporter and the HI-TRAC lift links, as shown in SAR Figures 4.3-4 through 4.3-6. These figures show the sequence of upending an empty transfer cask and cask transport frame. Downending of a loaded transfer cask and cask transport frame occurs in the reverse order as that depicted in these figures. Upon arrival at the CTF, the transfer cask and cask transport frame are set down in the horizontal position and the horizontal lift rig and lift slings are removed. The solid steel HI-TRAC lift links connect the cask transporter lift points to the transfer cask lifting trunnions. As discussed above, the downending/upending rockers on the cask transport frame provide for a smooth pivot to the vertical position without a sudden movement when the center-of-gravity of the cask moves over the corner of the cask transport frame. The lift links provide a straight, rigid connection between the cask transporter lift beam and the transfer cask lifting trunnions that prevent excessive motion past vertical upon up righting the assemblage.

(d) Transfer of multi-purpose canisters to the storage cask (for example, what are the steps to attach the restraints for the transporter and controls to ensure that the multi-purpose canister does not bind during transfer)

After the loaded transfer cask is placed atop the mating device on the overpack in the CTF, the lift links continue to maintain the structural connection between the cask transporter lift beam and the transfer cask lifting trunnions. To provide the necessary interim seismic stability of the stacked configuration. the lift links are only removed after the transfer cask has been bolted to the mating device and the seismic restraints connecting the transporter to the CTF apron have been installed.

After removal of the HI-TRAC lift links, the MPC downloader slings are connected between the cask transporter lift beam and the MPC lift cleats, with the slings traversing through the opening in the transfer cask top lid. The cask transporter, via the lift beam and the vertical towers, raises the MPC slightly to remove the weight of the MPC from the transfer cask pool lid, allowing the pool lid to be removed using the mating device (SAR Figure 4.2-11). The MPC is then lowered into the overpack using the cask transporter lift beam and towers, in the same manner as previously performed at other nuclear plant sites using the HI-STORM 100 System. The lengths of the downloader slings are precisely determined to ensure the MPC is essentially level during transfer. Binding of the canister with the transfer cask has not revealed itself to be a concern in over 30 MPC transfers performed to date at other nuclear power plants. This is because the weight of the loaded MPC (approximately 90,000 lbs) will overcome any minor occasions of binding due to small out-of-level conditions that may arise. In the unlikely event that a binding occurs to the extent that continued lowering of the MPC is impossible, the MPC can be raised back up into the transfer cask to allow investigation and corrective actions to be performed.

(e) Transport of loaded storage cask to the storage-pad.

After MPC transfer, the now-empty transfer cask is removed from atop the mating device using the cask transporter and the mating device is removed using other suitable lifting equipment, such as a mobile crane. While the overpack is still in the lowered condition in the CTF and the cask transporter out of the way, the overpack top lid and the lifting brackets are installed. The cask transporter is then brought back to the CTF and the loaded overpack is then raised by the CTF platform to its full up position and lifting brackets are attached to the lift beam (see SAR Figure 4.3-3). Once connected, the overpack is lifted to the minimum height necessary for travel to the ISFSI pad.

(f) Placement of storage cask on the storage-pad (e.g., alignment process and torque sequence for bolts)

Prior to the loaded overpack arriving at the ISFSI pad, the designated storage location will have been prepared for the cask to be placed on the pad. Specifically, a small number of alignment pins will have been installed in the anchor stud locations. These alignment pins ensure that the cask is properly located and the holes in the cask bottom flange match with the holes in the ISFSI pad embedment plate. When the cask is properly located and seated, the alignment pins are removed and the 16 anchor studs are threaded into the top of the embedded coupling (see SAR Figure 4.2-2). As discussed in RAI 5-13, the studs will be pre-tensioned using a stud tensioner and the nuts tightened in a cross-pattern, roughly 180 degrees apart, to avoid uneven loads on the baseplate.

Question 3-2

Provide details of the Cask Transfer Facility jack screw controls that are used to ensure a uniform lift of the storage cask.

Section 4.2.1.2 and 4.4.5 of the Diablo Canyon ISFSI Safety Analysis Report and supporting design calculations contain only a limited discussion of the operational characteristics of the cask transporter facility. The information should include a detailed discussion of the devices relied on to automatically shutdown the jack screw in a safe condition in the event of a failure. Moreover, the rationale for not classifying the jack screw controls and related safety features as important-to-safety must be provided.
The Cask Transfer Facility jacks are classified as Category B, Important to Safety in

Table 4.5.1 of the Diablo Canyon ISFSI Safety Analysis Report, but the table is unclear and does not include the jack screw controls. NUREG–1567 (Section 3.4.3) states that the applicant must provide a clear narrative description or flowcharts of the systems and system equipment and controls used to assure safety.

This information is necessary to determine compliance with 10 CFR §72.24(b) and §72.128(a).

PG&E Response to Question 3-2

The Cask Transfer Facility (CTF) screw jacks are commercially designed equipment, typically used to raise large, heavy objects, such as train cars, to facilitate maintenance. The CTF screw jacks are Important-to-Safety, Category B because they support the loaded overpack as it is raised to the full-up position in preparation for transport to the ISFSI pad. Combined, the screw jacks are designed to support 450 tons, which is two and one-half times the weight of a bounding loaded overpack and essentially eliminates the potential for jack structural failure due to overload. The screw jacks do not support the stacked casks during MPC transfer because the lift platform is resting on a support pedestal that transmits the load directly into the concrete and rock foundation below with no load applied to the jacks. With the lift platform in the full down position, the top 30 inches of the overpack remain above grade, so the overpack cannot become wedged in the CTF.

The CTF drive and control systems are also commercial components that are not unique to nuclear. The drive and control systems are not important to safety because their failure modes do not result in an uncontrolled lowering of the load or the inability to retrieve the cask. Diablo Canyon ISFSI SAR Table 4.5-1 has been revised to list the CTF drive and control systems in the "Not Important to Safety" column. As stated in SAR Section 3.3.4.2.3, the drive and control systems will be designed in accordance with NUREG-0612, Section 5.1.6(2), which refers to NUREG-0554, "Single Failure Proof Cranes for Nuclear Power Plants." Because the CTF is not a crane, the guidelines of NUREG-0554 will be implemented to the extent practical. The CTF load handling equipment drive and control systems will be functionally checked.

The failure modes of the power supply and the drive and control systems are discussed below.

Loss of Electrical Power Supply

The three screw jacks lift the lifting platform via the rotation of long threaded screw through a traveling nut. The traveling nuts are attached to the lifting platform and the platform runs up and down the screws as the screws rotate through the nuts. The threaded connection is an ACME-type thread, which is designed not to "unwind" under any condition, such as a loss of power, as described in SAR Section 8.1.6.3.2. The three screw jacks will stop simultaneously on a loss of all power to the system. The system will shut down on an out-of-level condition if one or two of the screw jack motors fail and the remaining motor(s) do not. Therefore, a loss of electrical power will not cause an uncontrolled lowering of the load or the inability to retrieve the cask.

Loss of Level Control

The three CTF screw jacks are electronically coupled with position feedback to ensure that the platform remains level (within ½ inch) at all times during travel. In addition to the primary electronic level control and feedback system, the lifting platform is equipped with independent level monitors which trip the drive system if an out-of-level condition is detected. Therefore, a loss of level control will not cause an uncontrolled lowering of the load or the inability to retrieve the cask.

Loss of Travel Control

The CTF lift platform travel on the screw jacks is controlled by redundant limit switches that trip the drive system in the event that the primary, pre-programmed position feedback circuits fail. These serve to provide redundant assurance that the CTF does not create a situation where it is jacking against a hard point. Failure of both redundant travel limit control systems would result in an eventual trip of the drive motors due to over-torque or over-current when the lift platform reaches a physical hard stop at the top or bottom of the CTF. Therefore, a loss of travel control will not cause an uncontrolled lowering of the load or the inability to retrieve the cask.

Operator Action

The design features of these control systems will be backed up by operator action, if necessary. The CTF operator will be able to tell by observation if the cask is significantly out-of-level or moving past established travel limits because the lifting/lowering speed is on the order of inches per minute. Upon detection of a malfunctioning automatic control feature, the operator can take appropriate action to shut down the system.

Question 3-3

Provide a description of the structural details and function of the seismic restraint of the cask transporter and storage cask in the Cask Transfer Facility, including associated diagrams. This should include the restraints themselves as well as their attachment points to both the transporter and the foundation.

The description given in Section 5.1.1.3 of the Diablo Canyon ISFSI Safety Analysis Report is insufficient. NUREG–1567 (Section 3.4.3) states that the applicant must provide a clear narrative description or flowcharts of the systems and system equipment and controls used to assure safety.

This information is necessary to determine compliance with 10 CFR §72.24(b) and §72.128(a).

PG&E Response to Question 3-3

This RAI is identical to RAI 5-12. The responses to both RAIs are provided herein.

The detailed design of the seismic restraint system for the cask transporter and the storage cask in the cask transfer facility (CTF) are not complete. The completed conceptual design and analysis of the CTF has produced loads for the future design of the restraint system, including attachment points, to ensure the design is viable.

To restrain the cask against seismically-induced impact loads on the main shell of the CTF, shimmed seismic restraints will be installed to transmit the load from the overpack to the CTF shell (Diablo Canyon ISFSI SAR Section 3.3.4.2.6). The response to RAI 5-7 discusses the control of these seismic impact loads and the thermal implication of the shimmed seismic restraints are discussed in more detail.

The restraints and attachment points on the cask transporter will be designed to meet the stress limits of ASME Section III, Subsection NF. The restraints themselves will be steel struts, steel cables, or similar equipment suitably sized to restrain the design loads Refer to PG&E Calculation M-1058 (Attachment 3-1). The attachment points in the CTF foundation will be designed in accordance with ACI 349-97, including draft Appendix B, as clarified by NRC draft Regulatory Guide DG-1098. The cask transporter tie downs are described in Diablo Canyon ISFSI SAR Section 4.2.1.2 and depicted in plan view in Figure 4.2-4. The tie downs function to prevent the transporter from seismically interacting with the storage cask while in the CTF during MPC transfer operations.

Chapter 4. Structures, Systems, and Components and Design Criteria Evaluation

Question 4-1

Provide a classification for the cask transport frame and any other components present but not listed in Table 4.5-1 of the Diablo Canyon ISFSI Safety Analysis Report.

The Diablo Canyon ISFSI Safety Analysis Report does not include the cask transport frame in Table 4.5-1 and does not classify it as a Category A, B, C, or not-important-to-safety item. As identified within the text of the Diablo Canyon ISFSI Safety Analysis Report, the main function of the cask transporter frame is to facilitate rotation of the loaded transfer cask from vertical to horizontal position, or vice versa, at the Fuel Handling Building/Auxiliary Building and Cask Transfer Facility. NUREG–1567 (Section 4.4.2) states that the applicant must identify all structures, systems, and components, and provide a rationale for the identification.

This information is necessary to determine compliance with 10 CFR §72.24(n).

PG&E Response to Question 4-1

The cask transport frame is classified as not-important-to-safety (NITS), as described in Diablo Canyon ISFSI SAR Section 4.3.2.4. This component has been added the Diablo Canyon ISFSI SAR, Amendment 1, Table 4.5-1.

Question 4-2

Provide the structural design criteria and bases (e.g., enhanced safety factors, redundant systems, or both) for exclusion of cask drop events during handling and transport.

The Diablo Canyon ISFSI Safety Analysis Report (Section 4.3.2.1.2) states that mechanical design features and administrative controls provide a defense-in-depth approach to preventing load drops during lifting and handling without specifying the structural design criteria and bases. A simple statement that design is according to the applicable guidelines of NUREG–0612 is not adequate. Justification for exclusion of cask drops should be provided. Otherwise, there is a need to establish a cask lifting height limit. Specific design analysis and calculation for the components of lifting and handling system should be provided. NUREG–1567 (Section 4.5.3) states that the principal design criteria and bases for structures, systems, and components important to safety must be provided.

This information is necessary to determine compliance with 10 CFR §72.24(c)(1) and (2), and §72.120(a).

PG&E Response to Question 4-2

The licensing basis for the statements in Section 4.3.2.1.2 of the Diablo Canyon ISFSI SAR may be found in the HI-STORM 100 System CoC, Amendment 1. Specifically, Sections 5.5.a.3 and 5.5.b.2 of Appendix A to the CoC allow the transfer cask or the overpack, when loaded with spent fuel, to be lifted to any height necessary during transportation between the fuel handling building/auxiliary building and the CTF and/or ISFSI pad provided the lifting device is designed in accordance with ANSI N14.6 and has redundant drop protection features. These CoC provisions allow general licensees to lift casks with equipment designed in accordance with these standards to whatever height is necessary for loading operations without establishing specific lift height limits or postulating drop events. Incorporating the certified Holtec cask handling design for Diablo Canyon, the requirements for cask handling are presented in the Proposed Diablo Canyon ISFSI Technical Specification 4.3.

The commitments to NUREG-0612 as it applies to each of the load-bearing components in the transfer cask, overpack, transporter, and associated lifting devices are summarized in Diablo Canyon ISFSI SAR Sections 4.2.3.2.4, and 4.3.2.2 through 4.3.2.9. Additional detail on these commitments is provided in the table below: Refer to Diablo Canyon ISFSI SAR, Amendment 1 for corrections to NUREG-0612 reference made in Sections 4.3.2.2 and 4.3.2.3 and Table 4.3-1.

COMPONENT	NUREG-0612 SECTION	DESIGN CODE	SAFETY FACTORS
Transporter Lift Points, Overhead Lift Beam, and Vehicle Body*	5.1.6	ASME III, NF, Class 3 for Linear Structures or AISC**	Per applicable Design Code
Transfer Cask Horizontal Lift Rig	5.1.6	ANSI N14.6	6 (Yield) 10 (Ultimate)
Transfer Cask Lift Slings	5.1.6	ASME B30.9	10
HI-TRAC Lift Links and Attachment Pins	5.1.6	ANSI N14.6	6 (Yield) 10 (Ultimate)
HI-TRAC Lifting Trunnions	5.1.6	ANSI N14.6	6 (Yield) 10 (Ultimate)
MPC Downloader Slings	5.1.6	ASME B30.9	10
MPC Lift Cleats and attachment points	5.1.6	ANSI N14.6	6 (Yield) 10 (Ultimate)
HI-STORM Lifting Brackets and attachment points	5.1.6	ANSI N14.6	6 (Yield) 10 (Ultimate)
HI-STORM Lift Links and attachment pins	5.1.6	ANSI N14.6	6 (Yield) 10 (Ultimate)

* Vehicle body means load-supporting members whose failure could result in an uncontrolled lowering of the load.

** Whichever is more limiting.

<u>Question 4-3</u>

Provide justification for the proposed Diablo Canyon Licensing Basis Velocities for Tornado-Generated Missiles in the form of (i)15.24-cm [6 in] diameter Schedule 40 pipe, (ii) 2.54-cm [1 in] diameter steel rod, (iii) utility pole, and (iv) 30.48-cm [12 in] *diameter Schedule 40 pipe, listed at the bottom of Table 3.2-2 of the Diablo Canyon ISFSI Safety Analysis Report.*

According to Section 3.2.1.1 of the Diablo Canyon ISFSI Safety Analysis Report, the tornado-generated missiles evaluated for the Diablo Canyon ISFSI are a compilation of those from the 1996 Diablo Canyon Power Plant Final Safety Analysis Report Update; NUREG–0800 (NRC, 1987), Section 3.5.1.4 Spectrum II missiles; and three 500-kV tower missiles specific to the Diablo Canyon ISFSI site. A review of the table indicated that the descriptions and masses for four missiles identified in the first sentence of this comment are consistent with Missiles B, C, D, and E of the Spectrum II missiles listed in NUREG–0800 (NRC, 1987); however, the associated velocity values are substantially smaller than those provided in NUREG–0800 (NRC, 1987).

This information is necessary to determine compliance with 10 CFR §72.92(a) and §72.122(b).

PG&E Response to Question 4-3

Diablo Canyon ISFSI SAR Section 3.2.1.1 states that the tornado winds and missile evaluations for the ISFSI are based on the DCPP site licensing-basis wind speed of 200 mph (SAR Table 3.2-1). The NUREG-0800 (NRC, 1987) missile velocity values are based on Regions I, II, and III, which have velocities of 360 mph, 300 mph, and 240 mph respectively, as stated in Regulatory Guide 1.76. The DCPP licensing-basis velocities for tornado-generated missiles (SAR Table 3.2-2) are based on excerpts from a1996 Simiu, E & R. Scanlan article titled Wind Effects on Structures: Fundamentals and Applications to Design 3rd Edition (Attachment 4-1). This article is a more recent version of the article referenced in NUREG-0800, Section 3.5.1.4. It provides a methodology and an associated equation (below) for establishing a correlation power factor to convert the maximum horizontal missile velocity by using the Tornado Type III curve for the 240 mph tornado in Figure 16.3.1 from the article stated above, to the maximum horizontal missile velocity corresponding to a 200 mph tornado event. The correlation power factor and maximum velocities were derived using the following equation:

$$\left(V_H^{\max}\right)_{lower\ tornado\ event} = \left(\frac{V_{lower}}{V_{higher}}\right)^N \left(V_H^{\max}\right)_{higher\ tornado\ event}$$

The given velocities from NUREG-0800 were used as a standard to find the correlation factor for an unknown velocity. This correlation factor was then used in the same equation to solve for the unknown maximum horizontal missile velocity for a tornado velocity of 200 mph. The values in SAR Table 3.2-2 are substantially smaller than those provided in NUREG-0800 because of the 40 mph velocity difference between the tornado wind speeds of the lowest velocities provided by NUREG-0800, Region III 240 mph and the 200 mph DCPP site licensing-basis wind speed.

As noted in SAR Table 3.2-2, the Holtec velocities are based on a Region II 300 mph wind velocity. A theoretical wind velocity of 300 mph greatly bounds the possible site wind speed of 200 mph and therefore ensures compliance with 10 CFR §72.92(a) and §72.122(b).

<u>Response 4-4</u>

Provide information to verify that the forces imposed on the transporter roadway, from the fully loaded transporter, are within design criteria of the as-built pavements and subgrade.

Section 4.3.2.1.1 of the Diablo Canyon ISFSI Safety Analysis Report only states that, "It is designed with two steel tracks to spread out the load on the transport route surface as a distributed pressure load."

This information is necessary to determine compliance with 10 CFR §72.24(b) and §72.24(c).

<u>PG&E Response to Question 4-4</u>

The roadways along the transport path were constructed, and have been maintained, to California highway standards (CALTRANS) for heavy vehicular traffic and have performed well. Evaluations show that the roadway and pavements will support the loads imposed by the transporter. The condition of the roadways and pavements will be monitored and periodically upgraded to ensure continued safe transport of spent fuel to the ISFSI and off-site.

<u>Transport Path</u>

When constructed, the plant site roadways comprising the transport route consisted of: 3-inch thick plant mix Type B asphalt, concrete with 3/4-inch maximum aggregate, and 85 - 100 penetration grade paving asphalt bituminous binder; 7 inches of Class 2 aggregate base with 3/4-inch maximum aggregate; and 10 inches of aggregate subbase with 100 percent passing the No. 3 sieve and minimum values of sand equivalent and resistance values (R values) of 20 and 50, per California Test Methods T-217 and -301 respectively. Design and construction complied with PG&E specifications and the 1964 CALTRANS Standard Specification.

Reservoir Road was constructed to the same specifications except that aggregate courses are each 4 inches thick. The road was initially constructed as a haul road for Unit 1 plant and borrow excavation, and surfaced after heavy earth moving equipment left the site. The pavement was designed to accommodate H-20 trucks, forklifts, and earthmoving equipment.

In the mid-1980s, a 2-inch thick asphalt concrete overlay was applied to plant site roads and Reservoir Road. A seal coat was applied in the late 1990s.

Original soil below the roadbed and fill within 2.5 ft of the finished grade was compacted to a density of 95 percent. Embankments were built one-half width at a time; hillside and embankment slopes were benched at least 6 ft horizontally as the fill was brought up in layers. Minimum relative compaction for the embankment was 90 percent. Compaction testing was per California Test Method T-216 (similar to modified proctor). Sandstone is located close beneath much of the roadway section in portions of the route located east of the auxiliary building and on Reservoir Road above elevation 190 ft; elsewhere on Reservoir Road roadway, fill is constructed of stiff sandy and gravelly clay material over rock.

The road surfaces and granular base are well drained by lined roadside drainage ditches. The ground water table does not reach the level of the roadway embankment at any point along the transport route.

Transporter Operation

The loaded transporter will travel slowly along the transport route. On Reservoir Road, the transporter will normally be offset from the centerline of the road toward the mountain side of the road. Total vehicle weight is 445,000 pounds. The transporter has 10 axles and 2 tracks, which are 294 inches x 29.5 inches in size and spaced at 192 inches center to center.

Discussion

The stability of the transport path on hillside portions of Reservoir Road under combined seismic and transporter loads was demonstrated in Calculation GEO.DCPP.01.28 (submitted in PG&E letter DIL-01-004 dated December 21, 2001. All sections of the roadway will support the loaded transporter with adequate margin (the estimated static factor of safety is at least 2). The controlling case for road qualification is the section of the roadway underlain by alluvial deposits (Calculation GEO.DCPP.01.28). Localized portions of Reservoir Road underlain by relatively small engineered fills, which extend across the entire roadway and are placed on benched rock and soil, were evaluated as being bounded by the controlling alluvial deposit portions of the roadway.

The existing asphalt concrete surfacing and overlay are in good condition and are supported by good crushed rock base and subbase and subgrade materials.

The roadway pavement sections will support traffic loads imposed by the transporter. Loads were assumed to be evenly divided among its road wheels and tracks to conservatively assess localized bearing stresses and also to look at its contribution (in terms of load equivalence factors, e.g., number of passes of equivalent 18 kip single axles with dual tires) to traffic related fatigue and deterioration of the pavement structural section.

The bearing capacity of the pavement structure is adequate to support the assumed concentrated bearing pressures imposed by the transporter.

The roadway pavement sections will support the load imposed by the transporter. Facilities and structures buried in or adjacent to the path have been identified and evaluated for impact of loading on the buried facilities and pavement; compensatory measures will be taken for each transporter move, e.g. the path will bypass the radwaste turntables and pavement will be temporarily protected where tight turns are made.

Prior to ISFSI construction, the movement of each loaded transporter, and periodically thereafter, the condition of the roadway sections and paving will be reviewed and upgraded. These reviews and upgrades will be performed as required to accommodate the heavy vehicle, to repair any pavement distress, and to maintain the useful life of the pavement.

The new Patton Cove bypass road embankment and pavement will be designed to accommodate all transporter movements.

Chapter 5. Installation and Structural Evaluation

Question 5-1

Provide an evaluation to support the conclusion that the concrete will not break out of the storage pads prior to failure of the ductile metal members.

The Diablo Canyon ISFSI Safety Analysis Report (Section 3.3.2.3, ISFSI Concrete Storage Pad: Design Criteria) states that the design strength capacity of the embedded base plate, concrete bearing, and diagonal tension shear capacity are in accordance with the design provisions of American Concrete Institute 349-97 and the embedded anchorage will meet the ductile anchorage provisions of the Proposed Draft New Appendix B to American Concrete Institute 349-97 (dated October 1, 2000). Supporting evidence that the concrete will not break out prior to failure of the ductile metal members is not provided in the Diablo Canyon ISFSI Safety Analysis Report. An evaluation of concrete breakout strength in tension of a group of anchor rods considering spacing and edge distance should be provided.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

PG&E Response to Question 5-1

BACKGROUND

Each loaded cask delivers a total shear load of 515 kips (for all 16 anchors) and a maximum pull-out tension load of 62.13 kips in the highest loaded anchor under a seismic event. These loads must be carried into the ISFSI concrete by the anchorage design as outlined in Reference 1. These loads, along with other design requirements such as satisfying stiffness requirements and minimizing pad uplift in a seismic event resulted in an anchorage system, consisting of 16 anchors per cask perimeter each 2.5 inches in diameter and 71.13 inches in length (See Reference 1, Page 20).

At the time of design of this anchorage system, the design team was aware of the pending new Appendix B to ACI 349-97 (draft dated October 2000). The design team was also aware that the NRC had never officially endorsed the old Appendix B to ACI 349-97 code (Reference 2). Therefore it was decided that the design would meet the requirements of the new proposed Appendix B. Since then, the new Appendix B has been officially issued as part of release of ACI 349-01 Code (Reference 3).

Section B.4.2.2 of Reference 3 states that for anchorage systems having diameter larger than 2 inches and anchorage length greater than 25 inches, the anchorage capacity shall be determined based on test data, and that the general equations of anchor pull-out and shear capacities are not applicable to anchors exceeding these size limitations because of lack of available test data.

Since it was obvious that the DCPP cask anchorage system would exceed these size limitations, the design team decided to adopt a new design philosophy, which would meet the intent of Appendix B as described below.

DESIGN PHILOSOPHY

The design philosophy adopted was to deliver the design pull-out and shear loads into concrete as follows:

(1) The tension pull-out load was to be carried from the cask using 16 tension tie-rods (also referred to as round bars in Reference 1) which would not only satisfy the stiffness requirements of design, but were designed to deliver the load to the concrete through upward compression imposed by a large 7.5- inch square plate (called the anchor plate in Reference 1) attached at the lower end of these tension tie-rods. This upward compression load into concrete would in turn, be resisted by concrete bearing and diagonal shear of the appropriate concrete section.

(2) The imposed horizontal shear load was to be delivered into concrete by bearing action of the "coupler" mechanism, which is located at the top of the tension tie-rods, against the surrounding concrete. The shear load is then resisted by

concrete through side bearing action. The tension tie-rods are not relied on to deliver any shear into concrete as a typical anchor would.

By adopting this design philosophy, the tension tie-rods supported by large base-plates (referred to as anchor plates in Reference 1) were treated as inverted columns on base plate, and were no longer treated as anchorage under jurisdiction of Appendix B. Therefore the design was carried out in accordance with shear provisions of the main body of the code (Sections 11.1 through 11.5 of Reference 2). However, to ensure that the intent of Appendix B is met, the design was carried out to achieve a ductile design by ensuring the following:

(1) That the concrete bearing and diagonal shear pull-out capacities as adjusted by appropriate code required strength reduction ϕ factors are larger than the ultimate capacity of tension tie-rods

(2) That the ultimate capacity of a tension tie-rod is larger than it's corresponding yield capacity

(3) That the yield capacity of a tension tie-rod was significantly larger than the demand tension pull-out load

This design philosophy ensured that not only there would be significant margin between the demand load versus the yield capacity of the tension tie-rods, but the tension tie-rod yield capacity would be lower than it's ultimate capacity and the code capacity of all other supporting members in the load path such as concrete and anchor plate, thus ensuring ductile behavior of tension tie-rods in the unlikely event that the imposed demand would equal the yield capacity of the tension tie-rods.

The detailed load paths for tension pull-out and shear loads are further described below.

<u>TENSION PULL-OUT LOAD PATH</u>

The load path for the tension pull-out load from the cask into concrete is through 16 pre-loaded bolts, which are each, tied to a coupler at top of the concrete. This load is then transmitted through the coupler into what is called a tension tie-rod (also referred to as round bar in Reference 1). These tension tie-rods are 2.5 inches in diameter and 71.13 inches in length (Reference 1, page 20). At the lower end of each tension tie-rod is a 7.5-inch square anchor plate (Reference 1, page 22, section 6.4). The tension pull-out load is transmitted into concrete through the bearing action of the anchor plate as an upward compressive force against the concrete. This vertical compressive load can also be resisted by concrete as a diagonal shear through the ISFSI cross section.

To ensure that the intent of Appendix B is met, and a ductile design is achieved, first it was ensured that the ultimate capacity of each tension tie-rod exceeds its yield capacity. This check is done in Reference 1, page 21, section 6.3, where the ultimate capacity is calculated as 220.34 kips versus yield capacity of 176.72 kips. This section also calculates the required ductile design strength for each tension tie-rod as 235.63 kips. The 7.5-inch square anchor plate is then sized (Reference 1, page 22, section 6.4) so that its design strength and corresponding concrete strength in bearing exceed the required ductile design strength of the tension tie-rod. Furthermore, the diagonal shear strength of the concrete is checked (Reference 1, Section 6.6) to ensure that it also exceeds this required ductile design capacity of 235.63 kips. Therefore this design would ensure that the tension tie-rods are the ductile element in the entire tension load path since its ultimate capacity of 220.34 kips is lower than design strength of the supporting anchor plate, and the various concrete strengths based on code equations reduced by appropriate ϕ factors. Furthermore, this ultimate tensile capacity of 220.34 kips was calculated based on the reduced section at the threaded root of the tension tie-rods (Reference 1, page 21) which is approximately 125 percent of the yield capacity of the unreduced gross section of the tension tie-rods computed as 176.72 kips (See Reference 1, page 21). These tension tie-rods are made of A36 steel, which has a well-defined yield plateau. Thus, if any overload occurs, the tension tie-rods will yield before any less ductile failure could occur, therefore ensuring a ductile behavior as intended by Appendix B of References 2 and 3.

Lastly, the yield strength of the tension tie-rods (176.72 kips) is more than 280 percent of the computed demand load of 62.13 kips per tension tie-rod thus ensuring substantial margin against yielding.

SHEAR LOAD PATH

Each cask has a total demand horizontal shear load of 515 kips, which needs to be delivered into concrete. Even though the cask bolts have high pre-load in each of the cask bolts thus ensuring adequate friction to resist the applied shear load, the design conservatively did not take credit for this frictional resistance. The load path of the applied shear load is through the couplers at the top end of tension tie-rods into bearing resistance of concrete. This check is done in Reference 1, pages 16 through 19, section 6.2. As stated on page 19 of Reference 1, the allowable shear load on the coupler as limited by concrete bearing is calculated as 1,350.4 kips, which is 260 percent of the demand shear load of 515 kips.

The tension tie-rods are not counted on to deliver any shear into concrete as a normal anchor system would; therefore provisions of B.4.1.1 and B.4.1.2 of Reference 3 are not applicable.

SUMMARY

The RAI requests supporting evidence that the concrete will not break out prior to failure of ductile metal members allowing for grouping of anchors and edge distance. The tension tie-rods are not treated like anchors for the reasons stated above in the design philosophy. They are treated as inverted columns on base plates and are sized to have lower ultimate strength than the surrounding concrete strength in bearing and diagonal shear as provided by the provisions of the main body of the code. As such, the design ensures ductile behavior, which meets the intent of Appendix B to the ACI 349 Code. Reference 1 provides various capacity calculations for different elements in the load path, thus providing the required evidence as stated above. Furthermore the design has substantial margin between the yield capacity of the weakest element (tension tie-rods) and the imposed tension pull-out demand load.

The load path for delivery of shear load into concrete is through the coupler at the top of the tension tie-rods. As such, the tension tie-rods are not relied on to deliver any shear load into concrete.

REFERENCES

1. Calculation PGE-009-CALC-001 (submitted in PG&E Letter DIL-01-004 dated December 21, 2001)

2. Code requirements for Nuclear Safety Related Concrete Structures, ACI-349-97 code.

3. Code requirements for Nuclear Safety Related Concrete Structures, ACI 349-01 code.

Question 5-2

Specify how Pacific Gas and Electric will identify changes to the final construction design and analysis of the Diablo Canyon ISFSI storage pad and the Cask Transfer Facility.

Section 4.2 of the Diablo Canyon ISFSI Safety Analysis Report states that final construction design and analysis of the Diablo Canyon ISFSI storage pad and the Cask Transfer Facility will be completed during the detailed design phase of the project and that no significant changes are anticipated from the information presented.
Section 5.4.3 of NUREG–1567 (NRC, 2000) indicates that design descriptions should include sufficient detail to support a detailed review and evaluation, and that design analyses should be prepared such that they may be readily audited to permit determination of the sources of expressions used, values of material properties, data from other supporting calculations, and assumptions. In addition, this information is needed to assess compliance with the applicable codes, standards, and other

functional design requirements (i.e., structural design requirements for off-normal and accident loading conditions).

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

<u>PG&E Response to Question 5-2</u>

SAR Table 4.2-5 describes conformance with the General Design Criteria (10 CFR 72, Subpart F). SAR Chapter 3 describes the principal design criteria for the ISFSI. SAR Chapter 4 provides detailed design descriptions and bases, including applicable codes and standards. SAR Chapter 4 also provides information relative to materials of construction, general arrangement, dimensions of principal structures, and descriptions of all structures, systems, and components important to safety. Additional information was provided in the calculations and drawings provided via PG&E letters DIL-01-004 dated December 21, 2001; DIL-01-007 dated December 21, 2001; DIL-01-008 dated December 21, 2001; DIL-02-005 dated May 16, 2002; and DIL-02-007 dated June 4, 2002. This information provides conceptual design and appropriate analyses and calculations and also references appropriate design standards.

This information provides sufficient detail to support a finding that the ISFSI will satisfy the design bases with an adequate margin for safety. Any changes to the ISFSI licensing basis made as part of final construction design will be made in accordance with 10 CFR 72.48.

<u>Question 5-3</u>

Provide details on the heat from hydration during placement of the concrete in the storage pads.

This is a massive structure based on the 1.9-m [7.5-ft] thickness and the overall size of the individual pads. Heat generated during hydration may result in unacceptable cracking of the pad structure. Cracking of the pad may adversely affect the ability of the anchor system for the storage casks to perform its intended safety functions.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

<u>PG&E Response to Question 5-3</u>

Calculation No. 52.27.100.701, (Attachment 5-1) provides the pad temperature through the thickness of the pad (0.5 ft increments) with respect to time. This temperature data is further utilized as an input to Calculation No. PGE-009-CALC-006 (Attachment 5-2) which computes the thermal and shrinkage stresses (page 33) as well as the internal forces (Page 38) due to the cement hydration and subsequent pad shrinkage. The calculated forces are used in sizing appropriate reinforcement during the final design stage to comply with ACI code. The concrete mix design will be formulated and the placement of the concrete will be controlled such that the heat of hydration will be minimized.

Question 5-4

Identify what stresses are imposed in the surrounding foundation rocks as a result of the static and dynamic loading of the Cask Transfer Facility and assess the potential consequences. This assessment should include the technical basis for the failure criteria used and a quantification of the factors of safety.

Section 4.4.5 of the Diablo Canyon ISFSI Safety Analysis Report contains only a brief discussion of the main shell. Sufficient detail and supporting analysis must be provided to identify the load paths, demand, and capacity of the various components.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

PG&E Response to Question 5-4

The analysis of the concrete structure housing the cask transfer facility (CTF) utilized the static and dynamic rock properties provided in PG&E Calculations 52.27.100.716 (Attachment 2-1) and 52.27.100.713 (submitted in PG&E Letter DIL-02-005 dated May 16, 2002). Calculation 52.27.100.716 provides the ultimate and design allowable values for lateral resistance of the rock while Calculation 52.27.100.713 provides the ultimate and design allowable values for bearing on the rock at the bottom of the CTF.

As stated in Calculation 52.27.100.716, the ultimate lateral resistance (ultimate capacity) of the rock at the bottom of the CTF is 100 ksf (694 psi) and the equivalent uniform ultimate lateral resistance of the rock on the sides of the CTF is 50 ksf (347 psi). As stated in Calculation 52.27.100.713, the ultimate bearing capacity (failure) of the rock at the bottom of the CTF is equal to 238 ksf (1653 psi)

For load combinations involving normal operating loads, the design allowable lateral rock capacity used in the analysis was determined as recommended in Calculation 52.27.100.716 by applying a factor of safety of 2.0 to the uniform ultimate lateral resistance of the rock. Thus, a design allowable lateral uniform rock resistance of 25 ksf (174 psi) was used for the rock on the sides of the CTF for normal operating load cases.

For load combinations involving normal operating loads, the design allowable vertical resistance for the rock at the bottom of the CTF was determined as recommended in Calculation 52.27.100.713 by applying a factor of safety of 3.0 to the ultimate bearing capacity (failure). This results in a design allowable bearing capacity of 79 ksf (549 psi).

However, Calculation 52.27.100.713 further limits the allowable bearing loads to ensure that potential settlement is within the acceptable range. This requirement results in a more conservative design allowable bearing capacity of 40 ksf (275 psi). This value was used in the calculation and is the basis for determining the design safety factor as defined below.

For load combinations involving seismic loads, the design allowable lateral resistance and the design allowable bearing capacity were increased by a factor of 1.33 as recommended in Calculations 52.27.100.716 and 52.27.100.713, respectively. This equates to a design allowable uniform lateral resistance for the rock of 33 ksf (229 psi) and a design allowable bearing capacity of 52 ksf (361 psi).

<u>Design Safety Factor and Calculated Safety Factor</u>

The design allowable rock stresses used in the calculation have an implicit (built-in) minimum safety factor as shown in Table 2. This safety factor, herein referred to as the minimum design safety factor, is defined as the ratio of the ultimate capacity to the design allowable used in the calculation. As shown in Calculation PGE-009-CALC-002 (submitted in PG&E Letter DIL-01-004 dated December 21, 2001), the calculated stresses are less than the design allowable values. This yields a higher safety factor as shown in Table 2. This safety factor, herein referred to as the calculated safety factor, is defined as the ratio of the ultimate capacity to the calculated pressure. Both safety factors are provided for completeness and clarity.

As stated in Calculation PGE-009-CALC-002, the maximum pressure placed on the rock beneath the bottom of the CTF is 125 psi (page 15) for the load case involving normal operating loads and 177.8 (page 15) psi for the load combination including seismic loads. This yields a calculated safety factor of 13.2 (1653/125) for the normal loads and 9.3 (1653/177.8) for the loads including seismic.

The pressure applied to the rock on the sides of the CTF can also be determined from Calculation PGE-009-CALC-002. Using the conservative assumptions described in the calculation, the total lateral pressure that must be resisted by the rock is 1939 kips (page 21). This pressure is resisted by a section of rock that is, ignoring the top 3 ft where the capacity is lower, 10 ft –10-1/4 inches (130.25 inches) x 6 ft –7-1/2 inches (79.5 inches). This results in an equivalent uniform lateral pressure of 187.3 psi {(1939 x 1000)/(130.25 x 79.5)}. Since the equivalent uniform ultimate lateral resistance (ultimate capacity) of the rock on the sides of the cask transfer facility is

347 psi as shown in PG&E Calculation 52.27.100.716, the calculated factor of safety is 1.85 (347/187.3). This factor of safety is for load combinations that include seismic forces. Normal operating loads essentially produce no pressure on the rock on the sides of the CTF. Thus, the factor of safety for the normal operating condition is near infinity.

The following Table 1 provides a summary of the calculated safety factors. Table 2 provides an overall summary of the allowable design values used in the calculation and the resulting minimum design and calculated safety factors.

Refer to the response to RAI 5-6 for information on the structural design and analyses of the CTF, including load paths, demand and capacity of the main shell, and various CTF components.

TABLE 1 - Calculated Safety Factors

	Rock beneath CTF	**Rock on sides of CTF**
Maximum Ultimate Resistance of the rock	238 ksf = 1653 psi	50 ksf = 347 psi
Pressure applied to rock (normal loads)	125 psi	≈ 0
Calculated Safety Factor: Ultimate Capacity/ Calculated Applied Pressure	1653/125 = 13.2	≈ ∞
Pressure applied to rock (seismic loads)	177.8 psi	187.3 psi
Calculated Safety Factor: Ultimate Capacity/ Calculated Applied Pressure	1653/177.8 = 9.3	347/187.3 = 1.85

TABLE 2 - Overall Summary of Factors of Safety

	Ultimate Capacity (ksf)	**Design Allowable (ksf) (Normal Accident)**	**Min. Design SF Ultimate Capacity Design Allowable (Normal/Accident)**	**Calculated SF Ultimate Capacity/Calculated Pressure (Normal/Accident)**
Vertical Pressure	238	40/52	5.95/4.58	13.2/9.3
Lateral Pressure (Equivalent Uniform)	50	25/33	2.0/1.5	NA/1.85

Question 5-5

Provide the material specifications and mechanical properties for the seismic anchor system including the embedment plate, compression coupling blocks, anchor rods, and anchor plates.

NUREG–1567 (Section 5.4.1.3) states that the Safety Analysis Report must (i) establish compatibility of materials and coatings to be used with the environments to be experienced; (ii) provide tables with material properties and allowable stresses and strains associated with temperature, as appropriate; and (iii) establish appropriate corrosion allowances and demonstrate these allowances are acceptable in the applicable structural analyses. Section 4.4.5.3 of the Diablo Canyon ISFSI Safety Analysis Report contains a statement that the main shell at the Cask Transfer Facility and its foundation are sufficient, but no supporting information is provided.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d); §72.24(i), and §72.122(b).

PG&E Response to Question 5-5

The embedded cask anchorage system (i.e., embedment ring, coupling, rods and embedded plates and jam nuts) is constructed of carbon steel material. Refer to SAR Figure 4.2-6 (Holtec Drawing 3769, item 4) for the cask anchor stud and drawing number PGE-009-SK-301 and –302 for the embedded anchorage in the concrete pad (See Appendix "DOC 1" to Calculation PGE-009-CALC-001, which was submitted in PG&E Letter DIL-01-004 dated December 21, 2001).

The steel components exposed to the environment (such as the top exposed surface of the embedment ring), will be properly coated per DCPP coating specifications, similar to the components in the power plant also located in the outdoor environment (see also the response to RAIs 16-2 and 18-14). The ISFSI reinforced concrete pad is located approximately 1/4 mile from the coastline at approximately 300 ft elevation and is not subjected to the harsh saltwater atmosphere that exists at other marine structures (such as the intake structure) located at DCPP. Existing DCPP structures with similar construction (i.e., uncoated reinforcement with minimum concrete cover per ACI Code) and environmental exposure conditions, as proposed for the ISFSI pad (e.g., the containment structure, auxiliary building), have been in service for over 20 years at DCPP and have shown no evidence of adverse degradation due to embedded steel corrosion. In order to provide necessary corrosion protection for the given environmental exposure, construction requirements specified in ACI 349 Part 3, Chapters 4 and 5, will be followed. These requirements include meeting the concrete durability requirement for the maximum water to cement ratio and a minimum compressive strength and providing the minimum concrete cover for the reinforcing steel based on placement. To provide added protection from the potential of reinforcing steel corrosion, the concrete pad surface will be maintained with a penetrating, breathable, water-repellent sealer to protect the concrete surfaces exposed to weather and marine air.

No corrosion allowance was applied to the embedded anchorage as necessary measures are taken to minimize / prevent the possibility of water intrusion into the pad. The pad will also be periodically and visually inspected as part of the 10 CFR 50 DCPP Maintenance Rule Program to monitor the materiel condition of the facility and its components.

Refer to the response to RAI 5-6 for a more detailed response to the cask transfer facility design and analysis.

<u>Question 5-6</u>

Provide additional information on the structural design and analyses of the Cask Transfer Facility given in Holtec Report No. HI–2012626, including (i) the main shell and the method used to anchor it to the surrounding concrete; (ii) the jack support platform; (iii) the lifting platform; and (iv) the Cask Transfer Facility concrete structure and the method used to anchor it to the surrounding rock foundation.

NUREG–1567 (Section 5.4.4.4) states that design analyses should be prepared such that they may be readily audited to permit determination of the sources of expressions used, values of material properties, data from other supporting calculations, and assumptions. Furthermore, NUREG–1567 (Section 5.5.4.) states that the following must be identified: (i) all dimensions, including locations, sizes, configurations, and weld specifications; (ii) structural materials with defining standards or specifications, including test requirements such as brittle fracture testing; (iii) fabrication, assembly, and test procedures for assemblies and subassemblies; and (iv) weld materials and weld codes, including pre- and post-heat requirements.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d); §72.24(i), §72.82, and §72.122(b).

PG&E Response to Question 5-6

The cask transfer facility (CTF) structure is fully embedded in the ground. The top of the structure is at grade and the bottom of the concrete base slab is approximately 20 ft below the surface of the adjacent competent rock (ref. Diablo Canyon ISFSI SAR Figure 4.2-4). Once the base slab is poured, the main shell steel structure is placed, plumbed and anchored to the base slab. Concrete is placed between the exterior surface of the main shell and the surrounding competent rock. Following concrete placement, the main shell remains embedded in the concrete.

The concrete portion of the facility is designed to transfer all loads to the rock in direct bearing of the concrete on the rock. The analysis demonstrates that all stresses in the concrete and the rock remain less than the allowable limits under all design conditions. Therefore, it is not necessary to anchor the concrete structure to the rock.

The design of the CTF is described in Calculation PGE-009-CALC-002, (submitted in PG&E Letter DIL-01-004 dated December 21, 2001). This calculation demonstrates that the concrete structure is capable of resisting all applied loads and adequately transferring these loads to the surrounding rock. This includes all applicable loads from the transporter, the CTF structure and the fully loaded cask. This calculation considers all operating loads in addition to other applicable loads including seismic.

Holtec Report HI-2012626, (submitted in PG&E Letter DIL-01-007, dated December 21, 2001), was intended to demonstrate the feasibility of the CTF conceptual design by modeling major components and developing the loads transmitted to the concrete support structure. The description of load paths is provided in Section 1.2. The demand and capacity of the main shell and various major components are provided in the Attachment A, Section A.10. The summary of safety factors of the major components is provided in Attachment A, Section A.11. In addition to the information provided in Report HI-2012626, Drawing 3770 (Diablo Canyon ISFSI SAR Figure 4.4-3) provides materials of construction and major dimensional information for the CTF. Diablo Canyon ISFSI SAR Table 3.4-5 specifies that ASME Section III, Subsection NF, Appendix F, NUREG-0612, and ACI-349 (including draft Appendix B) are the governing codes for the design of the CTF. These codes provide requirements for design, materials, welding, inspection, brittle fracture testing, etc., which will be reflected in the final design and procurement documents. Fabrication, assembly, and test procedures will be developed in accordance with the design criteria and specifications, drawings, and applicable codes after final design is complete.

For added documentation, PG&E submitted the Holtec-proprietary design criteria document for the CTF (HI-2002570) in PG&E Letter DIL-02-011, dated October 15, 2002, which provides additional detail of codes and standards, as well as performance requirements. The aforementioned documents provide the complete set of information available regarding the design of the CTF, including the main shell, jack support platform, and lifting platform. The final design will be performed in accordance with these design criteria and codes and the detailed design documents will include all of the information requested in this RAI. These design documents will be made available for inspection to allow verification that the final design is in accordance with the commitments made in the licensing basis. After construction, the CTF will be functionally tested prior to use.

Question 5-7

Provide an assessment of potential impact loads between the storage cask and the Cask Transfer Facility during an earthquake, or justify why they do not need to be considered as part of the analysis identified in Section 4.4.5 of the Diablo Canyon ISFSI Safety Analysis Report.

NUREG–1567 (Section 5.5.1.4) states that normal, off-normal, and accident load conditions should be defined and evaluated.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

PG&E Response to Question 5-7

There are no impact factors considered in the CTF analysis. After the empty overpack is positioned in the CTF, any radial gaps between the CTF shell and the body of the overpack just below the top of the CTF are closed to the extent practical by adding metallic shim material at the top of the CTF shell. The overpack base is restrained from sliding, relative to the platform, by vent plates welded to the platform top plate. The lifting platform is restrained against lateral movement by compression bars that ride up and down with the platform as the traveling nut moves along the jack screw. Assumption 3.5 in Section 3 of Holtec Report HI-2012626 recognizes that small gaps may still remain even after addition of shims to close the gap. These very small gaps (compared to the scale of the structure) may give rise to high frequency impact forces upon contact. However, since the structural analysis for Code qualification focuses on the response to low frequency loads from a seismic loading, any high frequency impact loads arising from the existence of any remaining very small gaps after shimming have been omitted.

After MPC transfer, the lid is installed on the loaded overpack, the shims are removed, and the CTF lift platform raises the overpack to the full up position. The time the loaded overpack may be in the CTF is limited to 22 hours by Proposed Diablo Canyon ISFSI Technical Specification Limiting Condition for Operation (LCO) 3.1.2. The actual time between MPC transfer into the overpack and raising the overpack out of the CTF is expected to be less than an operating shift, or 8 hours. The thermal implications of installing these shims are bounded by the 22-hour time limit of this LCO. In the "Applicable Safety Analysis" section of the bases for LCO 3.1.2, it is reported that if the loaded MPC is in the transfer cask and the transfer cask is located in a cask pit, the fuel cladding temperatures remain below the short term limit for up to 22 hours. This 22-hour limit is computed assuming only 10 percent of normal heat transfer capability while the MPC is in the transfer cask. This accident event is discussed in more detail in HI-STORM FSAR Section 4.5.2.1. With the seismic restraint shims in place between the loaded overpack and the CTF walls, there will still be some convective heat transfer through the overpack, albeit not at a rate commensurate with the conditions on the ISFSI pad. However, the analysis supporting the 22-hour time limit in the CTF provides a bounding case to ensure fuel cladding temperature limits are not exceeded.

<u>*Question 5-8*</u>

The analysis of the Cask Transfer Facility under seismic loading, given in Holtec Report No. HI–2012626, is performed using a quasi-static method. Provide the engineering basis for the assumption that the various components can be considered rigid. For example, identify what the axial mode of the screw jacks is when loaded by the HI-STORM 100 storage cask and multi-purpose canister. Identify what the buckling load for the screw jacks is when the system is at the top of its travel.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

<u>PG&E Response to Question 5-8</u>

The analyses performed in Holtec Report HI-2012626 considered the lifting/lowering operation to be a normal condition subject to dead and wind loading. Loadings involving seismic events were considered only for the longer duration scenario when the loaded stack was supported by the base of the CTF. In this configuration, the lowest frequencies are associated with lateral bending of the stacked configuration as a beam-like structure. These lateral frequencies are computed in Attachment E of HI-2012626 and are use to establish load amplifiers for lateral loads imposed by the stacked casks due to seismic effects. The vertical frequency of the stacked casks is in the rigid range, so no amplifier is used for vertical loads when the system is resting on the base of the CTF.

The screw jacks are only loaded in the short duration when the HI-STORM is being raised or lowered. When the HI-STORM is in the full-up position, the screw jacks have a minimal free length and the vertical natural frequency of the screw jack/loaded cask plus platform system is in the rigid range. The screw jacks are hung from the top; the lower screw jack support is to provide lateral support to the long screw. When loaded, the screw jack tensile load is always reacted at the top of the screw jack by the screw jack support structure. There is no mechanism by which large compression can be applied to the screw jack supports. Therefore, screw jack stability under compressive loading is not considered, nor is it a concern. Nevertheless, a straightforward calculation of the classical Euler buckling load of one screw jack, based on considering the maximum travel length of the platform as the unsupported length of the screw jack, gives the classical buckling load as 1,582,538 lb. This classical buckling load is over five times the rated capacity of the screw jack in tension.

<u>Question 5-9</u>

Provide operational and design details of the proposed fail-safe features identified in Section 3.3.3.2 of the Diablo Canyon ISFSI Safety Analysis Report that are intended to automatically shut-down the cask transporter into a safe, stopped, and braked condition if the operator is injured for any reason while handling a loaded cask.

NUREG–1567 (Section 5.5.4.) states that text descriptions along with drawings, figures, tables, and specifications included in the application should fully describe structures, systems, and components important to safety.

This information is necessary to determine compliance with 10 CFR §72.24 and §72.82.

<u>PG&E Response to Question 5-9</u>

The detailed design of the cask transporter has not yet begun. Compliance with the commitments in the Diablo Canyon ISFSI SAR (including referenced codes, as applicable) may be verified by inspection prior to ISFSI operation. Section 4.3.2.1 of the Diablo Canyon ISFSI SAR includes the following commitments for the transporter design in this regard:

- The cask transporter will have an automatic drive brake system that applies the brakes if there is a loss of hydraulic pressure or the operator releases the controls.

- The cask transporter will be equipped with a remote cut-off switch that shuts off the motor and automatically applies the brakes in the event that the operator cannot release the controls. The remote cut-off switch will be readily accessible from the ground when standing at the access ladder.

- The cask transporter brake system will be capable of stopping the cask transporter when handling a fully loaded transfer cask in the horizontal position with the cask transport frame attached on the maximum designed grade.

- The cask transporter will be designed to be incapable of coasting on a 10 percent downward grade with the brakes disengaged when handling a fully loaded transfer cask in the horizontal position with the cask transport frame attached.

A full description of the applicable codes, design criteria, and performance requirements for the cask transported are included in Holtec Report HI-2002501, (submitted in the PG&E Letter DIL-02-011 dated October 15, 2002).

The cask transporter is a commercially designed device that will be qualified by test prior to initial use as stated in SAR Table 4.5-1. There are no unique or novel aspects to the cask transporter design compared to tracked vehicles used in other industrial applications. In addition, ASME B30.5, "Mobile and Locomotive Cranes" Crane Manufacturer's Association Specification No 70 (CMAA 70), and NUREG-0554, "Single Failure Proof Cranes for Nuclear Power Plants," to the extent they can be applied to the cask transporter, will be consulted for guidance in designing the drive, control, and emergency stop systems to ensure the cask transporter is stopped and shut down if the operator becomes incapacitated for any reason.

The following information was provided by a crawler manufacturer regarding the braking system used:

(1) Positive action by the operator (i.e., movement of a joystick) must be taken and the joystick must be maintained in position to move the vehicle. There is no "lock-in" feature that allows the vehicle to continue moving if the manual control of the joystick is removed. Primary braking is achieved by using the hydrostatic transmission. When the joystick is released, flow from the transmission pump is stopped; therefore the hydraulic motor that drives the vehicle, which itself is driven by the transmission pump, is stopped. This provides a dynamic braking effect, which is fairly smooth. Also, the grouser plate assembly has an extremely high rolling resistance, which adds to the braking effect.

(2) The secondary brake system (emergency/parking brake) is in the drive gearbox. This system is spring applied, hydraulic released. When pressure to the brake circuit is removed, the springs will engage brake disks in the planetary gearbox. To activate, there is a palm button located on the console to remove the pressure from the brake circuit.

(3) There are no particular codes or standards used in the brake design. The brake design employed is the same as that used in almost all excavators worldwide. These machines receive a "TUV" approval in Germany. "TUV" is a government inspection that verifies that the brake systems operate properly and the machines require annual inspections to maintain this rating.

Lastly, there will be at least three emergency stop stations on the vehicle. One is located in the operator's cab and two are located opposite from one another outside the cab to allow escort personnel to stop the vehicle if the operator becomes incapacitated or the vehicle cannot maintain directionality or speed for any reason.

Question 5-10

Provide design analyses and calculation packages for the cask transporter, including (i) slings and special lifting devices; (ii) cask transporter lift points, overhead beam, vehicle body, and seismic restraints; and (iii) lifting towers.

NUREG–1567 (Section 5.4.4.4) states that design analyses should be prepared such that they may be readily audited to permit determination of the sources of expressions used, values of material properties, data from other supporting calculations, and assumptions. Furthermore, NUREG–1567 (Section 5.5.4.) states that the design analyses must identify: (i) all dimensions, including locations, sizes, configurations, and weld specifications; (ii) structural materials with defining standards or specifications, including test requirements such as brittle fracture testing; (iii) fabrication, assembly, and test procedures for assemblies and subassemblies; and (iv) weld materials and weld codes, including pre- and post-heat requirements.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), §72.82, and §72.122(b).

PG&E Response to Question 5-10

The final design of the cask transporter has not yet begun. Holtec Calculation HI-2012768, "Transporter Stability on Diablo Canyon Dry Storage Travel Paths", previously submitted in PG&E Letter DCL-01-007, dated December 21, 2001, was performed to confirm that a standard crawler design will be stable while performing its design functions. The cask transporter is a commercial design similar to those used in other industrial applications and, overall, is not unique to nuclear. However, as committed in the Diablo Canyon ISFSI SAR, Tables 3.4-4 and 4.3-1, the detailed design of the components comprising the transporter and associated lift devices will be in accordance with either ASME Section III, NF or NUREG-0612 (including daughter codes and standards) to ensure that the probability of load drops is sufficiently small that it may be considered incredible.

Please see the response to RAI 4-2 for a detailed listing of the applicable design codes and safety factors for the cask transporter and associated lifting devices. The response to RAI 5-9 provides discussion on the design of the cask transporter drive, control, and braking systems. The final cask transporter design will be developed in accordance with these codes and standards. Design analyses and calculations will be performed as necessary to ensure compliance with the commitments in the Diablo Canyon ISFSI licensing basis. These documents will be available for inspection prior to use of the cask transporter at the ISFSI.

Question 5-11

Provide design analyses and calculation packages that justify the assumption that the components of the cask transporter including (i) overhead beam, (ii) vehicle body, and (iii) lifting towers are rigid to 33 Hz

Use of static design assumes that the elements are rigid within the frequency range of the loading. Structural beam properties needed to ensure a rigid structure are more stringent than those required to resist other loadings. NUREG–1567 (Section 5.5.4.4) states that all load combinations for structures, systems, and components important to safety must be appropriately evaluated.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

PG&E Response to Question 5-11

The final design of the cask transporter is not yet complete. However, in response to this RAI, conceptual design studies were performed to validate the statements in the Diablo Canyon ISFSI SAR pertaining to cask transporter rigidity. These studies, as described below, demonstrate that the cask transporter, as a system, will behave as a rigid body, and that if the lift beam is modeled as flexible, the differences in the results of the existing stability analyses docketed in support of this application are insignificant. No changes to the information currently in the SAR pertaining to the cask transporter design and analysis are being made since this information is conceptual and any changes to the results of the design analysis and calculations during final design are not expected to be significant. Revisions to the licensing basis documents, SAR, calculations and analyses will be made as part of the Diablo Canyon ISFSI FSAR, which is currently envisioned to be submitted in accordance with 10 CFR 72.70 within 90 days after issuance of the license.

The cask transporter will ultimately be engineered to provide a kinematic response that simulates a rigid body under the seismic excitations postulated for the Diablo Canyon ISFSI and the transport route. The SARs statements pertaining to the cask transporter's rigidity are not intended to imply that all internal members of the cask transporter will behave, individually, as rigid bodies in a seismic event. Rather, the SAR commitment is focused to ensure that the global response of the loaded cask transporter, after final design, will not have dynamic amplifications that are typical of structures with natural frequencies in the range of the significant harmonics of the seismic input.

Specifically, of the three principal constituents of the cask transporter referred to in the RAI (the overhead beam, the vehicle body, and the lifting towers), the overhead beam and the lifting towers are beam-type structures (See Figure RAI 5-11-1). The vehicle body, on the other hand, is a three-dimensional weldment composed of plate, shell and beam element parts assembled on a large "caterpillar" base, resulting in a large platform, low center-of-gravity machine. Figure RAI 5-11-1 represents the conceptual design of the Diablo Canyon ISFSI cask transporter. The approximate dimensions of the vehicle body are 30 ft long (axial direction) by 18-1/2 ft wide (lateral direction) by 7 ft high. Although the final transporter design dimensions are likely to be somewhat different from the conceptual design dimensions cited above, it is evident that a dynamic amplification of the vehicle body in a global deformation mode (e.g., beam type bending or twisting) is not credible. To preclude the potential of low frequency deflection modes, the cask transporter will be designed without a suspension system or rubber tires. Instead, a set of all-metal caterpillars will provide a large load bearing surface and a deep gripping action on the ground.

In contrast to the transporter body, the physical dimensions of the lifting towers and the overhead beam render them into beam-like members that, if excited in the flexural modes, may possess frequencies that lie in a range that also contain significant harmonics of the seismic motion.

Because of physical constraints that exist in designing a cask transporter, it is not practical or necessary to harden all elements of it to place their fundamental frequencies in the "rigid range" (all natural frequencies greater than or equal to 33 Hz) for every source of inertial excitation. However, as explained below, it is possible to design the cask transporter with features that ensure its structural response to seismic excitation is moderate for the load transport scenarios germane to the Diablo Canyon ISFSI site. The load transport functions rendered by the transporter are:

(1) Move the loaded transfer cask from the plant to the CTF (Figure RAI 5-11-2)

(2) Move the loaded overpack from the CTF to the ISFSI pad (Figure RAI 5-11-3).

The commitment on global rigidity in the SAR ensures that the cask transporter's final structural response to seismic excitation under both of the above transport scenarios will not have a dynamic amplification that may produce unacceptable levels of stress or kinematic displacements significantly in excess of those reported in the SAR based on a rigid body model.

To ensure that the cask transporter behaves essentially like a rigid body under the horizontal seismic inputs included in the Diablo Canyon ISFSI licensing basis, two design and operational measures typically not deployed in dry storage cask transporters will be incorporated in the cask transporter.

(1) Typical plant-to-pad movement of the loaded cask by a cask transporter occurs with the cask in the vertical orientation. The cask transporter will carry the transfer cask in the horizontal orientation. As shown in Figure RAI 5-11-2, the transfer cask is surrounded on three sides by the vehicle body and fastened to it to create an essentially lumped, three-dimensional mass on caterpillars. Over 85 percent of

the total mass of the cask transporter, while carrying a loaded transfer cask, is located in the vehicle body region. It is evident from the geometry of the loaded cask transporter during transport from the fuel handling building/auxiliary building to the cask transfer facility (CTF) that it is appropriate to treat it as a rigid body to quantify its response under the horizontal seismic inputs. This is consistent with the modeling approach described in Holtec Report HI-2012768 (submitted in PG&E Letter DIL-01-007, dated December 21, 2001). The vertical inertia from the dead load and the vertical seismic input are partly supported by the overhead beam frame. Its loaded condition, however, is bounded by the HI-STORM overpack transport condition, discussed below.

(2) Movement of the loaded overpack from the CTF to the ISFSI pad cannot utilize the horizontal cask orientation strategy because the overpack is not engineered for horizontal transport. However, it is possible to equip the vehicle body with adjustable cask bumpers and a fastener design that secure approximately the lower 5 ft of the overpack against any lateral motion. This effectively simulates a condition for cantilevering the overpack with the top framework of the cask transporter, allowing the top frame to serve no load bearing function under the lateral seismic loads (See Figure RAI 5-11-4). The vertical seismic loadings, however, cannot be relied on to be resisted by the friction forces at the bumper/overpack interface. The overhead beam structure, and the vertical support columns must resist the vertical seismic loadings. However, the overhead beam of the transporter will become inordinately massive if the design objective is restricted to achieving the beam mode fundamental frequency in the rigid range without a corresponding effort to minimize its mass. An optimum structural design of the top frame would be one that minimizes its weight while ensuring that under the postulated vertical seismic time-histories input, the maximum primary membrane and membrane plus bending stresses are below ASME Section III Subsection NF allowables for the appropriate service conditions.

To maximize the rigidity of the upper region of the cask transporter to withstand the vertical seismic loads, the lifting towers are locked in place to prevent inadvertent lowering of the load. The overhead beam, typically made of a 16-inch I-beam on standardized transporters, is conceptualized here as a fabricated set of two 26-inch deep box beams, so as to elevate the natural frequency of the beam system (Figure RAI 5-11-5). The equivalent section moment of inertia of the overhead beam structure (two beams) for the transporter is expected to be in the range of 13,998 in^4, which is in the range of magnitude greater than the moment of inertia of a typical cask transporter overhead beam. Finally, the lowest linear natural frequency of the overhead beam structure, carrying a loaded HI-STORM mass is approximately 10 Hz.

A time-history analysis of a candidate frame design was performed using the ANSYS finite element code.

For conservatism in the original time-history simulation, the overpack was assumed to be rigidly attached to the cask transporter. In the conceptual study performed for this RAI response, the vertical oscillation of the support location interacts with the motion of the overpack, resulting in a non-linear mass effect. In a similarly conservative manner, the ends of the overhead beam are assumed to be simply supported and the total structural and material damping was assumed to be limited to 4 percent for this time history stress analysis. The transporter overhead beam was assumed to be supporting the full weight of the loaded overpack. Five sets of seismic time histories are applicable for the loaded cask transporter and were used in the time history analysis to determine the response of the cask transporter overhead beam. The deflection histories at the center of the beam and at the lifting points were plotted. The simulation was terminated when the strong seismic motion was over; therefore the simulation time was less than the time history duration. The maximax (maximum in time and space) stresses from time-history solution and the corresponding safety factors based on Code stress limits (1.2 times material yield stress for Level D) are provided in the table below.

Time History Analysis Results of the Cask Transporter Overhead Beam

Seismic Time History Set	ZPA of Time History (g's)	Maximum Deflection of the Overhead Beam (in)	Maximum Bending Stress of the Overhead Beam (psi)	Safety Factor (SA516-70 with yield strength=38 ksi)
1. Lucerne Valley (48s)	0.6975	0.355	36,110	1.263
2. Yarimca (40s)	0.7371	0.337	34,280	1.330
3. LGPC (22s)	0.7339	0.358	36,420	1.252
4. El Centro (40s)	0.7411	0.365	37,130	1.228
5. Saratoga (40s)	0.7339	0.365	37,130	1.228

In addition, the time-history plot of the deflection of the beam shows the maximum deflection to be well within the guidelines of the Manual of Steel Construction (maximum deflection less than or equal to $\ell/360$, where ℓ = unsupported span (approximately 182 inches).

The above results demonstrate that it is feasible to engineer the cask transporter, as a system, to maintain its structural response under the postulated DCPP ISFSI seismic events to modest values.

To confirm the assertion that vertical flexibility of the overhead beam has little effect on the cask transporter's global response on the transport route under a seismic event, a configuration previously analyzed in Holtec Report HI-2012768, was reconsidered and vertical flexibility of the connection between the transfer cask and the cask transporter was introduced into the model. Specifically, the model shown in Figure 8.2 of the cited report, consisting of a transporter carrying a loaded transfer cask on a flat roadway, was modified to include flexibility in the vertical direction. In the original analysis reported in HI-2012768, the transfer cask and the cask transporter were assumed to move as a single rigid body under the action of a seismic event. For this confirmatory study, the constraint equation associated with vertical motion of the transfer cask relative to the cask transporter was eliminated and replaced by a linear spring/damper between the center of the top cross structure and a point on the centerline of the cask directly below the overhead beam. The transporter overhead beam structure can be designed with a lowest natural frequency of 9-11 Hz (carrying either a transfer cask or an overpack). Therefore, for the confirmatory global dynamic analysis, the vertical spring rate is chosen to have a natural oscillation at 10 Hz.

$$K = \left(\frac{W}{g}\right)(2\pi f)^2$$

where W = 250,000 lb and f = 10Hz.

Substituting, K = 2,653,723 lb/inch. Assuming 5 percent of critical damping for the global dynamic analysis, the associated linear viscous damping constant is:

$$C = 0.05\left(2\sqrt{KW/g}\right)$$

or C = 1,634,000 lbm/sec.

This original simulation used the "Set 6" seismic event and results are shown graphically in Figure 8.7 of Holtec Report HI-2012768. The conceptual study results, including vertical flexibility of the overhead beam, are presented below. A comparison of peak displacements of the cask transporter, relative to the road, is reported in the table below.

Cask Transporter Stability Displacement (Relative to Roadway) - Set 6 Seismic Event		
Case	Peak Longitudinal Displacement (inch)	Peak Transverse Displacement (inch)
Rigid Transporter (results from Table 2 of HI-2012768, Rev. 2)	8.912	8.907
Cask Transporter Rigid Body Model with Overhead Beam Flexibility Modeled	8.587	8.366

The results above document that there is an insignificant difference in the resulting peak displacement between the "rigid body" and the "flexible overhead beam" solutions. A measure of the vertical movement of the cask, relative to the transporter, due to the introduction of overhead beam flexibility, is obtained by dividing the peak tensile load change (from the static load) in the spring by the spring constant K. The peak relative movement computed from the VN simulation is:

Dv=(600,000 lb – 250,000 lb)/K = 0.132 inch

The overhead beam flexibility is expected to have a similar minimal effect on the global response in other transport modes such as when carrying an overpack from the CTF to the ISFSI pad. Finally, the stress analysis of the top member during the lift and transfer of an MPC at the CTF is bounded by the results produced above using a loaded overpack since the dynamic mass is decreased.

In summary, the design features incorporated in the cask transporter discussed above are configured to protect the structural response of the cask transporter against dynamic amplification from the postulated seismic inputs and to thus ensure a structural behavior that approximates that of "rigid" equipment. Once the final cask transporter design is complete after licensing, all relevant cask transporter calculations, analyses, and SAR information will be reviewed and updated as necessary to reflect the final design.

Question 5-12

Provide or reference design analyses and calculation packages on the seismic restraints of the cask transporter at the Cask Transfer Facility. This should include the restraints themselves as well as their attachment points.

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d); §72.24(i), and §72.122(b).

PG&E Response to Question 5-12

Please refer to the RAI response 3-3.

Question 5-13

Provide an evaluation of the effects of torque on the embedded anchor rods.

The torque is the result of applying the preload (698 kN/anchor [157 kips/anchor]) to the cask anchor studs. The cask anchor studs are threaded into compression/coupling blocks that enable the anchor studs to be preloaded to approximately 698 kN [157 kips]. However, the embedded anchor rods are threaded into the coupling blocks and the torque applied to the anchor studs will be transmitted to the anchor rods. The *anchor system must perform its safety function and is of a unique design. The uniqueness is associated with the high preload of the anchor studs, the use of coupling blocks, the depth of embedment, and the interaction between the anchor studs and the embedded anchor rods. NUREG–1567 (Section 5.4.1.4) states that design analyses should be prepared such that they may be readily audited to permit determination of the sources of expressions used, values of material properties, data from other supporting calculations, and assumptions.*

This information is necessary to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(i), and §72.122(b).

PG&E Response to Question 5-13

The preload on the cask anchor studs is applied without employing a torque wrench. Therefore, no torque is induced on the embedded anchor rods or compression couplings during the preload operation. A stud tensioner is used to apply preload on the anchor studs using hydraulic pressure to elastically "stretch" the bolt. The nuts are then tightened on the "stretched" stud to maintain the pre-load. This tension is transferred to the cask base/embedment plate interface as a compressive force via the stud nut and compression coupling. There is no significant torque applied on the nuts during tightening (i.e., hand-tightening is adequate).

Chapter 6. Thermal Evaluation

Question 6-1

Provide the insolation source data collected by the California Irrigation Management Information System during the period May 1, 1986, to December 31, 1999, at the site 12 mi [19.31 km] from the proposed ISFSI location.

NUREG–1567 (Sections 2.4.3.1 and 6.5.3) states that this information should be provided by the applicant. This information is necessary to confirm that the Diablo Canyon site parameters are within the parameters analyzed for the HI-Storm 100 system.

This information is necessary to determine compliance with 10 CFR §72.92(b) and §72.122(b)(3).

PG&E Response to Question 6-1

Attached are the daily and monthly insolation source data (Attachments 6-1 and 6-2 respectively) collected by the California Irrigation Management Information System during the period May 1, 1986 to December 31, 1999 at the California Polytechnic University, about 12 miles northeast of the ISFSI site.

Question 6-2

Provide clarification of the units used to quantify the Diablo Canyon Power Plant spent nuclear fuel rod burnup limits in Footnote (a) of Table 3.1-2 in the Diablo Canyon ISFSI Safety Analysis Report.

NUREG–1567 (Section 6.5.2.2) states that this information is needed to establish acceptable storage fuel cladding temperatures under normal, off-normal, and accident conditions.

This information is necessary to determine compliance with 10 CFR §72.24, §72.26, and §72.44.

PG&E Response to Question 6-2

The units shown in SAR Table 3.1-2, footnote (a) are incorrect and are the result of a typographical error. The units should read MWD/MTU, which is defined in the SAR glossary as megawatt–days per metric ton of uranium. Refer to Amendment 1 of the Diablo Canyon ISFSI SAR for revised Table 3.1-2.

Question 6-3

Provide the monthly average temperatures for the Diablo Canyon site.

This information is required to ensure the long-term environmental temperatures of the site are bounded by the cask limiting condition of operation. NUREG–1567 (Section 6.5.3) state that this information should be provided by the applicant.

This information is necessary to determine compliance with 10 CFR §72.92(b) and §72.122(b)(3).

PG&E Response to Question 6-3

The following table presents the monthly average temperatures for San Luis Obispo from 1948 to 2000. The information was provided by The Western Regional Climate Center.

Month	Temp (°F)	Month	Temp (°F)
Jan	52.2	Jul	65.2
Feb	54.1	Aug	66.0
Mar	54.6	Sep	65.8
Apr	56.9	Oct	63.3
May	58.9	Nov	58.2
Jun	62.4	Dec	53.3

The above temperatures bound the monthly average temperatures for the DCPP site

SAR Section 2.1.1 states that the ISFSI will be located within the PG&E owner-controlled area of Diablo Canyon, which consists of approximately 750 acres of land located in San Luis Obispo County, California adjacent to the Pacific Ocean. The area is approximately 12 miles west-southwest of the city of San Luis Obispo. SAR Section 1.2 states that the climate of the site is typical of that along the central California coast and reflects a strong maritime influence. Because of where the ISFSI will be located relative to the city of San Luis Obispo, the temperatures for the DCPP site are typically lower than the monthly average summer temperatures and higher than the monthly winter average temperatures for San Luis Obispo.

Question 6-4

Provide thermal analyses of the ISFSI storage pad and Cask Transfer Facility concrete structure.

NUREG–1567 (Section 6.5.2.3) states the maximum calculated concrete temperatures should be assessed and must not exceed the material temperature criteria for normal, off-normal, and accident conditions.

This information is necessary to determine compliance with 10 CFR §72.92(a), §72.92(b), §72.92(c), §72.122(b), and §72.128(a).

PG&E Response to Question 6-4

ISFSI Pad

The temperatures of the outside center of the overpack baseplate bottom surface, assuming the bounding MPC (MPC-32), design basis maximum heat load of 28.74 kW and an insulated base plate are shown below for the loaded overpack on the ISFSI pad. The assumption of an insulated baseplate allows heat flow through the baseplate, with an adiabatic boundary at the bottom of the baseplate. This approach maximizes the temperature of the bottom of the baseplate.

- Normal Condition (ambient temperature = 80°F) the maximum temperature is 111°F (HI-STORM LAR 1014-1, Table 4.4.36).
- Off-Normal Condition (ambient temperature = 100°F) the maximum temperature is 131°F. This value is conservatively computed by simply adding the 20°F increase in ambient temperature to the normal condition baseplate temperature.
- Accident Condition (all inlet ducts blocked, ambient temperature = 80°F) the results of transient simulation at 68 hours and at 100 hours are tabulated below:

Time (hr)	Maximum Temperature (°F)
68	177
100	217

These accident event temperature values were extracted from the FLUENT computer runs used to simulate the all-inlet-ducts-blocked accident event (see Holtec Report HI-2002407, Revision 3, submitted to the NRC on July 3, 2001 in support of LAR 1014-1). The duration of this event, per the HI-STORM licensing basis, as discussed in HI-STORM FSAR Section 11.2.13.2, is 72 hours. Based on the above tabulated data, the maximum temperature of the HI-STORM baseplate for this accident, at 72 hours, is linearly interpolated to be 182°F. The extreme environmental temperature event yields a baseplate temperature of 156°F, computed by adding the 45°F ambient temperature increase to the normal baseplate temperature of 111°F. In the fire accident, the fuel is postulated to be burning in a pool surrounding the cask, therefore, the concrete short-term temperature limit will be exceeded and is an expected consequence of the event. Recovery from a fire event on the ISFSI pad will require a technical evaluation of the ability of the ISFSI pad, in the affected area, to perform its design function, and appropriate corrective actions taken as necessary.

The calculated normal baseplate temperature is less than the 150°F recommended limit specified in Section A.4.1 of Appendix A to ACI-349-97. The highest off-normal baseplate temperature of 131°F is less than the 200°F limit provided in NUREG-1567, Section 6.5.2.3 for normal and off-normal conditions. The highest accident baseplate temperature of 182°F is less than the 350°F recommended limit specified in Section A.4.2 of Appendix A to ACI-349-97.

Cask Transfer Facility

In order to evaluate the CTF concrete temperatures, accident overpack baseplate and outer shell temperatures are used for comparison against the normal and accident concrete temperature limits to account for the enclosed space created by the CTF vault. The overpack baseplate and outer shell temperatures will always be greater than the surrounding concrete due to the nature of heat transfer, and provide a limiting case comparison for the concrete against the temperature limits.

For normal conditions, the steel seismic restraint shims will be installed and the loaded overpack is limited to a maximum of 22 hours in the CTF in accordance with the Proposed Diablo Canyon ISFSI Technical Specification Limiting Condition for Operation (LCO) 3.1.2. For the accident condition described in SAR Section 8.2.17, the steel shims may or may not be in place and again the loaded overpack is limited to a maximum of 22 hours in the CTF. This is based on a conservative evaluation of the degraded heat rejection capability of a loaded transfer cask in a cask loading pit, as described in HI-STORM FSAR Section 4.5.2.1. By engineering judgment, the overpack baseplate and outer shell temperatures for the all-inlet-ducts-blocked accident scenario may be used to estimate the normal and accident conditions' CTF concrete temperatures.

The baseplate and outer shell temperatures for the all-inlet-ducts-blocked condition are 182°F and 185°F, respectively. They provide a reasonably bounding set of temperatures for the normal and accident CTF conditions where the steel shims are installed as seismic restraints in the annulus between the overpack and the top circumference of the CTF and natural convective cooling will be reduced below normal values. This is because, although natural convection cooling will be reduced while the overpack is in the CTF, there will be some cooling flow through the inlet and outlet air ducts and up to the environment through the openings between the shims. CTF concrete temperatures will actually be lower than these values as heat is transferred from the outer surfaces of the overpack, through the intervening steel CTF structural components, and air to the surrounding concrete. Therefore, the CTF concrete temperatures during normal conditions will be lower than the 200°F normal and off-normal temperature limit specified in NUREG-1657, Section 6.5.2.3 and the 350°F accident temperature limit specified in Section A.4.2 of Appendix A to ACI-349-97.

Please see the response to RAI 5-7 for additional discussion of the thermal effect of the CTF seismic restraint shims.

Question 6-5

Provide clarification and rationale explaining the difference between the highest recorded hourly temperature of 36.1 °C [97 °F] and the extreme hot ambient temperature of 40 °F C [104 °F] for the Diablo Canyon site.

NUREG–1567 (Sections 2.4.3.1 and 6.5.3) states that this information should be provided by the applicant.

This information is necessary to determine compliance with 10 CFR §72.92(a), §72.92(b), §72.92(c), §72.122(b), and §72.128(a).

PG&E Response to Question 6-5

SAR Section 2.3.2 states the highest hourly temperature recorded as 97°F and SAR Section 8.2.6 states that the highest ambient temperature predicted for the Diablo Canyon ISFSI site is 104°F and would normally (99 percent of the time) be no more than 85°F. The extreme predicted ambient temperature of 104°F was required by PG&E as a design margin to ensure that the cask design also envelops possible future ambient temperature extremes beyond currently recorded highs.

Question 6-6

Provide clarification as to the maximum net allowable decay heat load and concomitant uncertainty for each applicable multipurpose canister and verify that these values are bounded by the assumed values used to analyze the normal, off-normal, and accident conditions in the cask Diablo Canyon ISFSI Safety Analysis Report.

NUREG–1567 (Section 6.5.3) states that this information should be provided by the applicant.

This information is necessary to determine compliance with 10 CFR §72.92(a), §72.92(b), §72.92(c), §72.122(b), and §72.128(a).

PG&E Response to Question 6-6

Fuel proposed for storage at the Diablo Canyon ISFSI is bounded by the thermal analyses described in Chapter 4 of the HI-STORM 100 FSAR, Revision 1. The thermal design is also summarized in Section 4.2.3.3.3 of the Diablo Canyon ISFSI SAR. Off-normal and accident conditions are addressed in HI-STORM FSAR, Revision 1, Sections 11.1 and 11.2, respectively. In summary, the HI-STORM cask system is analyzed for a design maximum decay heat load (Q*) from stored fuel in any multipurpose canister for normal, off-normal and accident conditions. Actual cask heat load (Q) is a function of fuel weight (W), burnup (B) and cooling time (T) wherein Q monotonically increases with W and B and exponentially attenuates with T. To ensure that Q is conservatively bounded by Q* for all fuel proposed for storage at the Diablo Canyon ISFSI, a design basis fuel assembly is selected (B&W 15x15 for PWR fuel) to overstate W and limits are established for B (i.e. $B < B_{max}$) and T (i.e. $T > T_{min}$) in the CoC. For all MPCs, Q is bounded by Q* with a substantial margin. The uncertainty in the decay heat limits was not specifically evaluated as part of the generic HI-STORM licensing effort. Rather, the margin in the thermal analyses, expressed in terms of fuel cladding temperature, is quantified in Appendix 4.B of the HI-STORM 100 System FSAR, Revision 1.

The fuel assembly-specific limits on burnup, decay heat, and cooling time proposed in the Diablo Canyon ISFSI SAR and now the technical specifications, are identical to those in approved Amendment 1 to the HI-STORM CoC for the applicable fuel assembly array/classes (17x17A and 17x17B). These assembly-specific limits are directly related to the total heat load analyzed for each MPC and vary based on the MPC model. For example, for a given maximum heat load, each assembly to be stored in a 24-assembly MPC is permitted to have a higher heat emission rate (expressed as limits on burnup and decay heat as a function of cooling time in the technical specifications) than those stored in a 32-assembly MPC because there are eight fewer assemblies in the 24-assembly MPC. These limits also vary depending on whether a uniform or regionalized storage strategy is used. All of these fuel assembly limits are provided in Diablo Canyon ISFSI SAR Tables 10.2-2 through Table 10.2-10, including limits on non-fuel hardware. These limits have also been added to the proposed technical specifications per the response to RAI 16-1 and are identical to the same limits found in the HI-STORM CoC, Appendix B, Section 2.0.

<u>*Question 6-7*</u>

Provide a revision of the proposed Technical Specifications for the ISFSI that includes an administrative procedure to prohibit transfer cask handling operations at environmental temperatures below -18 ° C [0 °F].

Section 8.1.2.3 of the Diablo Canyon ISFSI Safety Analysis Report states that administrative procedures based on DC ISFSI TS 5.1.3 prohibit cask handling operations at environmental temperatures below -18 □C [0 °F]. Technical Specification 5.1.3 does not appear to contain this limitation, however. NUREG–1567 (Section 6.5.2.1) states that this information should be provided by the applicant.

This information is needed to determine compliance with 10 CFR §72.24(h).

<u>PG&E Response to Question 6-7</u>

The Diablo Canyon ISFSI TS program 5.1.3 will be revised to include a prohibition of cask handling operations at environmental temperatures below -18 °C (0 °F) as indicated in SAR Section 8.1.2.3. Refer to Amendment 1 of the Proposed Technical Specifications for revised TS 5.1.3.

<u>*Question 6-8*</u>

Revise Section 10.2.2.3 of the Diablo Canyon ISFSI Safety Analysis Report, Multi-Purpose Canister Drying Characteristics, to adopt the appropriate sections of Appendix 2.B, The Forced Helium Dehydration System, from the Holtec HI-STORM 100 Final Safety Analysis Report, Amendment 1.

The Forced Helium Dehydration System is a new drying method. As a result, the Diablo Canyon ISFSI Safety Analysis Report should be revised to include the recommended analyses and a description of the acceptance testing procedures that will be implemented for the Forced Helium Dehydration System. NUREG-1567 (Section 6.5.1.2) states that the Safety Analysis Report should provide evidence that (i) the liquid in the cask does not boil during fuel assembly transfer operations to avoid uncontrolled pressures on the cask and the connected dewatering, purging, and recharging system(s); (ii) an adequate subcooling margin has been identified and a corresponding operating procedure to prevent boiling that may result in an inadvertent criticality due to optimum moderator conditions has been provided; and (iii) the ISFSI maximum temperature (under normal conditions) of the pool water and other water that may be used in the cask cavity during loading and unloading operations is below the *temperature assumed in the cask criticality safety analysis if a time restriction exists in the corresponding technical specifications.*

This information is needed to determine compliance with 10 CFR §72.24(i).

PG&E Response to Question 6-8

The Diablo Canyon ISFSI SAR, Amendment 1, revised Section 10.2.2.3 to include the analysis required and acceptance testing procedures to be used if Diablo Canyon is the first time user of the Holtec system.

Question 6-9

Provide clarification as to whether a Vacuum Drying System will be used at the Diablo Nuclear Power Plant for drying canisters containing moderate and high burnup spent fuel as an alternative method to the Forced Helium Dehydration System.

If the Vacuum Drying System is used, the temperature of the fuel could be high enough to cause hydrides to reorient in a radial direction in highly oxidized high burnup fuel cladding. NUREG–1567 (Section 6.5.2.2) states that the Safety Analysis Report should address burnup dependent effects that could potentially lead to a failure of the cladding and dispersal of the fuel during transfer and handling operations.

This information is needed to determine compliance with 10 CFR §72.24(i).

PG&E Response to Question 6-9

A vacuum drying system may be used at the Diablo Canyon Power Plant (DCPP) for drying canisters containing only moderate burnup fuel (i.e., burnup < 45,000 MWD/MTU). This option is being retained in the Diablo Canyon ISFSI SAR based on vacuum drying of moderate burnup fuel being previously licensed for use with the HI-STORM 100 System. All moderate and high burnup DCPP fuel proposed for storage at the Diablo Canyon ISFSI under the site-specific license, including burnup, decay heat, and cooling time limits, is bounded by the previously approved analyses supporting general certification of Revision 1 to the HI-STORM 100 System CoC. Likewise, the MPC, overpack, and transfer cask designs to be used at the Diablo Canyon ISFSI are the same as those generally certified for use by any general licensee. Additional information, including a description of the vacuum drying analyses for moderate burnup fuel in the HI-STORM 100 System is provided in Section 4.5 of the HI-STORM 100 System FSAR, incorporated by reference into the Diablo Canyon ISFSI license application.

For high burnup fuel, the forced helium dehydration system (see RAI 6-8) will be used for moisture removal.

Chapter 7. Shielding Evaluation

The staff had no comments regarding the general description of the proposed Diablo Canyon ISFSI.

Chapter 8. Criticality Evaluation

Question 8-1

Provide a description of the differences between the multi-purpose canister-24E and multi-purpose canister-24EF and discuss how these differences allow fuel debris to be loaded into the multi-purpose canister-24EF compared to the multi-purpose canister-24E.

A review of the drawings has found some differences between the multi-purpose canister-24E and multi-purpose canister-24EF, but it is not clear how these differences affect the criticality performance of the canister and how the calculation models have accounted for these differences. Such differences are not addressed in Table 6.3.3 or Figure 6.3.1A of the HI-STORM 100 Safety Analysis Report.

This information is necessary to determine compliance with 10 CFR §72.124(a), §72.124(b), §72.126(a), and §72.236(a).

PG&E Response to Question 8-1

The fuel baskets and basket-to-shell interface dimensions of the MPC-24E and the MPC-24EF designs are identical. Therefore, fuel spacing, neutron poison dimensions, B-10 areal density, flux trap sizes, and all other physical inputs to the criticality models are identical between the two canister designs. Fuel classified as fuel debris will be stored in damaged fuel containers (DFCs) in an MPC-24EF. The DFCs are sized to fit into standard size fuel cells, which are identical between the MPC-24E and MPC-24EF.

The differences between the MPC-24E and MPC-24EF designs are the thickness of the MPC enclosure vessel shell at the top of the canister (including a conforming change to the MPC lid diameter) and the size of the MPC lid-to-shell weld. The top 8-inch segment of the MPC-24EF shell is 1 inch thick, as compared to the 1/2-inch thick MPC-24E shell. To accommodate the thicker upper shell without increasing the outer diameter of the MPC, the MPC-24EF lid is 1 inch smaller in diameter than the MPC-24E lid. The MPC-24EF lid to shell weld is 1-1/4 inches deep versus 3/4 inches deep for the MPC-24E.

These differences are all strictly related to structural qualification of the MPC design for 10 CFR 71 certification for transportation in the HI-STAR 100 System (Docket 71-9261). The MPC is qualified as a "separate inner container" per

10 CFR 7.163(b) for the transportation of plutonium in fuel debris, where the fuel cladding may not be intact. The differences between the MPC-24E and MPC-24EF design allow fuel debris to be loaded, stored at the ISFSI under 10 CFR 72, and shipped to a central repository in a transport-certified overpack under 10 CFR 71, without re-packaging the spent fuel. The MPC-24EF unique design features are not required for storage under 10 CFR 72, but are included in the storage SARs due to the dual-purpose nature of the Holtec MPC design.

Question 8-2

Provide the configurations for the various missing fuel rod and collapsed fuel cases referenced in Section 6.4.4.2.2 of the HI-STORM 100 Safety Analysis Report that were used to model the "realistic" assembly configurations. This information may be supplied by illustrations or a more detailed description in the text. Provide enough detail so that independent calculations can be performed.

This information is necessary to determine compliance with 10 CFR §72.124(a), §72.124(b), §72.126(a), and §72.236(a).

PG&E Response to Question 8-2

The MPC-24E and -24EF were licensed to store damaged fuel and fuel debris under Amendment 1 to the HI-STORM 100 Certificate of Compliance (CoC), which became effective on July 15, 2002. All DCPP fuel requested to be licensed in this site-specific application is bounded by Amendment 1 of the generic Holtec HI-STORM 100 certification. The fuel parameter limits in the proposed Diablo Canyon ISFSI SAR, Chapter 10, and proposed technical specifications are identical to those in the HI-STORM 100 System FSAR and CoC for the applicable fuel assembly array/classes (see also the response to RAI 16.1).

The Holtec-proprietary criticality analysis supporting the Holtec generic licensing effort, HI-951321, Revisions 12 and 13 were submitted to the NRC on Docket 72-1014 on November 20, 2000 and July 3, 2001, respectively. Attachment F of this analysis report specifically addresses damaged fuel modeling. In addition, a Request for Additional Information on Holtec's amendment request included questions in the criticality area, to which responses were provided on July 3, 2002. The Diablo Canyon ISFSI license application incorporates the use of the Holtec HI-STORM 100 certified cask design by reference and no additional criticality analyses were performed in support of this licensing action. Since the criticality design is previously licensed, we believe the referenced material on the generic HI-STORM 100 docket includes adequate information to provide the basis for the criticality design.

Question 8-3

Provide a table of the results for all the criticality cases analyzed, as summarized in Table 6.4.9 of the HI-STORM 100 Safety Analysis Report. Clarify the fuel configurations assumed in the pressurized water reactor damaged fuel analysis, and explain how to compare these results to the data plotted in Figure 6.4.14 of the HI-STORM 100 Safety Analysis Report.

Table 6.4.9 only gives the maximum calculated value for a series of cases. The table should give the calculated value for each case along with a short description of the different configurations assumed in each case. For example, Section 6.4.4.2.2 of the HI-STORM 100 Safety Analysis Report states that lattice spacings from 8x8 to 27x27 (20 different lattices?) were analyzed but does not describe how half rods of the lattice were treated and how the lattice was centered or modeled off-center in the damaged fuel container. A maximum, typical, and minimum pellet diameter was analyzed for each lattice spacing, but individual results are not tabulated. In addition, figure 6.4.14 of the HI-STORM 100 Safety Analysis Report uses the parameter, fuel mass per unit length, but does not tie this to the lattice configuration for each data point.

This information is necessary to determine compliance with 10 CFR §72.124(a), §72.124(b), §72.126(a), and §72.236(a).

PG&E Response to Question 8-3

The MPC-24E and -24EF were licensed to store damaged fuel and fuel debris under Amendment 1 to the HI-STORM 100 Certificate of Compliance (CoC), which became effective on July 15, 2002. All DCPP fuel requested to be licensed in this site-specific application is bounded by Amendment 1 of the generic Holtec HI-STORM 100 certification. The fuel parameter limits in the proposed Diablo Canyon ISFSI SAR, Chapter 10, and proposed technical specifications are identical to those in the HI-STORM 100 System FSAR and CoC for the applicable fuel assembly array/classes (see also the response to RAI 16.1).

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Question 8-4

Clarify the configuration assumed for the fuel debris analysis and how it differs from the damaged fuel model. Specify the number of fuel pellets that are assumed to change to powder. Indicate whether broken clumps or chunks of fuel (including shapes, sizes and spacing) were considered.

This information is necessary to determine compliance with 10 CFR §72.124(a), §72.124(b), §72.126(a), and §72.236(a).

PG&E Response to Question 8-4

The MPC-24E and -24EF were licensed to store damaged fuel and fuel debris under Amendment 1 to the HI-STORM 100 Certificate of Compliance (CoC), which became effective on July 15, 2002. All DCPP fuel requested to be licensed in this site-specific license application is bounded by Amendment 1 of the generic Holtec HI-STORM 100 certification. The fuel parameter limits in the proposed Diablo Canyon ISFSI SAR, Chapter 10, and technical specifications are identical to those in the HI-STORM 100 System FSAR and CoC for the applicable fuel assembly array/classes (see also the response to RAI 16.1).

The Holtec-proprietary criticality analysis supporting the Holtec generic licensing effort, HI-951321, Revisions 12 and 13 were submitted to the NRC on Docket 72-1014 on November 20, 2000 and July 3, 2001, respectively. Attachment F of this analysis report specifically addresses damaged fuel modeling. In addition, a Request for Additional Information on Holtec's amendment request included questions in the criticality area, to which responses were provided on July 3, 2002. The Diablo Canyon ISFSI license application incorporates the use of the Holtec HI-STORM 100 certified cask design by reference and no additional criticality analyses were performed in support of this licensing action. Since the criticality design is previously licensed, we believe the referenced material on the generic HI-STORM 100 docket includes adequate information to provide the basis for the criticality design. The following additional information is provided regarding the specific questions in this RAI.

(1) Clarify the configuration assumed for the fuel debris analysis and how it differs from the damaged fuel model.

One single modeling approach that bounds both fuel debris and damaged fuel was reviewed and approved for Amendment 1 to the HI-STORM 100 CoC. The model consists of regular arrays of bare fuel rods, i.e. all non-fuel materials including the fuel cladding are conservatively neglected and replaced by water. Arrays sizes are varied over a large range, and the rod pitch is selected for each array size so that the array fills the entire cross section of the DFC. In addition, the rod diameter is varied within the range of fuel pellet diameters found in PWR or BWR fuel assemblies. These variations were performed to identify the optimum moderation situation, i.e. the pellet size and fuel to water ratio that results in the highest reactivity. FSAR Figure 6.4.13 in HI-STORM LAR 1014-1 shows the results of these parametric variations, as a function of the fuel to water ratio, for PWR fuel, which is specified as fuel mass per unit length of the damaged fuel container. The results show a distinct maximum of the reactivity as a function of the water to fuel ratio. This maximum is below the regulatory limit. Further, no significant effect of the different rod diameters on reactivity is found. These figures also show results for typical damaged fuel conditions, such as missing rods or collapsed assemblies. The reactivity of these cases is significantly below the peak reactivity of the bounding model.

(2) Specify the number of fuel pellets that are assumed to change to powder.

Powdered fuel is not explicitly modeled in the analysis. Note that a homogenized fuel and water mixture typically has a lower reactivity than a corresponding discrete geometry of fuel rods surrounded by water. This is why criticality models of fuel assemblies need to model the fuel rod in detail rather than using a homogenized region for the assembly.

(3) Indicate whether broken clumps or chunks of fuel (including shapes, sizes and spacing) were considered.

Evaluations performed with different rod diameters in the damaged fuel/fuel debris model show no significant effect of the rod diameter on the reactivity. Therefore, no other variations of shapes and sizes were performed. The spacing of the rods was varied in the analyses to determine the optimum moderation situation.

Chapter 9. Confinement Evaluation

The staff had no comments regarding the general description of the proposed Diablo Canyon ISFSI.

Chapter 10. Conduct of Operations Evaluation

Question 10-1

Provide a statement as to whether the Diablo Canyon ISFSI would contain any structures, systems, or components important to safety, for which functional adequacy or reliability have not been demonstrated. Provide a schedule showing how any safety questions for these items would be resolved prior to initial receipt of spent nuclear fuel or high-level waste.

This information is needed to determine compliance with 10 CFR §72.24(i).

PG&E Response to Question 10-1

The Diablo Canyon ISFSI SAR references the HI-STORM 100 system, which has been certified. The SAR demonstrates that the HI-STORM 100 certification conditions bound the Diablo Canyon ISFSI except as specifically identified in the SAR. For those cases where the Diablo Canyon ISFSI conditions are not bounded by the conditions assumed for the HI-STORM 100 system, a full description of the design and associated analyses are provided in the SAR and other docketed information. Therefore the SAR and other docketed information provide adequate design description and associated analyses to demonstrate functional adequacy and reliability.

Should new safety questions arise prior to, or during ISFSI operation, they will be handled as part of the Diablo Canyon ISFSI operating experience and, if necessary addressed formally in the corrective action program.

Question 10-2

Provide a more complete description of the delegations of authority, required skills, and experience levels for the Diablo Canyon ISFSI management organization.

In particular, (i) define any responsibilities of the Director of Site Services relative to the Station Director; (ii) identify the responsibilities and reporting relationships of subordinates to the Director of Site Services; (iii) specify the qualifications and responsibilities for the ISFSI Specialists, Security Staff, the Director of Maintenance Services, the Manager of Radiation Protection, the Manager of Operations, the Manager of Chemistry and Environmental Operations, and any of their subordinates who may have responsibilities important to safety; (iv) identify whether persons other than the Station Director require designation of personnel to act in their absence; and (v) identify any positions having stop-work authority other than the Station Director. This information is required to allow the staff to determine that reporting relationships and assignments of responsibility are adequate to support safe operations at the Diablo Canyon ISFSI as specified in Section 10.4.1 of NUREG–1567.

This information is needed to determine compliance with 10 CFR §72.28(c).

PG&E Response to Question 10-2

SAR Figure 9.1-2 contained an error, which incorrectly depicted the reporting relationships of ISFSI specialists as reporting to the Director, Site Services. The plant operating and maintenance personnel and/or contract personnel (ISFSI specialists) will report to either the Manager, Operations or the Director, Maintenance Services according to their discipline. The Manager, Operations and the Director, Maintenance Services report directly to the Station Director. The Manager, Operations is responsible for administering, coordinating, planning, and scheduling all ISFSI operating activities. He is responsible for ensuring that appropriate operating procedures are available and that operating personnel are familiar with the procedures. The Director, Maintenance Services exercises direct supervision over ISFSI maintenance and work planning. ISFSI Specialists will report to either the Manager, Operations or the Director, Maintenance Services according to their discipline. The ISFSI Specialist responsibilities are identified in SAR Section 9.1.6.2. The reporting relationship of the ISFSI Specialist has been added to SAR Section 9.1.3. Refer to Amendment 1 of the Diablo Canyon ISFSI SAR for revised SAR Section 9.1.3 and Figure 9.1-2.

PG&E made a recent organizational change regarding the reporting relationship of the ISFSI Program Manager. The ISFSI Program Manager now reports to a new position of Director, Strategic Projects and Assistant to the Vice President, Nuclear Services. The director will report directly to the Vice President, Nuclear Services. The responsibilities of the ISFSI Program Manager are outlined in SAR Section 9.1.3. Refer to Amendment 1 of the Diablo Canyon ISFSI SAR for revised Section 9.1.3 and Figure 9.1-1.

SAR Section 9.1.7 provides the qualifications that will be met for personnel performing work on the Diablo Canyon ISFSI. SAR Sections 9.1.5 and 9.1.7 provide information on the responsibilities for ISFSI activities.

SAR Section 9.1.5 states that the functions, responsibilities, and authorities of the Diablo Canyon ISFSI personnel identified in Figures 9.1-1 and 9.1-2 are described in Section 13.1 of the DCPP FSAR Update. Not identified in the DCPP FSAR Update, Section 13.1 is the ISFSI Program Manager and the ISFSI Specialists. Refer to Amendment 1 of the SAR for revised Section 9.1.5.

SAR Section 9.1.6.2 indicates a formal order of succession and delegation of authority will be established as part of the onsite ISFSI operating organization.

Section 17.1 of the Quality Assurance Program states that the Director, Nuclear Quality, Analysis, and Licensing has the authority and responsibility to stop work.

The above information will allow the NRC staff to determine that reporting relationships and assignments of responsibility are adequate to support safe operations at the Diablo Canyon ISFSI as specified in Section 10.4.1 of NUREG-1567.

Question 10-3

Provide an assessment that demonstrates that the proposed additional 11 staff members are sufficient to safely conduct the range of operations that might be required simultaneously at both the power plant and the ISFSI.

An assessment is needed as to whether the additional 11 staff members required for ISFSI operations (as discussed in Sections 9.1.2, 9.1.5, and 9.1.6.1 of the Diablo Canyon ISFSI Safety Analysis Report) will require that overall Diablo Canyon Power

Plant staffing levels be increased. The Diablo Canyon ISFSI Safety Analysis Report should confirm that this additional staffing is sufficient for operating circumstances that could arise simultaneously at the power plant and the ISFSI.

This information is needed to determine compliance with 10 CFR §72.40(a).

PG&E Response to Question 10-3

SAR Section 9.1.6.1 states that approximately 11 full-time equivalent personnel will be used from existing DCPP organizations to perform the functions of ISFSI specialists and security. The ISFSI specialists and security staff will be responsible for the day-to-day operation of the ISFSI. The day-to-day operations consist of ISFSI security and operations surveillance activities.

The security staffing requirements is safeguards information in accordance with 10 CFR 73.21 and is contained in the DCPP Physical Security Plan, which was submitted to the NRC (Reference PG&E Letter DCL-02-042 dated April 18, 2002). Justification for the security staffing requirements is provided in the DCPP Physical Security Plan revision for the ISFSI.

The operations surveillances consist of a walkdown of the ISFSI every 24 hours by one operator to ensure that the cask vents are not blocked. This walkdown is estimated to require less than 30 minutes per day (see SAR Table 7.4-3) and can easily be performed by the existing personnel of shift. The walkdown is not required to be performed at a specific time and can be scheduled and performed as part of normal daily activities. Should circumstances occur at DCPP, which prevent performance of this daily surveillance, additional on-shift personnel would be called in to perform the required cask vent surveillance.

Cask handling operations will be performed during a cask loading campaign where several casks will be loaded and moved to the ISFSI for storage. These activities will be performed by security, maintenance, and operations personnel. Maintenance and operations personnel estimates for these activities are listed in Table 7.4-1. Security staffing requirements for these activities that are provided in the DCPP Physical Security Plan are withheld from disclosure in accordance with 10 CFR 2.790(d) and 10 CFR 73.21. Personnel requirements for these activities are much less than would be normally experienced during a plant outage and therefore existing plant staffing (which may be supplemented by contractor personnel) are more than sufficient to perform these activities.

Question 10-4

Provide supporting information for the determination that accidents and emergencies at the Diablo Canyon ISFSI can be adequately managed by personnel trained for power plant emergencies. A rationale is required for the fact that the minimum on-shift staffing *requirements shown in Table 5.1 of the Emergency Plan do not require any additional personnel, nor personnel trained in ISFSI operations.*

This information is needed to determine compliance with 10 CFR §72.32(b) and §72.40(a).

PG&E Response to Question 10-4

Personnel staffing identified in Section 5, Table 1 of the Emergency Plan is based on responding to emergencies at the Diablo Canyon Power Plant. ISFSI SAR Chapter 8 identifies design basis accidents that were postulated to occur at the ISFSI. The ISFSI SAR Chapter 8 accidents are substantially less severe than those postulated for the DCPP Emergency Plan and thus would require substantially less emergency actions and equipment. NRC regulations do not require postulating two unrelated accidents simultaneously at a co-located power plant and ISFSI. Therefore, the DCPP Emergency Plan staffing, equipment and training are adequate to manage an accident at the Diablo Canyon ISFSI.

Also see the response to RAI 2-10.

Question 10-5

Provide supporting information for the determination that no emergency equipment in addition to that provided for the Diablo Canyon Power Plant is required to support potential emergencies at the Diablo Canyon ISFSI.

Clarification is required for the allocation and location of any emergency equipment specifically for the Diablo Canyon ISFSI. The description of emergency facilities and equipment in Chapter 7 of the Diablo Canyon Power Plant Emergency Plan does not identify any such equipment that would be located within the ISFSI or that would be provided specifically for use by the ISFSI.

This information is needed to determine compliance with 10 CFR §72.32(b) and §72.40(a).

PG&E Response to Question 10-5

Emergency equipment that is available for the DCPP is described in Section 7 of the Emergency Plan. This equipment would also be available to the ISFSI. The ISFSI SAR Chapter 8 accidents are substantially less severe than those postulated for the DCPP Emergency Plan and thus would require substantially less emergency actions and equipment. Therefore, the emergency equipment for DCPP as described in Section 7 of the DCPP Emergency Plan is adequate for responding to the plant itself as well as to the ISFSI.

Question 10-6

Describe the mechanism in place for the case where accident conditions at the ISFSI continue to degrade to the point where the accident level should be escalated to a more severe emergency class.

The ISFSI emergency actions levels are at the Notification of Unusual Event (NOUE), with no apparent means for progression to the Alert level.

This information is needed to ensure compliance with 10 CFR §72.32.

PG&E Response to Question 10-6

In accordance with NEI 99-01, a site-specific analysis was performed as documented in the Diablo Canyon ISFSI SAR, Chapter 8. It was concluded that emergency action levels (EAL) applicable to ISFSI activities would only result in an emergency classification level (ECL) of NOUE. Postulation of a severe accident beyond the 10 CFR 72 requirements is not required. Should a severe accident occur that is beyond the 10 CFR 72 design basis, the Emergency Director, who has overall responsibility of the event, has the authority to escalate to a higher ECL if exceeding the threshold is imminent and further escalations are required.

Question 10-7

Describe the communication equipment available for staff to report emergencies from the ISFSI to the Control Room.

This information is needed to ensure compliance with 10 CFR §72.32.

PG&E Response to Question 10-7

The DCPP Emergency Plan, Amendment 1, Section 7.2.1 contains a revision to include an available telephone line at the ISFSI to report any emergencies. During cask handling and transportation both security and operations personnel are present with plant radios systems. During normal storage conditions security in the vicinity of the ISFSI are equipped with plant radios systems.

Question 10-8

Describe how information about the ISFSI will be incorporated into the emergency plan training for staff and off-site responders, such as fire and police.

This information is needed to ensure compliance with 10 CFR §72.32.

PG&E Response to Question 10-8

The ISFSI will be incorporated into the DCPP Emergency Plan as discussed in Section 2 of the Plan. Section 8.2.2 of the DCPP Emergency Plan describes training that is provided to off-site support personnel such as fire and police.

Chapter 11. Radiation Protection Evaluation

Question 11-1

Provide a description of all nonfuel hardware at the plant which could be inserted into a fuel assembly prior to the assembly being loaded into a canister.

The SAR indicates that burnable poison rod assemblies and thimble plug devices are no longer in use in the core and therefore the inventory of these types of nonfuel hardware will not increase. Rod cluster control assemblies are still used. Other types of nonfuel hardware which are currently in inventory at the plant and could be placed in the canister need to be identified. (SAR Section 7.2.1.4, Nonfuel Hardware Source)

This information is needed to determine compliance with 10 CFR §72.104.

PG&E Response to Question 11-1

SAR Section 7.2.1.4 discusses the non-fuel hardware source terms that were used for the radiological analyses. As indicated in SAR Section 3.1.1.3, nonfuel hardware, consisting of borosilicate absorber rods, wet annular burnable absorber rods, thimble plug devices, and rod cluster control assemblies may be stored integral with spent fuel assemblies. The nonfuel hardware type, burnup, and cooling time will be limited to that specified in Section 10.2 of the SAR. SAR Table 10.2-10 lists nonfuel hardware cooling and average activation. The source term used in the dose calculations for nonfuel hardware are provided in calculation HI-2002563, which was submitted in PG&E Letter DIL-01-007 dated December 21, 2001.

DCPP neutron sources are not authorized for loading into the HI-STORM 100 System at the present time (SAR Section 3.1.1.3). Neutron sources will be added to the authorized contents of the HI-STORM 100 System by amendment at a later date.

Question 11-2

Provide a summary of the sky-shine analyses prepared for the dose calculations. (SAR Section 7.3.2, Shielding)

This information is needed to determine compliance with 10 CFR §72.104.

PG&E Response to Question 11-2

Diablo Canyon ISFSI SAR Section 7.3.2 describes the methodology that was used to calculate the dose rate versus distance from the Diablo Canyon ISFSI. This description, which is similar to that provided in SAR Section 7.5 of the shielding calculation package, Holtec Report HI-2002563 (reference PG&E Letter DIL-01-007, dated December 21, 2001), describes how the dose from the ISFSI was calculated in two parts: radiation emanating off the side of the casks and radiation emanating off the tops of the casks. These values were calculated as separate components and summed to provide the total dose versus distance from the ISFSI. Appendix E of the calculation package shows the dose versus distance from radiation emanating off the side of a single cask and from radiation emanating off the top of a single cask. These results were used in Appendix G of the calculation package where the dose from the ISFSI was calculated. The results in that appendix distinguish between radiation emanating off the sides of the casks and radiation emanating off the tops of the casks (skyshine). SAR Table 7.5-1 provides the dose rate (2.7×10^{-3} mrem/hr) at the controlled area boundary from the direct radiation from the ISFSI. This result was calculated in Appendix G of the calculation package where it was shown that the dose rate from radiation emanating off the sides of the overpack was 2.6×10^{-3} mrem/hr and the dose rate from radiation emanating off the tops of the overpacks (skyshine) was 8.0×10^{-5} mrem/hr.

Question 11-3

Provide a figure which identifies the location of the nearest resident.

The SAR indicates nearest resident is located 2,414 meters from the ISFSI but does not indicate which sector. (SAR Section 7.5, Offsite Collective Dose)

This information is needed to determine compliance with 10 CFR §72.104 and 10 CFR Part 20.

PG&E Response to Question 11-3

The Diablo Canyon ISFSI SAR, Section 2.1.3.1, states that the nearest residence is approximately 1.5 miles (2,414 meters) north-northwest of the ISFSI site and is occupied by two persons.

SAR Figure 2.1-3 identifies the population distribution from 0 to 10 miles within specific sectors. As discussed in SAR Section 2.1.3, the population data for the ISFSI are based on distances from the Unit 1 containment rather than distances from the ISFSI site. The 0.22-mile offset to the ISFSI was considered to have a negligible effect on the population estimates at various distances and directions from the ISFSI.

The above information will allow the NRC staff to determine compliance with 10 CFR 72.104 and 10 CFR 20.

Question 11-4

Provide a summary description of the analyses performed to determine the dose to an individual at the DCPP site boundary.

This information is needed to determine compliance with 10 CFR §72.104.

PG&E Response to Question 11-4

The offsite dose calculations to demonstrate compliance with 10 CFR 72.104 consist of the following calculations.

(1) Direct radiation dose contribution from the ISFSI (including skyshine). These calculations are described in SAR Section 7.3.2 and additional detailed discussion is provided in calculation package HI-2002563, which was submitted in PG&E Letter DIL-01-007, dated December 21, 2001.

(2) Direct radiation dose contribution from HI-STORM loading operations. Since transfer of the loaded MPC from the HI-TRAC transfer cask to the HI-STORM overpack will take place at the CTF, located adjacent to the ISFSI, a contribution to the off-site dose was calculated due to operations with the loaded HI-TRAC transfer cask while it is outside the 10 CFR 50 structure. This calculation is described in SAR Section 7.5.3.

(3) Normal condition effluent release from the ISFSI. These calculations are described in SAR Section 7.5.2.

(4) Dose contribution from the other uranium fuel cycle operations in the vicinity (i.e. the Diablo Canyon Power Plant). This information is discussed in SAR Section 7.5.4.

(5) Dose contributions due to off-normal conditions at the ISFSI. This only affects the effluent release. These calculations are discussed in SAR Section 8.1.3.

The results of the first four contributions were summarized in SAR Table 7.5-4 and ER Table 5.1-1. In the first issuance of this document, the contribution from off-normal conditions on the ISFSI was inadvertently neglected in SAR Table 7.5-4 and ER Table 5.1-1 for comparison to the 10 CFR 72.104 limits. This contribution has been added to SAR Table 7.5-4, Amendment 1 and ER Table 5.1-1, Amendment 1 in response to this RAI to demonstrate compliance with 10 CFR 72.104. Please also see the response to RAI 11-5.

Question 11-5

Provide an analysis which demonstrates compliance with the 40 CFR Part 190 dose rate limit of 25 mrem/year from all site sources.

This information is needed to determine compliance with 10 CFR Part 20.

PG&E Response to Question 11-5

The 40 CFR 190 annual dose limits are identical to the dose limits in 10 CFR 72.104. Therefore, compliance with 10 CFR 72.104, as demonstrated in Diablo Canyon ISFSI SAR Table 7.5-4 also demonstrates compliance with 40 CFR 190. Note that 10 CFR 20 establishes dose limits for occupational radiation exposure and compliance is separate from the dose limits established for the controlled area boundary in 10 CFR 72.104. Compliance with 10 CFR 20 is demonstrated through implementation of an ALARA-based work philosophy and monitoring of actual personnel exposure under the Diablo Canyon Power Plant radiation protection program.

In reviewing the ISFSI SAR for this RAI, it was discovered that SAR Table 7.5-4 does not currently report annual doses for off-normal conditions, which is included in the 10 CFR 72.104 regulation. Therefore, this table has been modified to add the dose from the hypothetical confinement boundary leak off-normal event. SAR Section 7.5.4 was also revised to indicate that SAR Table 7.5-4 also reports off-normal conditions. Further, the description of the analysis of this off-normal event in SAR Section 8.1.3 and the results reported in SAR Table 8.1.1 have been revised to reflect the dose from a single cask, rather than 140 casks. The single cask analysis is consistent with the guidance contained in Interim Staff Guidance Document 5, Revision 1. This value will be the value used in revised Table 7.5-4, as discussed above.

Refer to SAR Amendment 1 for revised Sections 7.5.4 and 8.1.3 and Tables 7.5-4 and 8.1-1. Refer to ER Amendment 1 for revised Table 5.1-1.

Chapter 12. Quality Assurance Evaluation

The staff had no comments regarding the general description of the proposed Diablo Canyon ISFSI.

Chapter 13. Decommissioning Evaluation

The staff had no comments regarding the general description of the proposed Diablo Canyon ISFSI.

Chapter 14. Waste Confinement

The staff had no comments regarding the general description of the proposed Diablo Canyon ISFSI.

Chapter 15. Accident Analysis

Question 15-1

Provide detailed information for the selection process and analysis used to eliminate a particular hazard from further consideration.

It is not clear how the potential off-normal and accident events have been selected for further consideration. This information is necessary to demonstrate that all appropriate potential hazards have been considered in the Diablo Canyon ISFSI Safety Analysis Report.

The information is needed to determine compliance with 10 CFR §72.92(a), §72.92(b), §72.94(a), and §72.94(b).

PG&E Response to Question 15-1

In developing the accidents to be analyzed, PG&E used the guidance provided in NUREG-1567 Section 15.2. NUREG-1567 provides a list of accidents all of which analyzed for the Diablo Canyon ISFSI except accidents involving pool facilities. A wet storage accident is not applicable to the Diablo Canyon ISFSI since the ISFSI is a dry cask facility. PG&E then evaluated the Diablo Canyon ISFSI site-specific conditions and identified additional accidents to be considered such as potential accidents which may result from the onsite transmission lines. PG&E also reviewed other site-specific applications and their associated NRC safety evaluations to ensure the list of accidents to be considered was complete. Therefore PG&E believes that all appropriate potential hazards have been considered in the Diablo Canyon ISFSI SAR.

Question 15-2

Provide information on what safety features and/or administrative procedures would be used to avoid a potential collision between the cask transporter or other on-site vehicle and a storage cask, a transportation cask, the transfer facility, or the storage pad. In addition, describe any measures, such as safety features or administrative procedures relied on to mitigate the consequences from such hazards.

This information is necessary to determine whether collision of vehicles with important-to-safety structures is a credible hazard at the proposed facility.

This information is needed to determine compliance with 10 CFR §72.122(b)(1), §72.122(e) and §72.122(g).

<u>PG&E Response to Question 15-2</u>

SAR Sections 3.3.3.2.8 and 4.3.2.1.2 describe the transporter control system design criteria. This section indicates that the transporter is equipped with a operator control panel. The control panel includes controls for all cask transporter operations including speed control, steering, braking, load raising and lowering, cask restraining, engine control and "dead-man" and emergency stop switches. SAR Section 2.2.2.3 describes the Cask Transportation Program, which will be developed and maintained to ensure hazard limitation and a transport route walkdown prior to cask transport activities. This program will also control all movement of vehicles or activities during onsite transport that could have an adverse effect on the loaded overpacks or transfer cask.

See also the response to RAI 15-14.

<u>Question 15-3</u>

Provide an assessment of a cask drop of less than design-allowable height.

NUREG–1567, Subsection 15.5.1.1, Cask Drop Less than Design Allowable Height, indicates that drops of the casks at less than their allowable design heights during handling operations are hypothetical off-normal scenarios that the applicant must evaluate. An acceptable alternative to evaluating drops of the various fuel confinement components at less than design allowable heights is to demonstrate that their integrity and fuel spacing geometry will not be compromised when subjected to postulated drop and tipover accident scenarios. NRC considers the consequences of drops less than the allowable design heights to be bounded by these accident scenarios.

<u>PG&E Response to Question 15-3</u>

No drops of the loaded HI-STORM overpack or HI-TRAC transfer cask are postulated in the design and licensing basis for the Diablo Canyon ISFSI. This is based, primarily, on Sections 5.5.a.3 and 5.5.b.2 of Appendix A to the HI-STORM 100 CoC, Revision 1 and Diablo Canyon ISFSI SAR Section 4.3, as discussed in the response to RAI 4-2.

Design of the lifting components in accordance with NUREG-0612, ANSI N14.6, and ANSI B30.9, as applicable, provides adequate assurance that a cask drop is unlikely. However, for defense-in-depth, the loaded casks will be transported as low as practical at all times.

Question 15-4

Provide an assessment of storage and transfer cask drops.

NUREG–1567, Subsection 15.5.2.2, Cask Drop, indicates that drops of the casks are hypothetical accident scenarios that must be evaluated by the applicant. Alternatively, provide justification for why such events are non-credible (see RAI # 4-2)

This information is needed to determine compliance with 10 CFR §72.128(a).

PG&E Response to Question 15-4

Please see the response to RAI 15-3.

Question 15-5

Provide the technical bases for the proposed setback distances of transient sources of combustibles.

Site topography and potential thermal load must be considered in the development of these bases. Specifically address the 7,300 l [2,000 gal] tanker truck that will routinely pass near the ISFSI site on its way to the maintenance shop.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-5

The minimum required separation distance between the 2,000-gallon tanker truck and the storage cask is 180 ft. Refer to Attachment 15-1, PG&E Calculation M-1046, Revision 0. This setback distance will be administratively controlled. However, as stated in SAR Section 8.2.6, an exception to the distance criterion is when the 2,000-gallon gasoline tanker truck is using the transport route near the ISFSI pad. The truck will only be in this area momentarily while passing by the ISFSI pad.

Also, as stated in SAR Section 8.2.6, a probabilistic risk analysis was performed and it was determined that the risk is insignificant using Regulatory Guide 1.91 risk acceptance criteria. This PRA is provided in response to RAI 15-9.

Question 15-6

Provide an analysis to justify the assertion that a potential fire in any existing stationary fuel tanks would not pose a hazard to the ISFSI facility. Provide additional information on the type(s) of fuel, capacity of the fuel tanks, construction of the tanks, and the safety features.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-6

The analysis that justified that a potential fire in the existing stationary fuel tanks would not pose a hazard to the ISFSI facility is provided in a Holtec letter dated February 15, 2001 from Evan Rosenbaum to Eric Lewis, titled "Justification of a 50-gallon Transporter Fire Bounding Other Fires. The letter is provided as Attachment 15-2 to this response.

SAR Section 8.2.6 states that there are three stationary fuel tanks, a 250-gallon propane tank, a 2,000-gallon diesel fuel tank, and a 3,000-gallon gasoline tank, located no closer than 1,200 ft from the cask transport route. The 1,200-ft separation distance between the three fuel tanks located next to the main plant road, and the closest possible cask location ensures that the engulfing transporter fuel tank fire will bound this event. Because of the separation distance, only radiant heat transfer will act to deposit released fire energy into a cask. The surface area of a hemisphere with a 1,200-ft radius is in excess of 9 million square ft while the projected area of a single cask is about 220 square ft. Thus, less than 2.5×10^{-3} percent of the total fire energy releases from these three tanks could possibly be directed toward a single cask. This is such a small amount as to be negligible, so the transporter fuel tank fire will be bounding. This evaluation assumes that a fire occurs simultaneously on all of these tanks. SAR Section 8.2.6 discussed the effects of explosion from these tanks. Since diesel fuel cannot detonate (but it can burn and contribute to the total amount of heat released), Event 4 in SAR Section 8.2.6 considered simultaneous detonation from both the propane and gasoline fuel tanks.

Question 15-7

Provide additional information to justify assumptions used in calculating the effects of wild fires in calculation HI–2012615, "Evaluation of Site-Specific Wild Fires for the Diablo Canyon ISFSI," regarding the characteristics of the site-specific wild fires (e.g., flame height, flame front velocity, fireline intensity).

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-7

The wildfire evaluation uses predictive models called FARSITE and FLAMMAP (Reference 1) to determine the potential characteristics of wildfire in the Diablo Canyon. Both models utilize mapped data about the type of vegetation (fuel model), slope, aspect, elevation, wind, and moisture to predict wildfire characteristics such as flame length, rate of spread, heat per unit area, etc. The proposed ISFSI site, located immediately southeast of the power plant's raw water reservoirs, is surrounded on the south, southeast, and north sides by a vegetation type of "annual grassland".

(Reference 2). The main access road forms the northwest boundary of the proposed site. The annual grassland vegetation is grazed and has relatively low cover. Consequently, the fire risk of this fuel type is relatively low.

The following table summarizes the results from the FARSITE and FLAMMAP models for the F1 fuel model in the vicinity of the proposed ISFSI site.

Wildfire Characteristic	No Wind	15 mph Uphill Wind
Fireline Intensity (kW/m)	84	203
Rate of Spread (m/min)	4	12
Flame Length (m)	0.5	0.9

References Cited:

1. M. A. Finney, and P. L. Andrews, The FARSTIE Fire Area Simulator: Fire Management Applications and Lessons of Summer 1994, In: Fire Management Under Fire (adapting to change): Proceedings, 1994 Interior West Fire Council meeting and program, 1994, Fairfield, CA: Interior West Fire Council, 1998.

2. Michael Fry, Wildlands Fuel Management Program; Annual Report. Diablo Canyon Land Stewardship Program, PG&E, 1999.

Question 15-8

Provide analyses on explosion-generated missiles for Explosion Event Scenarios 1 through 3 to show that these missiles would not affect the ability of structures, systems, and components important to safety to perform their intended safety functions.

In the Diablo Canyon ISFSI Safety Analysis Report, the applicant cites existing information and analyses provided in Regulatory Guide 1.91 (NRC, 1978). The information and analyses in Regulatory Guide 1.91 are intended, however, for an overpressure that does not exceed 6.9 kPa [1.0 psi]. Regulatory Guide 1.91 clearly states that "If the overpressure criteria of this guide are exceeded, the effects of missiles must be considered." For Explosion Event Scenarios 1 through 3, as listed in Table 8.2-11 of the Diablo Canyon ISFSI Safety Analysis Report, the associated incident over-pressures are more than 6.9 kPa [1 psi]. Consequently, the effects of explosion-generated missiles due to Explosion Event Scenarios 1 through 3 must be analyzed.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-8

Regulatory Guide (RG) 1.91 is a power reactor licensing document that was developed to provide guidance to plant designers in the evaluation of explosion hazards postulated to occur near nuclear power plants. The RG establishes an overpressure limit of 1 psig for nuclear power plant structures, beyond which the effects of higher external pressure must be evaluated for credible explosions. The MPC enclosure vessel is designed for 60 psid external pressure for reasons related to 10 CFR 71 licensing, and the HI-STORM overpack is qualified for an overpressure of 10 psid without overturning (reference HI-STORM FSAR Tables 2.0.1 and 2.0.2). There are no explosion-generated missiles evaluated generically for HI-STORM. The tornado-generated missiles for which the HI-STORM system is designed include a 1,800 kg vehicle and a 125 kg steel cylinder traveling at 126 mph (see also the response to RAI 15-18).

SAR Section 8.2.6 is revised in Amendment 1 to rely upon administrative controls either to: (a) keep onsite gasoline-powered vehicles at a sufficient distance such that any explosion overpressure is less than 1 psig, or (b) perform a probabilistic risk analysis which demonstrates that the risk meets acceptance criteria; or (c) require the use of diesel-powered vehicles.

Also, SAR Section 8.2.6 is revised in Amendment 1 to rely upon administrative controls to ensure propane and acetylene bottles are either: (a) at sufficient distance from the ISFSI storage pad (at all times), the CTF (while transferring an MPC) to ensure the explosion overpressure is less than 1 psig or (b) a risk assessment will be performed using Regulatory Guide 1.91 risk acceptance criteria.

Question 15-9

Provide the analysis that concluded that the risk of an explosion of the gasoline tanker truck, having a capacity of 7,300 l [2,000 gal] of fuel, will not affect the safety functions of the ISFSI and Cask Transfer Facility.

The applicant states in Section 8.2.6 of the Diablo Canyon ISFSI Safety Analysis Report that a probabilistic risk analysis, based on Regulatory Guide 1.91, was performed to show that the risk of this accident scenario is insignificant, but this analysis was not submitted for staff review.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-9

PG&E calculation PRA 01-01 (Attachment 15-3) was performed for a gasoline tank truck using the transport route near the ISFSI pad. Using Regulatory Guide 1.91 guidance, Calculation PRA 01-01 demonstrates that the risk of damage due to explosion of a gasoline tanker truck passing the ISFSI is sufficiently low to be considered insignificant.

SAR Section 8.2.6 indicates that administrative controls per the Cask Transport Evaluation Program (Proposed Diablo Canyon ISFSI Technical Specification 5.1.5) will be used to ensure that tanker trucks are maintained a sufficient from the CTF during MPC transfer activities.

Question 15-10

Provide an analysis to demonstrate that the probability and risk of an explosion in the transformers due to an electrical fault while the transfer cask is in the proximity will not impair the essential safety functions of the ISFSI or Cask Transfer Facility.

Section 8.2.6, Explosion, of the Diablo Canyon ISFSI Safety Analysis Report cites the risk acceptance criteria of Regulatory Guide 1.91 (NRC, 1978). This analysis was not submitted to the staff for review.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-10

PG&E Calculation PRA 01-01 was performed to determine the risk of an explosion in the transformers due to an electrical fault while the transfer cask is in the proximity and determined that the risk is not significant. The calculation is provided as Attachment 15-3 of this submittal.

Question 15-11

Provide information and analysis to demonstrate that any explosion of the hydrogen bottles, shown in Figure 2.2-1 to be located close to the path of the transporter and the ISFSI pads, will not pose an undue hazard to structures, systems, and components important to safety at the proposed facility.

The Diablo Canyon ISFSI Safety Analysis Report did not provide the capacity of the hydrogen bottles or the maximum number of such bottles that can be stored at a given time. Additionally, no analysis has been provided.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-11

SAR Section 8.2.6.2.3 indicates that a bulk hydrogen facility is located east of the FHB/AB. This facility contains 6 tanks for a total of 300 cubic ft and is near the transport route. As shown in SAR Figure 2.2-1, this bulk hydrogen facility is not located in the vicinity of the ISFSI pads and is at a lower elevation. The hydrogen facility is located next to the power plant approximately 0.14 miles from the ISFSI pad and its elevation is several hundred feet below the ISFSI. Therefore the hydrogen facility cannot affect the ISFSI. Calculation PRA 01-01 (Attachment 15-3) was performed to determine the risk of damage due to a hydrogen explosion during cask transport and concluded that the risk is within the risk acceptance criteria of Regulatory Guide 1.91 (NRC, 1978).

Question 15-12

Provide the maximum amount of acetylene to be stored in one bottle. Describe the physical or administrative controls that would prevent more than one acetylene or propane bottle from being transferred in a single trip.

NUREG–1567 (Section 15.5.2.4) states that this information should be provided in the Safety Analysis Report.

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-12

The following table provides the physical data including the bottle capacity. (by volume or weight of Acetylene) This is the largest Acetylene cylinder made by Taylor-Wharton and is used as basis for the explosion analysis.

Item	Cylinder Size	Comments
Model number	WM-397	Harsco Corporation Gas & Fluid Control Group – Taylor-Wharton Acetylene Data Table (http://www.taylor-wharton.com/ig_record_rec31_tid8.html & http://www.taylor-wharton.com/ig_record_rec31_tid9.html)
DOT	DOT-8AL	
Acetylene capacity (volume)	397 cf	
Tapping	3/4 - 14NGT	
Diameter – OD	12.268 inches	
Height w/cap and valve	46.25 inches	
Water volume – cu in	4171	
Tare weight	170 lbs	Steel shell + porous medium + acetone + saturated gas allowance

Item	Cylinder Size	Comments
Acetylene capacity (weight)	27.0 lbs	
Full weight	197 lbs	
Service pressure	250 psig	
Test pressure	750 psig	

A probabilistic risk analysis (PRA Calculation PRA02-10) was performed for a truck carrying multiple gas (acetylene or propane) storage bottles exploding while passing the ISFSI and concluded that the risk was is insignificant using the Regulatory Guide 1.91 risk acceptance criteria. See Attachment 2-6.

SAR Section 2.2.2.3 indicates that administrative controls will be utilized to ensure that gas bottle detonation sources in the vicinity of the CTF are maintained either at a safe setback distance or precluded from transport past the CTF during MPC transfer activities per the Cask Transport Evaluation Program (Section 5.1.5, "Proposed Technical Specifications for Diablo Canyon Independent Spent Fuel Storage Installation").

<u>*Question 15-13*</u>

Provide an analysis to demonstrate that any explosion of the vapor cloud resulting from rupture of the propane and gasoline storage tanks, considering atmospheric dispersion, will not generate an air overpressure that may pose undue hazard to structures important to safety at the proposed facility.

Any atmospheric dispersion of the vapor cloud can bring the flammable mixture closer to the structures, systems, and components important to safety than the distances used in the analyses given in the Diablo Canyon ISFSI Safety Analysis Report and calculation HI–2002512. A delayed ignition of the vapor cloud may produce an unacceptable level of air overpressure near the structures important to safety.

This information is needed to determine compliance with 10 CFR §72.122(c).

<u>PG&E Response to Question 15-13</u>

As noted in Diablo Canyon ISFSI SAR Section 8.2.6, both the gasoline and propane storage tanks are located approximately 1,200 ft from the cask transfer route at its closes point. The transporter will only be in this vicinity for a very short period of time and during this time, all filling of the tanks will be suspended and all vehicle movement will be administratively controlled in accordance the cask transportation program. Therefore, a catastrophic rupture of these tanks resulting in release of a vapor cloud during the period of time that the cask transporter is traversing the area is not credible.

The location of the tanks is well over 1/2 mile from the ISFSI site itself. The tanks are located southwest of the ISFSI site and approximately 200 ft below the ISFSI elevation. For a vapor cloud to get to the ISFSI from the tanks, it would be required to move up and north around a large hill between the tanks and the ISFSI site, as there is no line of site between the ISFSI site and the tanks. The prevailing winds are southeastern in the area and would normally try to take any vapor cloud south of the ISFSI site. In addition, there is a major cut in the hillside directly above and east of the tanks, which would be the likely route of any vapor cloud and would further direct the vapor cloud away from the ISFSI site.

For gasoline, its properties do not support a credible possibility that a vapor cloud could remain intact and reach the ISFSI site based on travel distance.

For propane, this is a larger concern because propane's properties would support the gas staying close to the ground and intact for a much longer period of time. However, the terrain between the tanks and the ISFSI site, elevation differences, and the prevailing winds in this area do not support a credible possibility for a vapor cloud to move close enough to affect the ISFSI site and to stay intact at a concentration supporting ignition.

<u>*Question 15-14*</u>

Provide information on how gasoline, diesel, propane, acetylene, and other combustible materials would be supplied to the facility.

Ilf gasoline, diesel, and propane are replenished using tanker trucks, the size and number of the trucks that may be present at any time, and the location of the trucks with respect to structures, systems, and components important to safety should be provided. Analysis should also be presented to demonstrate that the tanker trucks would not pose any undue hazard to the facility. Similar information and analysis should be submitted for combustible and explosive materials supplied in bottles (e.g., acetylene, hydrogen).

This information is needed to determine compliance with 10 CFR §72.122(c).

<u>PG&E Response to Question 15-14</u>

Diablo Canyon ISFSI SAR Sections 8.2.5 and 8.2.6 provide summary information on fires and explosions. The following summarizes this information and provides information on additional evaluations which were performed:

(1) No gasoline, diesel, propane, acetylene, and other combustible materials will be supplied to the ISFSI site. As discussed in SAR Section 8.2.5.2, administrative controls will be imposed to ensure that no combustible materials are stored within the protected area fence around the ISFSI storage pads. In addition, prior to any cask transport, a walkdown will be performed to ensure that all local combustible

materials, including transient combustibles, are controlled in accordance with the Proposed Diablo Canyon ISFSI Technical Specification cask transport evaluation program.

(2) SAR Section 8.2.6 states that there are 3 fuel tanks (propane, No. 2 diesel and gasoline) located beside the main plant road and are 1,200 ft from the cask transport route at its nearest point. Because of the distance from these tanks to the ISFSI pad and cask transfer facility (CTF), estimated at more than 1/2 mile and at an elevation at least 200 ft below the ISFSI pad and CTF, an explosion from these stationary tanks only has the possibility of affecting the transfer cask during transportation and is analyzed and found acceptable in Holtec Calculation HI-2002512, which was provided to the NRC in PG&E letter DIL-01-007 dated December 21, 2001. These tanks will be filled periodically by standard tanker trucks with a capacity of 3,000 to 4,000 gallons. As discussed in SAR Section 8.2.6, the location of any tanker truck will be administratively controlled to ensure the total energy received is less than the design-basis event. In addition, during any transporter operation all filling of tanks will be suspended and all vehicle movement will be administratively controlled in accordance with the Proposed Diablo Canyon ISFSI Technical Specification cask transportation evaluation program.

(3) In addition to the diesel delivered at the stationary tanks discussed above, diesel fuel oil is delivered to the emergency diesels at the power plant 7,000 to 8,000 gallons at a time. This volume arrives in either one large tanker truck or in a smaller tanker truck, each tank holding half the volume. Most of the deliveries occur during an outage when they will use approximately 3,000 gallons/month. Deliveries during non-outage periods are approximately once every 1 to 2 months. The location of the emergency diesel fuel oil tanks are west of the DCPP turbine building and at an elevation of approximately 85 ft. This location is on the opposite side of DCPP from the ISFSI site and is more than 200 ft below the ISFSI, which would preclude any potential affect on the ISFSI site. The truck route could potentially come close to the transporter route, however, during any transporter operation all filling of tanks will be suspended and all vehicle movement will be administratively controlled in accordance with the Proposed Diablo Canyon ISFSI Technical Specification cask transportation evaluation program.

(4) Hydrogen has been delivered once every 7 to 10 days and the turn-around time for filling the hydrogen tanks is 2 to 4 hours. The fill truck normally uses the protected area gate near the Unit 2 Cold Machine Shop and the south radiologically-controlled area gate. This shipment was evaluated as having no potential for impacting the cask transfer facility (CTF) or the ISFSI pad due to the distance and elevation differences (hydrogen tanks at elevation 115 ft and the CTF and ISFSI pad at elevation greater than 300 ft). As discussed in SAR Section 2.2.2.3, during any transporter operation all filling of tanks will be suspended and all vehicle movement will be administratively controlled in accordance with the Proposed

Diablo Canyon ISFSI Technical Specification cask transportation evaluation program. Shipments of diesel and gasoline to the vehicle maintenance shop passing near the ISFSI site will be done by the 2,000-gallon fuel trucks on an intermittent basis. The evaluation of a 2,000-gallon tanker truck is addressed in response to RAI 15-5. Gasoline tanker shipments will be administratively controlled in accordance with the Proposed Diablo Canyon ISFSI Technical Specification cask transportation evaluation program to ensure that no shipments occur in the vicinity of the CTF during MPC transfer activities.

There are 2 plant 2,000 gallon tanker trucks used onsite. While not used, they are parked in locations discussed below. The following evaluation addresses their impact to the transfer cask operation while these trucks are in the parked location:

One of the trucks is normally parked at the maintenance facility, northeast of the ISFSI site at a distance of approximately 1,600 ft, while the other is parked inside or just outside the protected area at the power plant, which is well west and approximately 200 ft below the ISFSI site and CTF. Each of these fuel trucks has the capability of holding 2,000 gallons of fuel. Presently one of the vehicles is configured to hold 1,650 gallons of diesel fuel and 350 gallons of gasoline while the other holds 1,000 gallons of diesel and gasoline. Since the gasoline has a lower flashpoint than diesel fuel an evaluation was performed using the methodology used in PG&E Calculation M-1046, "Minimum Separation Between Fuel Tanks and Storage Tanks" (Attachment 15-1). The calculation determined the minimum setback for a 2,000-gallon tank is 180 ft. Based on the actual setback distance of the truck located at the maintenance facility, it is not a concern for the transporter, its cargo, the ISFSI site or the CTF. In addition, with the other truck at its storage location, there would be no potential affect on the ISFSI pad or CTF because of the distance to these facilities (over a quarter of a mile) and the difference in elevation. Also when considering the truck located at the power plant, the calculation determined that no damage would occur to the transfer cask and its cargo during transport operations with the fuel truck stored in this area. As such, no additional requirements are required for the fuel truck stored at the minimum setback distance. However, to further ensure no potential effect on the transporter, during any transport operation all vehicle movement and setback distances will be administratively controlled in accordance with the Proposed Diablo Canyon ISFSI Technical Specification cask transportation evaluation program.

(5) SAR Section 8.2.6 addresses other miscellaneous combustible material, such as acetylene and propane being shipped in bottles. Again, all such shipments will be suspended during cask transportation and transfer operation in accordance with the Proposed Diablo Canyon ISFSI Technical Specification cask transportation evaluation program.

(6) As discussed in SAR Section 8.2.6 the cask transporter refueling activities will be administratively controlled to ensure the total energy potential received by ISFSI facilities is less than the design-basis fire event.

Question 15-15

Provide justification for the electrical resistivity values used to assess the consequences of lightning strike and 500-kV transmission line drop on the HI-STORM 100 storage cask and HI-TRAC transfer cask.

According to the American Society for Metals (1985), electrical resistivity for American Iron and Steel Institute-Society of Automotive Engineers (AISI–SAE) Grade 1042 carbon steel is 17.1 μΩ-cm at 20 °C (68 °F). AISI–SAE Grade 1042 carbon steel is relevant because it has a chemical composition that is similar to the outer shell material, SA 516 Grade 70. NUREG–1567 (Section 15.5.2.5) states that a discussion of the structural materials or components that might be damaged by heat or mechanical forces generated by passing electrical current to ground should be provided by the applicant.

This information is needed to determine compliance with 10 CFR §72.122(b)(1) and §72.122(b)(2).

PG&E Response to Question 15-15

Electrical resistivity is only used in the analysis of the lightning strike. The methodologies used to evaluated the lightning stroke and 500-kV line drop are described in Section 2.0 of Holtec Report HI-2002559 (submitted in PG&E Letter DIL-01-007 dated December 21, 2001). The electrical resistivity value for iron (10 μΩ-cm) was obtained from the CRC Handbook of Chemistry and Physics and conservatively increased by 20 percent to obtain an estimated value of 12 μΩ-cm for steel, which was used in the lightning strike analysis. Even if the resistivity were doubled from this value (to 24 μΩ-cm), the temperature rise from the lightning event would still be less than 1°F. Therefore, the sensitivity of the value of resistivity used in the analysis is low enough that even if the value suggested in the RAI (17 μΩ-cm) was used, it would result in no significant change to the conclusion of the analysis.

Question 15-16

Provide an assessment of the potential consequences of a lightning strike or 500-kV transmission line drop on the site transporter while a cask is being transferred.

NUREG–1567 (Section 15.5.2.5) states that a discussion of the structural materials or components that might be damaged by heat or mechanical forces generated by passing electrical current to ground should be provided by the applicant.

This information is needed to determine compliance with 10 CFR §72.122(b)(1) and §72.122(b)(2).

PG&E Response to Question 15-16

The effect of a potential lightning strike on the cask transporter while carrying a loaded overpack or transfer cask has been qualitatively evaluated and is discussed in Diablo Canyon ISFSI SAR Section 4.3.2.1.2. A lightning strike on the cask transporter would not structurally affect the transporter's ability to hold the suspended load due to the massive amount of steel in the structure. The current from a lightning strike would be transmitted to the ground without significantly damaging the transporter structure. Lightning may affect the operator and/or the drive and control systems of the transporter. However, the transporter is designed to shut down in a fail-safe condition as described in further detail in the response to RAI 5-9.

Question 15-17

Provide an analysis of the potential lateral and axial sliding distances that the transporter may slide on the roadway during an earthquake.

In Section 8.2.1.2.1 of the Diablo Canyon ISFSI Safety Analysis Report, analysis is provided to demonstrate limited sliding of the transporter on those portions of the roadway underlain by bedrock. No such analysis is provided for vibratory ground motions on portions of the roadway underlain by soil and manmade fill (see RAI 2-19). The applicant should provide analyses demonstrating that the transporter will remain on the roadway, within a safe margin from the edge of the roadway, during the design basis ground motions.

This information is needed to determine compliance with 10 CFR §72.92(a) and §72.122(b).

PG&E Response to Question 15-17

See response to RAI 2-19.

Question 15-18

Provide a detailed basis for the bounding values of large, intermediate, and small tornado missiles (see RAI 4-3).

This information is needed to determine compliance with 10 CFR §72.24 (c)(1), §72.24(c)(2), §72.92(a) §72.92(b), §72.92(c), and §72.122(b).

PG&E Response to Question 15-18

As discussed in Diablo Canyon SAR Section 3.2.1.3 and HI-STORM FSAR Section 2.2.3.5, the large, intermediate, and small missile categories are based on the guidance in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants", Section 3.5.1.4. The large missile category defines the high kinetic energy missile that deforms on impact and is postulated to test the resistance of the cask to overturning due to a missile strike; the intermediate missile category is used to test the penetration resistance of the structure from a rigid object; and the small missile category is used to evaluate the effect of missiles small enough to pass through penetrations in the structure. Therefore, each missile category is defined according to the type of threat it poses to the cask system.

For generic HI-STORM 100 System licensing, the NRC accepted a 1,800 kg automobile; a 125 kg, 8-inch diameter solid steel cylinder; and a 1-inch diameter solid steel sphere as the bounding large, intermediate, and small missiles, respectively (reference HI-STORM FSAR Table 2.2.5). For the Diablo Canyon ISFSI application, the generic HI-STORM licensing basis missiles in each category were compared to the Diablo Canyon site-specific licensing basis missiles and additional missiles unique to the ISFSI site to determine the bounding missile in each category for the ISFSI licensing basis.

The bounding missile in the large, intermediate, and small tornado missile categories were determined based on kinetic energy comparisons as stated in SAR Section 8.2.2.2. Additional information is provided here to further describe this comparison process. Each of the thirteen missiles in Table 3.2-2 of the ISFSI SAR was first placed into one of the above-referenced categories (i.e., large, intermediate, or small) according to its size and mass. The bounding missile in each category was then chosen as the missile with the highest kinetic energy. The table below lists the kinetic energies, as well as the category designation, of all thirteen missiles from the HI-STORM licensing basis, the Diablo Canyon Power Plant licensing basis, and the Diablo Canyon ISFSI site. As evident from the table, the bounding large, intermediate, and small missiles are the 1,800-kg automobile, the 500-kV insulator string, and the 1-in diameter steel rod, respectively.

Missile Description	Missile Category	Mass (kg)	Velocity (mph)	Kinetic Energy ($kg\text{-}m^2/s^2$)
Automobile	Large	1,814	33.3	2.01×10^5
Automobile*	Large	1,800	126	2.86×10^6
Utility Pole	Intermediate	510	107.4	5.88×10^5

Missile Description	Missile Category	Mass (kg)	Velocity (mph)	Kinetic Energy ($kg\text{-}m^2/s^2$)
500-kV Insulator String*	Intermediate	344.7	157	8.49×10^5
12-in Diameter Sch. 40 Pipe	Intermediate	340	62.6	1.33×10^5
6-in Diameter Sch. 40 Pipe	Intermediate	130	93.9	1.15×10^5
8-in Diameter Solid Steel Cylinder	Intermediate	125	126	1.98×10^5
4-in x 12-in x 10-ft Board	Intermediate	49.0	200	1.96×10^5
3-in Diameter x 10-ft Long Sch. 40 Pipe	Intermediate	34.5	66.7	1.53×10^4
500-kV Insulator Segments and Misc. Conductor Hardware	Intermediate	6.8	157	1.67×10^4
2-in x 2-in x 1/8-in Steel Angle (5-ft Long)	Intermediate	3.9	157	9.61×10^3
1-in Diameter Steel Rod*	Small	4	89.5	3.20×10^3
1-in Diameter Solid Steel Sphere	Small	0.22	126	3.49×10^2

* Bounding missile for the applicable category

For defense-in-depth, in addition to the penetration evaluation contemplated by the SRP for the intermediate missile category, the HI-STORM 100 licensing basis also includes a global stress evaluation for an intermediate category missile impact on the MPC and overpack lids. That is, a check of the stresses in the MPC lid-to-shell (LTS) weld and bending stress on the overpack lid due to forces induced by an intermediate category missile were performed. Different methodologies were used for the local penetration and global stress analyses.

The local missile penetration analyses rely on empirical formulas that equate the kinetic energy of the missile to a minimum required shell thickness to prevent penetration. These formulas, taken from References 1 and 2 for penetration of steel plates and lead-backed shells, respectively, do not depend on the material properties of the missile. Therefore, the insulator string is the bounding intermediate missile for penetration since it has the highest kinetic energy in that category.

The global stress evaluation, on the other hand, uses the failure stress of the missile material to determine the impact force. Then stresses are calculated based on the impact force. For the global stress analysis of a direct missile strike on the center of the MPC closure lid, the impact forces generated by the insulator string and the 8" diameter steel cylinder are 392,700 lb and 2,262,000 lb, respectively. The higher impact force caused by the eight inch diameter steel cylinder leads to a smaller factor of safety against failure of the MPC lid weld (7.1 vs. 1.23) (References 3 and 4). The eight-inch steel cylinder also causes a higher bending stress in the overpack top lid than the insulator string. The safety factors for the insulator string and the steel cylinder are 1.6 and 1.4, respectively (References 5 and 6).

References

1. Bechtel Topical Report BC-TOP-9A, Design of Structures for Missile Impact, Revision 2.

2. H. A. Nelms, Structural Analysis of Shipping Casks, Effect of Jacket Physical Properties and Curvature on Puncture Resistance, Vol. 3 ORNL TM-1312, Oak Ridge National Laboratories, June 1968.

3. Holtec Report HI-2002497, Appendix B.

4. HI-STORM FSAR, Appendix 3.H, Section 3.H.7.

5. Holtec Report HI-2002497, Appendix C.

6. HI-STORM FSAR, Appendix 3.G, Section 3.G.6.4.

SAR Section 8.2.2.2 has been revised to clarify the intermediate category tornado missile evaluation for the LTS weld. Refer to the Diablo Canyon ISFSI SAR, Amendment 1.

Question 15-19

Provide analyses or technical bases to demonstrate that the bounding large missile, 1,800 kg [4,000 lb], would not cause damage to the cask transfer facility that results in a drop of transfer cask from the top of overpack or damage to the overpack.

This information is needed to determine compliance with 10 CFR §72.92(a) and §72.122(b).

PG&E Response to Question 15-19

As described in Section 3.3.4 of the Diablo Canyon ISFSI SAR, the cask transfer facility (CTF) is an underground structure and, as such, it is not susceptible to missile impacts.

The loading operations for transferring an MPC from a HI-TRAC transfer cask into a HI-STORM storage overpack are summarized as follows. An empty overpack is placed in the CTF using the DCPP cask transporter. The CTF platform is lowered to the full down position leaving the top of the overpack body approximately 30 to 40 inches above the top surface of the pad. The overpack lid is removed and a mating device is attached to the top of the overpack. The transfer cask, containing a loaded and sealed MPC, is upended, raised and placed onto the mating device using the cask transporter. Seismic restraints secure the cask transporter to ground. Once the pool lid is removed, the MPC is lowered into the overpack using the lift system attached to the transporter main overhead beam.

Calculations documented in Holtec Report HI-2012768, Section 6.5, (submitted in PG&E Letter DIL-01-007 dated December 21, 2001) demonstrate that, even when unrestrained, a loaded cask transporter (carrying a storage cask vertically) will not overturn due to a large missile impact. Missiles were postulated to impact the transporter at the top and at the base, with trajectories perpendicular to the base. The consequences of a direct missile impact on the transfer cask are reported in Subsection 3.4.8.2.2 of the HI-STORM FSAR. The FSAR results show that the retrievability of the MPC in the wake of a large tornado missile strike is not adversely affected since the inner shell does not experience any plastic deformation. As for the overpack, the tight clearance between the overpack body and the CTF main shell, not to mention that it is almost entirely below ground, ensure that the overpack remains kinematically stable.

Besides the analytical and technical bases, damage to the CTF and the HI-STORM System is even more unlikely because of administrative controls in the ISFSI operating procedures that preclude cask transport and transfer operations during severe weather (SAR Section 8.2.3.1).

Question 15-20

Provide calculations to demonstrate that the transporter would not overturn while moving a loaded transfer cask to the Cask Transfer Facility and a loaded storage cask to the storage pads due to an impact by a design-basis tornado missile.

It is stated in Section 4.3.2.1.2, Design, that "the cask transporter is designed to withstand Diablo Canyon Power Plant design-basis tornado winds and tornado-generated missiles without overturning, dropping the load, or leaving the transporter *route," but the design analysis was not presented. Alternatively, the applicant may present an analysis demonstrating that there are no radiological consequences even if the transporter overturns.*

This information is needed to determine compliance with 10 CFR §72.122(c).

PG&E Response to Question 15-20

The calculations demonstrating that the transporter will not overturn due to an impact by a design basis tornado missile are presented in Section 6.5 of Holtec Report HI-2012768 (submitted in PG&E Letter DIL-01-007 dated December 21, 2001). This calculation was performed for a transporter carrying a storage cask vertically and for a transporter not carrying any cask. The calculation results envelope the condition when the transporter is carrying a loaded transfer cask horizontally to the CTF.

Question 15-21

Provide a technical basis to support the statement in Section 8.2.2.2.2, Transfer Operations at the CTF, of the Diablo Canyon ISFSI Safety Analysis Report that "cask transport and transfer operations will not be conducted during severe weather. The top of the multiple-purpose canister will only be exposed for a short duration (nominally less than 4 hours). Therefore, in the configuration with the lid removed, a tornado missile impact is not credible."

This conclusion lacks a sufficient technical basis because an acceptable definition of credible was not provided. Alternatively, the applicant can provide information to demonstrate that the exposed multipurpose canister would be able to withstand impact of any tornado-generated missiles without loss of its safety functions. In addition, the applicant should define "severe weather."

This information is needed to determine compliance with 10 CFR §72.92(a), §72.92(b), §72.92(b), and §72.122(b).

PG&E Response to Question 15-21

Per DCPP FSAR Update, Section 3.3.2.1.1, the NRC has estimated that the design basis tornado wind speed of 200 miles per hour has a frequency of 1.0×10^{-7} per year at the plant site. Therefore, the conditional probability of a design basis tornado missile generation with potential to impact the MPC during cask transfer operations in the CTF, with a 4 hour exposure time window, is fraction of a year that the MPC will be potentially exposed to the tornado missile hazard. This conditional probability is calculated by multiplying the annual frequency by the activity duration in hours divided by the total number of hours in a year. The resultant conditional probability is 4.56×10^{-11} which demonstrates that the postulated event is not credible.

The Cask Transportation Evaluation Program discussed in SAR Section 2.2.2.3 will include requirements to evaluate the weather conditions projected to be present during cask transport activities and MPC transfer activities in the CTF and ensure that no severe winds are projected (sustained or gusting wind speed greater than 70 miles per hour). Wind speeds less than 70 miles per hour do not have the potential to generate missiles than could pose a hazard to the cask transporter or CTF.

Question 15-22

Provide the analyses that demonstrate collapse of the electrical transmission towers will not adversely affect the multipurpose canister while at the Cask Transfer Facility or the loaded overpacks stored on the pads.

NUREG–1567 (Section 15.4.3) states that the applicant must list and evaluate accidents that are specific to the design.

This information is needed to determine compliance with 10 CFR §72.122.

PG&E Response to Question 15-22

Calculation HI-2012634, which was submitted in PG&E Letter DIL-01-007 dated December 21, 2002, demonstrates that collapse of the electrical transmission towers will not adversely affect the MPC while it is at the CTF or the loaded overpacks while stored on the pads.

Question 15-23

Provide a fire analysis of a loaded overpack inside the Cask Transfer Facility.

This scenario may arise as the result of a fuel spill from the 7,300 l [2,000 gal] gasoline tanker truck that passes near the facility on a regular basis. NUREG–1567 (Section 15.4.3) states that the applicant must list and evaluate accidents that are specific to the design.

This information is needed to determine compliance with 10 CFR §72.122.

PG&E Response to Question 15-23

The cask transfer facility (CTF) is used on a short term basis (likely for less than 4 hours per cask) to facilitate the transfer of a loaded MPC from the transfer cask to the overpack. This is estimated from the time the loaded transfer cask is placed atop the empty overpack to the start of transport of the loaded overpack to the ISFSI pad with the cask transporter. The portion of that time in which an overpack, with a loaded MPC inside, will be in the lowered position in the CTF will be a fraction of that time. A fire in the CTF while it contains a loaded overpack arising as a result of a fuel spill from a

2,000-gallon gasoline tanker truck is precluded by administrative controls. Appropriate procedural controls will be in place to prohibit gasoline tanker trucks (and other vehicles containing flammable materials) from passing within any distance of the CTF where fire would pose a threat to the integrity of the cask.

However, the cask transporter includes a fuel tank that is integral to the transporter during travel between the power plant and the ISFSI/CTF location. The fuel tank volume is limited to 50 gallons by the Proposed Diablo Canyon ISFSI Technical Specification 4.3.1.b. A potential fire in the CTF due to the release of the 50 gallons of fuel from the cask transporter has been addressed. The cask transporter will be designed with features (e.g., a removable fuel tank) that ensure the fuel, if spilled, will not migrate into the CTF structure. The CTF opening will be located at a higher elevation that the local surrounding area such that any fuel spilled will flow away from the CTF by gravity. This ensures that any fire that may occur is bounded by the fire analysis described in Section 11.2.4 of the HI-STORM System FSAR.

Chapter 16. Technical Specifications

Question 16-1

Provide Technical Specifications (TS) that follow the format and content of the HI-STORM 100 storage system.

The criticality aspects of the Diablo Canyon ISFSI Safety Analysis Report rely on the approved HI-STORM 100 storage system. The Diablo Canyon ISFSI Safety Analysis Report shows that the fuel to be loaded at Diablo Canyon falls within the bounds of fuel already approved for the HI-STORM 100 system. The staff's approval of the HI-STORM 100 application, as amended, was based, in part, on the TS also approved for that system. The applicant should use the previously approved documents (HI-STORM 100 Safety Analysis Report and accompanying Technical Specifications) as a basis in developing the Diablo Canyon ISFSI TS, with appropriate changes to reflect any limitations or site specific features (such as the applicable multipurpose canister and fuel types). Alternatively, the applicant must sufficiently describe and justify differences between the proposed TS for the Diablo Canyon ISFSI and those approved by the staff for the HI-STORM 100 system.

This information is needed to determine compliance with 10 CFR §72.44(c).

PG&E Response to Question 16-1

The Proposed Diablo Canyon ISFSI Technical Specifications (TS), Amendment 1; Technical Specification Bases for Diablo Canyon Independent Spent Fuel Storage Installation, Amendment 1; and the comparison between Holtec Technical Specifications and Diablo Canyon ISFSI Technical Specifications, Amendment 1; are being provided in PG&E Letter DIL-02-010, dated October 15, 2002. The TS generally follow the format and content of the HI-STORM 100 storage system, with any deviations justified in the comparison matrix.

The changes to the TS are summarized as follows:

(1) The TS Table of Contents was revised to show the inclusion of Limiting Condition for Operation (LCO) 3.1.1, Multi-Purpose Canister (MPC) and 3.1.3 Fuel Cool-Down, and the renumbering of LCO Spent Fuel Storage Cask (SFSC) Heat Removal System to 3.1.2 and LCO Spent Fuel Cask (SFSC) Time Limitation in Cask Transfer Facility (CTF) to 3.1.4.

(2) Section 2.0 was revised to make it similar to the approved HI-STORM 100 Technical Specifications, but specific to the Diablo Canyon ISFSI. This revision included adding Tables 2.1-1 through 2.1-10 and Figures 2.1-1 through 2.1-3. This revision provides the specification for allowed contents to be stored, the use of uniform and regional loading configurations, and actions required for any violation to functional or operating limits. The information provided in TS Section 2.0 is from Section 10.2 of the Diablo Canyon ISFSI SAR. As discussed below, most of the information is exactly the same as in the original license application submittal, however, there have been some changes to TS Table 2.1-10 and SAR Table 10.2-10 to bring them into compliance with the HI-STORM 100 approved CoC. The change to these tables was the result of an oversight not identified prior to the December 21, 2001 submittal. Since this information has been already approved in the Holtec CoC, which is the basis of the DC ISFSI license application, its use ensures maintenance of the DC ISFSI design basis and has no effect on the other information in the December 21, 2001 license application submittal.

(3) LCO 3.1.1 concerning the MPC integrity was added. This is a duplicate of the LCO in the approved HI-STORM 100 Technical Specifications, which has been modified to support DC ISFSI specific limits on MPC drying, backfilling, and leakrate testing. The TS Bases were also revised to address this LCO and its bases.

(4) LCO 3.1.2 (3.1.1 previously) was renumbered and revised to clarify the APPLICABILITY by eliminating unnecessary information that is duplicated in the TS definition of STORRAGE OPERATION. In addition, the associated Surveillance Requirement was renumbered to 3.1.2.1 and the words "...and are intact." were removed to duplicate the approved HI-STORM 100 Technical Specifications.

(5) LCO 3.1.3 "Fuel Cool-Down" was added, which provides the limitation for helium exit temperature prior to reflooding an MPC for unloading of fuel contents. This is a duplicate of the approved HI-STORM 100 Technical Specifications. The TS Bases were also revised to address this LCO and its bases.

(6) LCO 3.1.4, "Spent Fuel Cask Storage Cask (SFSC) Time Limitation in Cask Transfer Facility (CTF)" and the associated Surveillance Requirement were renumbered. This was completed to support the addition of LCO 3.1.1 and 3.1.3, as discussed above.

(7) The ACTIONS in LCO 3.2.1, "Dissolved Boron Concentration", were revised to be similar to the approved HI-STORM 100 Technical Specifications. The TS Bases were also revised in support of these changes.

(8) TS Section 4.2.1 was added to provide control of the approval process of alternatives to the listed confinement boundary codes and standards in TS Section 4.2 and SAR Table 3.4-6.

(9) Two references in TS Section 4.3.3 were revised from 4.5.2 to 4.3.4.

(10) Per RAI 6-7, TS Administrative Program 5.1.3 was revised to include a requirement for verifying that no transfer cask handling operations are allowed at temperatures below -18°C [0°F]. This change renumbered items (a) through (i) of that program. Also a typo was corrected under item j of that program to change the statement "For DCPP VANTAGE 5 assemblies without IFBA ...." to "For DCPP VANTAGE 5 assemblies with IFBA ....". Neither of these changes has any affect on the previous submittal.

(11) Per RAI 16-2, the TS Administrative Program 5.1.4 was revised to include a verification program of the ISFSI Pad anchor bolt surface coatings exposed directly to the elements.

In addition to the TS changes listed above, SAR Section 10.2 and its tables also were revised to support the revisions to the TS as follows:

(1) Section 10.2.1 was revised to discuss the additional LCOs that were added to the TS for MPC integrity and fuel cool-down.

(2) Section 10.2.1.2 was revised to address the duplication of the tables in Section 10.2 in the TS tables.

(3) Section 10.2.1.4 was revised to address the duplication of the Section 10.2 Figures 1, 2, and 3 in the TS as Figures 2.1-1 through 2.1-3.

(4) Section 10.2.1.5 was revised to add a statement that the listed actions are required by the TS.

(5) Section 10.2.5.2 was revised to identify that the specification for allowed content of an MPC is also contained in the TS Section 2.0, and that the new LCOs for the MPC integrity and fuel cool-down are contained in the TS and TS Bases.

(6) Section 10.2.9 was revised to add MPC dryness, backfill pressure, leakrate limitations, and fuel cool-down exit gas temperature limitations as items that are controlled in the DC ISFSI TS.

The following revisions to the SAR Section 10.2 Tables are incorporated into SAR Amendment 1:

(1) Table 10.2-1, Note 2, was clarified by listing Zircaloy-2, Zircaloy-4 and ZIRLO, which are the fuel rod cladding materials used at DCPP.

(2) Tables 10.2-2, 10.2-3, 10.2-4, and 10.2-5. Revised the abbreviation ZR to Zr to be in agreement with the SAR glossary and Note 2 was clarified by listing Zircaloy-2, Zircaloy-4 and ZIRLO, which are the fuel rod cladding materials used at DCPP.

(3) Table 10.2-6, Note 2, and Table 10.2-8, Note 3, were clarified to state that burnup for fuel assemblies with ZIRLO cladding are limited to 45,000 MWD/MTU or the value in the table, whichever is less.

All of these Table changes are being done to clarify general information and provide more plant specific information. All of the previous notes bound the specific information being provided in these revisions. As a result, there is no effect on any other information or specification in the previous submittal.

SAR Table 10.2-10 was revised to bring that table into compliance with the approved Holtec HI-STORM 100 Safety Analysis Report and accompanying Technical Specifications. The previous submittal was incorrectly based on older information from Holtec. The revised information is provided directly from the approved Holtec HI-STORM 100 SAR and accompanying TS. Although it does significantly revise the previous cooling time requirements and activation limits for nonfuel hardware, these limits are already approved in the Holtec HI-STORM 100 FSAR and accompanying TS and are part of the design bases of the Diablo Canyon ISFSI.

Question 16-2

Develop a maintenance program for the purpose of monitoring and verifying the preload of the HI-STORM 100SA overpack anchor studs. Specify the coating to be used on the exposed surfaces of the anchor studs and the embedment plate for corrosion protection. The program should also specify the time interval for periodic inspection of the anchor studs. This program should be included in the Technical Specifications.

Section 4.2.1.1.6 of the Diablo Canyon ISFSI Safety Analysis Report states that: "Each cask is compressed against the embedment plate using 16 studs. Each stud is preloaded to approximately 157,000 lbf." In addition, Section 8.2.1.2.3.1 of the Diablo Canyon ISFSI Safety Analysis Report states that: "The preloaded cask anchor studs are threaded into compression/coupling blocks to ensure a continuous compressive state of stress at the interface between the lower surface of the HI-STORM 100SA overpack and the top surface of embedment plate. The continued contact ensures development of interface friction forces sufficient to resist lateral movement of overpack base relative to the embedment plate. It also ensures that the ISFSI storage pad embedment structure provides the resisting moment to stabilize the system under seismic loading." To be certain that the anchorage system will maintain its safety functions during an earthquake, it is important that the anchor stud preload will not be reduced over the design life of the anchorage system.

This information is needed to determine compliance with 10 CFR §72.24(a), §72.24(b), §72.24(c), §72.24(d), §72.24(n), and §72.44(c).

<u>PG&E Response to Question 16-2</u>

PG&E has added a specific requirement for a coatings maintenance program to TS program 5.1.4 "ISFSI Operations Program". This program will provide for periodic visual inspection of the exposed portions of the overpack anchor studs, nuts, washers, and storage cask baseplate surrounding the nuts (ref. Diablo Canyon ISFSI SAR Figure 4.2-6) to ensure integrity of the coating of these elements so as to ensure that the structural function of these components is not challenged.

The preloading of the anchor studs is performed and verified at the time the overpack is anchored to the ISFSI pad embedment plate. Relaxation of the preloaded friction connection (ASME III NF) between the storage overpack and pad embedment is highly unlikely due to operational and environmental design factors. Operationally, there is no torque applied to elongate each anchor stud and there will be no significant thermal cycling of the storage cask temperature.. The anchor studs will be elongated using conventional hydraulic tensioning technology. Environmentally, the service temperature of the connection is well below the 600 degree F service temperature associated with relaxation. In addition, the coupling of the overpack and pad anchorage structures will not be loosened by vibration as there is not any vibration-inducing equipment continuously operating adjacent to them as can be found in the power plant. Therefore, vibration-induced relaxation of the connection is not of concern.

Nevertheless, SAR Section 8.2.1.2.3.1 has been revised to discuss the monitoring and verification of the preload of the HI-STORM 100SA overpack anchorage. PG&E will develop an inspection program that periodically checks a sampling of the anchor studs, washers and nuts to note any degradation or relaxation of these connections. This program will verify that the studs, washers and nuts have not turned from their as-left preloaded position, are not loose to the touch, and that visually their mating surfaces remain engaged. This inspection and verification will be performed as part of the 10 CFR Part 50 DCPP Maintenance Rule Program and will have similar periodic inspection requirements. This change to the SAR will ensure that the appropriate controls are established and maintained via 10 CFR 72.48 for this important to safety equipment.

Chapter 17. Environmental Review

Question 17-1

Provide a concise description identifying the purpose of the proposed action.

Chapter 1, Proposed Activities, provides the facility background, need for the proposed action, and schedule but does not include a written statement identifying the purpose of the proposed action.

10 CFR §51.45(b) states that the applicant's environmental report shall contain a description of the proposed action and a statement of its purposes.

This information is needed to determine compliance with 10 CFR §51.45(b).

PG&E Response to Question 17-1

The purpose of the Diablo Canyon ISFSI is to provide interim on-site storage capability for spent nuclear fuel in accordance with the Nuclear Waste Policy Act of 1982, pending disposal by the Department of Energy at a high level waste repository.

As indicated in ER Section 1.2, the Diablo Canyon ISFSI as currently proposed will hold up to 140 storage casks (138 casks plus 2 spare locations). This capacity will be adequate to store the spent fuel generated by DCPP Units 1 and 2 over the term of the current operating licenses (through 2021 and 2025, respectively). The ISFSI is sized to accommodate a single 40-year operating license term for both units and to support subsequent decommissioning of the units and termination of the Part 50 licenses. ER Section 3.1 indicates that initially two pads will be constructed followed by the remaining pads on a schedule to meet DCPP operational requirements. PG&E will continue to evaluate the availability of the alternative methods of meetings its National Waste Policy Act of 1982 obligations to store spent fuel as discussed in Section 8.2. PG&E may decide to not utilize the full capacity if other alternative options of transferring spent fuel to an offsite storage facility of high level waste repository become a viable option to meet the plant spent fuel storage needs.

ER Sections 1.2, 3.1 and 8.2 have been revised to further clarify the purpose of the Diablo Canyon ISFSI and its implementation strategy.

<u>*Question 17-2*</u>

Provide wind roses which show the average meteorology for the site. Provide information to show any seasonal variation in wind speed and direction.

Section 2.4.2, Local Meteorology, does not provide this information. Wind speed and direction are necessary to determine the radiological impact from the proposed action.

This information is needed to determine compliance with 10 CFR §51.45(b)(1).

<u>PG&E Response to Question 17-2</u>

As noted in the introduction to Section 2.4 of the ISFSI ER, Climatology and Meteorology, meteorological information for the Diablo Canyon area is provided in Section 2.3 of the DCPP FSAR Update. Section 2.3 of the DCPP FSAR Update is incorporated by reference in support of Section 2.4 of the ISFSI ER.

In Section 2.3.3 of the FSAR Update, the DCPP historical and current onsite meteorological measurement program is described. In the historical program, data were collected from an onsite network of six stations, designated as Stations A through F and located as shown in Figure 2.3-3 of the DCPP FSAR Update. Station E is located about 800 ft south of the DCPP power block and currently serves as the primary tower site. Station A is located about 4500 ft southeast of the power block and currently serves as the backup tower site.

Five wind rose figures showing the frequency distribution of wind speed and direction at the six stations are included in the response to the RAI as Attachment 17-1. These figures are based on data collected from July 1, 1967 through October 31, 1969 and are contained in the historical licensing database files (see discussion in FSAR Update Section 2.3.2.1 and associated Reference 27 in FSAR Update Section 2.3.7). The specific figures attached are:

1. Annual Wind Roses for the Diablo Canyon Site
2. Wind Roses for the Dry Season (May through September)
3. Wind Roses for the Wet Season (November through March)
4. Wind Roses for the Transitional Months (April and October)
5. Annual Wind Roses for Nighttime and Daytime

Question 17-3

Provide a description of the calculations or provide the calculation packages for determining atmospheric dispersion factors for normal and accident conditions. This information is necessary to determine the radiological impact from the proposed action. (Section 2.4.4 Diffusion Estimates)

This information is needed to determine compliance with 10 CFR §51.45(b)(1).

PG&E Response to Question 17-3

Diffusion estimate calculations for the Diablo Canyon Power Plant (DCPP) site are described in Sections 2.3.4 and 2.3.5 of the DCPP FSAR Update.

As noted in Section 2.4.4 of the ISFSI ER, the χ/Q values for the ISFSI site were taken from Tables 11.6-13 and 2.3-41 of the FSAR Update.

PG&E believes that the atmospheric dispersion factors from the DCPP FSAR Update are applicable to the ISFSI site for the following reasons. Imaginary receptors at the site boundary in the most probable downwind sector are no closer than 800 meters. The ISFSI is no closer than 1.2 miles to the nearest real receptor. The ISFSI site's close proximity to the DCPP site (0.22 miles or approximately 400 meters apart), and the conservative χ/Q values from the FSAR Update with a downwind distance of 800 meters makes it applicable to the ISFSI site.

Question 17-4

Describe how this area is of great spiritual importance to a local Native American and assess how the ISFSI may impact that spiritual importance. (Section 2.9.6, Native American Consultation)

This information is needed to determine if the proposed action may cause indirect cultural or historical impacts to the area.

This information is needed to determine compliance with 10 CFR §51.45(c).

PG&E Response to Question 17-4

A total of four local Chumash individuals/groups and the federally recognized Santa Ynez Band of Mission Indians were contacted by letter on April 13, 2000. The letter requested concerns and comments from the local Native American community and extended an invitation to meet on April 29, 2000, to discuss the proposed project. There was no verbal or written response to the meeting notice nor did anyone participate on the meeting date. Those contacted by mail were then contacted by phone for their comments and concerns and to explain the proposed ISFSI project if desired. A meeting was held with one individual on June 6, 2000; this person's comments and concerns were noted. In addition to providing comments and concerns, this individual stated that one of the contacts, a relative, had not received PG&E's letter. A second letter was then sent to this individual on June 6, 2000. One contact did respond by mail. Two additional contacts provided comments when they were called.

The concerns expressed by the Chumash ranged from general concern for anything occurring at Diablo Canyon to potential harm to the environment from the proposed ISFSI project. While the contact who responded by letter noted no specific location of concern, it was expressed that the ISFSI area is of great spiritual importance, a comment similar to those of others contacted.

On August 18, 2000, a second letter was sent to the Santa Ynez Band of Mission Indians. The letter was sent to the tribal elders, the tribal subgroup that is responsible for commenting on proposed projects. No comments have been received to date from the Santa Ynez elders.

There are no archaeological resources in any of the proposed impact areas for the project since this area has been significantly disturbed and altered to accommodate the construction of the power plant and supporting facilities.

How this "area is of great spiritual importance to a local Native American and assess how the ISFSI may impact that spiritual importance" is a philosophical question which can only truly be addressed by direct consultation with both the Federally recognized Santa Ynez Chumash and other local Chumash who have been involved with consultation for other activities at CA-SLO-2 (the archaeological site immediately adjacent to DCPP).

Over the recent years, local Chumash have held ceremonies and repatriated human remains out on CA-SLO-2. The spiritual importance of CA-SLO-2 and the Diablo Canyon area was described in a taped interview for a PG&E cultural resource awareness video immediately following a solstice ceremony. The local Chumash that have been involved with past consultation at CA-SLO-2 have expressed to our Senior Cultural Resources specialist and other DCPP staff that the Diablo Canyon area is of spiritual importance.

Question 17-5

Provide a summary of the response from the Tribal Elders of the Santa Ynez band of Chumash to the letter dated August 7, 2000, sent by PG&E. (Section 2.9.6, Native American Consultation)

This information is needed to determine if the proposed action may cause indirect cultural or historical impacts to the area.

This information is needed to determine compliance with 10 CFR §51.45(c).

PG&E Response to Question 17-5

The Diablo Canyon ISFSI ER, Section 2.9.6 refers to an August 17, 2000, letter that was sent to the Santa Ynez Band of Chumash. The date of the letter was incorrectly noted in the ER. A letter dated August 18, 2000, was sent to Ms. Elaine Schaulder, Chairperson, Santa Ynez Elders Council. The letter requested comments on the proposed ISFSI Project by September 21, 2000. To date, no comments have been received for the Santa Ynez Elders Council.

Refer to Amendment No. 1 of the Diablo Canyon ISFSI ER for revised Section 2.9.6.

Question 17-6

Provide a description of the environmental impacts expected from the alternative actions which were considered. (Chapter 8, Siting and Design Alternatives)

The regulations in 10 CFR Part 51 require the environmental impact from both the proposed action and the alternatives be described.

This information is needed to determine compliance with 10 CFR §51.45(b)(3).

PG&E Response to Question 17-6

Additional information on environmental impacts from alternative actions that were considered is discussed in the revised Diablo Canyon ISFSI Environmental Report, Section 8.2, Amendment 1.

Question 17-7

Identify all permits and approvals needed from the State of California, and also from local and county officials, and the dates they were, or will be, received. Provide the names and telephone numbers of the local, county, and State of California officials responsible for issuing the necessary permits for the ISFSI. (Chapter 9, Environmental Approvals and Consultation)

This information is needed to determine compliance with 10 CFR §51.45(d).

PG&E Response to Question 17-7

ER Section 9.2 identifies the local and county permits. The lead agency for the building permit and grading permit identified in ER Section 9.2 is the County of San Luis Obispo Building/Engineering Department. The contact for these permits is Elizabeth Szwabowski, Plans Examiner, 805-781-5725.

ER Section 9.3 provides information regarding the Coastal Development Permit. The lead agency for this permit is the County of San Luis Obispo Planning Department. The contact for this permit is James Caruso, Project Manager, 805-781-5702.

Chapter 18. Materials

Question 18-1

Describe the considerations and criteria that are or will be used at Diablo Canyon to classify fuel as either intact or damaged for storage in the proposed ISFSI. Provide information on any tests or inspections conducted to determine the fuel condition.

The information is needed to determine compliance with 10 CFR §72.124(a), 10 CFR §72.124(b), and 10 CFR §72.236(m).

PG&E Response to Question 18-1

The considerations and criteria for classification of fuel stored in the Diablo Canyon ISFSI and assessment of its physical condition is explained in Diablo Canyon ISFSI SAR Sections 5.1.1 and 10.2.1.1. The definitions for Damaged Fuel Assembly, Fuel Debris, and Intact Fuel are found in the Diablo Canyon ISFSI SAR Glossary. Fuel is classified as intact, damaged, or fuel debris for the purpose of selecting the proper authorized Holtec canister model. The fuel selection and inspection process is consistent with NRC SFPO ISG-1 Rev. 0 guidance.

Question 18-2

Provide the following information for the storage of damaged fuel:

(a) Whether any of the fuel assembly structure is mechanically damaged or has geometrical changes to the assembly structure such that the assembly cannot be handled using normal (i.e., crane and grapple) handling methods.

(b) Whether the fuel assemblies have missing or displaced structural components such as grid spacers, and

(c) Whether any of the fuel is no longer in the form of a fuel bundle and consists of debris, loose fuel pellets, or rod segments.

Subcriticality and adequate confinement of the spent fuel must be maintained under all conditions of storage and transportation. In addition, the spent fuel must be readily retrieved from the storage systems and the design of spent fuel storage casks should consider ultimate disposition by the Department of Energy.

The information is needed to determine compliance with 10 CFR §72.124(a), 10 CFR §72.124(b), and 10 CFR §72.236(m).

PG&E Response to Question 18-2

Based on the September 19, 2002 meeting between PG&E, NRC, and Southwest Research Institute in San Antonio Texas, it is PG&E' s understanding that this RAI was withdrawn.

Question 18-3

Provide information for fuel retrievability under normal, off-normal and accident conditions.

The information is needed to determine compliance with 10 CFR 72.122(l) and 10 CFR 72.236(m).

PG&E Response to Question 18-3

Based on the September 19, 2002 meeting between PG&E, NRC and Southwest Research Institute in San Antonio Texas, it is PG&E' s understanding that this RAI was withdrawn.

Question 18-4

Provide an analysis of the potential for fuel reconfiguration during storage operations for ZIRLO and Zircaloy-4 (See ISG-11, Revision 2). This analysis should include low burnup fuel and high burnup fuel.

The analyses should discuss cladding temperatures for normal, off-normal, repeated thermal cycling, and accidents. Additionally, the applicant should indicate the oxide thickness and methodology used to determine the thickness. Proposed TS 5.1.3.i. should be revised, as appropriate.

This information is needed to determine compliance with 10 CFR §72.122(h)(1).

PG&E Response to Question 18-4

The Diablo Canyon ISFSI SAR application incorporates the approved HI-STORM 100 cask system, including the limits on fuel and other contents, by reference without modification. All DCPP fuel proposed for storage at the Diablo Canyon ISFSI under this site-specific license application is bounded by the previously approved contents for the HI-STORM 100 System Certificate of Compliance (CoC), Amendment 1. All low-burnup, zirconium-based alloys, including ZIRLO™, Zircaloy-2, and Zircaloy-4, among others, are approved for storage in the HI-STORM 100 System, subject to the assembly-specific physical parameters, burnup, cooling time, and decay heat limits specified in the CoC and in the Proposed Diablo Canyon ISFSI Technical Specifications, as applicable (see also the response to RAI 16.1). High burnup fuel is limited to fuel with Zircaloy-2 or Zircaloy-4 cladding in this initial license application, consistent with Amendment 1 of the HI-STORM 100 CoC.

Conversations held between NRC's Spent Fuel Project Office and Holtec International on September 6, 2002 on ISG-11, Revision 2, revealed that distinguishing between Zircaloy and non-Zircaloy zirconium-based fuel cladding material is not necessary for burnups less than or equal to 45,000 MWD/MTU. It was decided that a modification to the HI-STORM 100 System FSAR, authorized under the provisions of 10 CFR 72.48, would be appropriate to clarify the allowed cladding materials for low burnup fuel, and will be implemented by Holtec International. Tables 3.1-1 and 3.1-2 and Section 10.2 of the Diablo Canyon ISFSI SAR describe the cask contents for which approval is requested and do not require revision. However, for added clarity and consistency with the HI-STORM 100 FSAR, an addition to the glossary of the Diablo Canyon ISFSI SAR, Amendment 1 has been provided to define the term "Zr" and any reference to Zircaloy elsewhere in the SAR where low burnup fuel is discussed, to mean Zircaloy-2, Zircaloy-4, or ZIRLO fuel cladding material. Discussion of high burnup fuel strictly applies to Zircaloy-2 and Zircaloy-4 fuel cladding material.

Since all fuel and non-fuel hardware proposed for storage at the Diablo Canyon ISFSI were previously approved by the NRC for storage in the HI-STORM 100 System, no additional thermal or materials analyses have been performed in support of this application. The thermal evaluations for the fuel permitted to be stored in the HI-STORM 100 System under a 10 CFR 72 general license were all previously approved and do not address fuel reconfiguration for fuel of any burnup level. The review guidance contained in ISG-11, Revision 2 was issued after the approval of HI-STORM CoC Amendment 1 and after the submittal of the Diablo Canyon ISFSI license application. Therefore, this guidance is not applicable to the Diablo Canyon ISFSI license application since it incorporates Amendment 1 of the HI-STORM CoC without modification. The thermal calculations supporting the approved contents specified in the HI-STORM 100 System CoC are described in detail in Chapter 4 of the HI-STORM 100 System FSAR, Revision 1. The description of cladding corrosion reserve for high burnup fuel, in the form of oxide thickness, is specifically discussed in Appendix 4.A of the HI-STORM 100 System FSAR. The thermal analyses are summarized in Section 4.2.3.3.3 of the Diablo Canyon ISFSI SAR and the limits on cask contents are specified in SAR Section 10.2 and the proposed technical specifications.

It is PG&E's intention to adopt the applicable changes in Amendment 2 to the HI-STORM 100 CoC after approval of that generic licensing action. Holtec License Amendment Request 1014-2, currently under NRC review and being revised by

Holtec in response to NRC's acceptance review, addresses the review guidance in ISG-11, Revision 2 (see Holtec letter to NRC Document Control Desk dated September 25, 2002).

Question 18-5

Provide a table that clearly indicates the burnups, cooling times, exact quantity of different rods, and temperatures (normal, off-normal, and accident) for all fuel types (i.e., Zirlo, Zircaloy-4, etc.) to be stored at the Diablo Canyon ISFSI.

The application contains conflicting and confusing information concerning temperature limits and which fuel types are high burnup.

The information is needed to determine compliance with 10 CFR §72.122(h)(1).

PG&E Response to Question 18-5

The Diablo Canyon ISFSI license application incorporates the approved HI-STORM 100 cask system, including the limits on fuel and other contents, by reference without modification. All DCPP fuel proposed for storage at the Diablo Canyon ISFSI under this site-specific license application is bounded by the previously approved contents for the HI-STORM 100 System Certificate of Compliance (CoC), Amendment 1. Diablo Canyon ISFSI SAR Table 3.1-1 shows a comparison of the approved fuel characteristics from the HI-STORM 100 CoC and the characteristics of the DCPP fuel proposed to be stored at the ISFSI that demonstrates that the CoC fuel characteristics bound the proposed site-specific fuel characteristics. The assembly-specific physical parameters, burnup, cooling time, and decay heat limits specified in the HI-STORM 100 CoC, Amendment 1 are incorporated into the Diablo Canyon ISFSI SAR (Section 10.2) and the Proposed Diablo Canyon ISFSI Technical Specifications, as applicable (see also the response to RAI 16-1).

Normal, off-normal, and accident fuel cladding temperature limits are discussed in the response to RAI 18-6. Computed fuel cladding temperatures under normal, off-normal, and accident conditions are discussed in Sections 4.4, 4.5, 11.1, and 11.2 of the HI-STORM 100 FSAR, Revision 1.

Question 18-6

Provide the Diablo Canyon ISFSI Safety Analysis Report sections that identify the allowable cladding types and temperature limits and the helium backfill gas parameters.

Revise Table 3.4-2, to adopt Appendix 4A to incorporate the temperature limits for high burnup fuel. Appendix A of the Diablo Canyon ISFSI Safety Analysis Report indicates that Sections 4.2.6.1 and 4.2.6.2 of the Diablo Canyon ISFSI Safety Analysis Report contain the required information. However, the version of the Diablo Canyon ISFSI

Safety Analysis Report submitted to NRC does not include these two sections. The concern is that cladding types, temperature limits, and helium backfill parameters could affect the integrity of the spent nuclear fuel cladding.

The information is needed to determine compliance with 10 CFR §72.122(h)(1).

PG&E Response to Question 18-6

The fuel cladding materials allowed to be stored in the HI-STORM 100 System are, for low burnup fuel, stainless steel and any zirconium-based alloy; and for high burnup fuel, Zircaloy-2 or Zircaloy-4, as specified in Appendix B to the HI-STORM 100 System CoC, Amendment 1. Only fuel with zirconium alloy fuel cladding will be stored at the Diablo Canyon ISFSI, including Zircaloy-4 and ZIRLO™. Diablo Canyon ISFSI SAR Table 3.1-1 shows a comparison of the approved fuel characteristics from the HI-STORM 100 CoC and the characteristics of the DCPP fuel proposed to be stored at the ISFSI that demonstrates that the CoC fuel characteristics bound the proposed site-specific fuel characteristics. ISFSI SAR Tables 10.2-1 through 10.2-9 provide the specific limits for the storage of fuel, based on the particular MPC-model being used, consistent with the HI-STORM 100 System CoC, Amendment 1. In addition, the limits in SAR Tables 10.2-1 through 10.2-9 have also been added to the Diablo Canyon ISFSI technical specifications (refer to the response to RAI 16-1).

Fuel cladding temperature limits for long-term storage of zirconium-alloy clad, low burnup fuel, applicable for use of the HI-STORM 100 System at the Diablo Canyon ISFSI are listed in Table 4.3-7 of the HI-STORM 100 System FSAR, Revision 1. HI-STORM 100 System FSAR Revision 1, Table 4.A.2 provides the long-term fuel cladding temperature limits for Zircaloy-2 and Zircaloy-4 high burnup fuel. A short-term temperature limit of 1058°F was used for all transient, off-normal, and accident conditions. These limits are all intended to be incorporated by reference in SAR Table 3.4-2. In researching this RAI, it was found that a reference to the HI-STORM FSAR for high burnup fuel cladding temperature limits was not included in the Diablo Canyon ISFSI SAR. Refer to the Diablo Canyon ISFSI SAR, Amendment 1, for a revision to Table 3.4-2 to reference HI-STORM FSAR, Revision 1, Table 4.A.2 for allowable cladding temperature limits for high burnup fuel.

Helium backfill gas parameters are specified in Diablo Canyon ISFSI SAR Section 10.2.2.4 and are identical to the parameters in Table 3-1 of Appendix A to the HI-STORM 100 System CoC. These parameters have now also been included in new technical specification Limiting Condition for Operation (LCO) 3.1.1 per the response to RAI 16.1.

Question 18-7

Revise Diablo Canyon ISFSI Safety Analysis Report Section 10.2.4.1, to adopt the corrosion allowance tables that provide an alternate criterion in lieu of the guidance in

NRC ISG-15 for high burnup Zircaloy-4 fuel cladding. The values are given in Table 4.A.4 and 4.A.5 of Appendix 4.A of the Holtec Safety Analyses Report, amendment 1.

The information is needed to determine compliance with 10 CFR §72.122(h)(1).

PG&E Response to Question 18-7

Section 5.1.3.i of the Proposed Diablo Canyon ISFSI Technical Specifications, included in the Diablo Canyon ISFSI license application, includes fuel cladding oxide thickness limits for DCPP fuel. These limits were computed by executing the equation in Section 5.6 of Appendix A to the HI-STORM 100 System CoC, using DCPP-specific fuel characteristics and internal rod pressure. In researching this RAI, an editorial error was discovered in this proposed technical specification. In the seventh line on page 5.0-3 of the Proposed Diablo Canyon ISFSI Technical Specifications, the phrase "without IFBA fuel" has been changed to "with IFBA fuel." The cladding oxide limit for this type of fuel remains correct.

The information contained in Tables 4.A.4 and 4.A.5 of Appendix A to the HI-STORM 100 System FSAR is applicable to all fuel types authorized for loading the HI-STORM 100 System under a 10 CFR 72 general license. Specifically, Table 4.A.4 lists the allowable corrosion reserve for high burnup PWR fuel and Table 4.A.5 lists the allowable reserve for high burnup BWR fuel. This information supports the limits on high burnup fuel cladding oxidation thickness computed by each user by execution of the equation in Section 5.6 of Appendix A to the HI-STORM 100 System CoC, Amendment 1. The information in HI-STORM FSAR Table 4.A.5 only applies to BWR fuel and is not applicable to the Diablo Canyon ISFSI license application since the DCPP is comprised of two PWR units. As discussed in Diablo Canyon ISFSI SAR Section 3.1.1.1, only Holtec-defined PWR fuel assembly array/classes 17x17A and 17x17B are applicable to DCPP fuel (see Section 6.2 of the HI-STORM FSAR, Revision 1 for the definitions of fuel array/classes). However, as discussed above, the allowable fuel cladding corrosion reserve, expressed as a limit on fuel cladding oxidation thickness, is specified in Section 5.1.3.i of the Proposed Diablo Canyon ISFSI Technical Specifications. This is based on a more conservative site-specific value for internal fuel rod pressure, chosen by PG&E, than that used in the generic thermal evaluations for HI-STORM 100.

Question 18-8

Provide information on any alternatives to American Society of Mechanical Engineers Boiler and Pressure Vessel Code and clearly specify which alternatives have not been approved by the NRC.

It is recognized by the staff that not all of the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code may be practical at the Diablo

Canyon ISFSI. Alternatives to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code must, however, be evaluated and approved by staff.

This information is needed to determine compliance with 10 CFR §72.122(a), §72.122(b), and §72.122(c).

<u>PG&E Response to Question 18-8</u>

The alternatives to the ASME Code that are being requested for approval under the Diablo Canyon ISFSI application have been added to the Diablo Canyon ISFSI SAR, Amendment 1, Section 3.4 and Table 3.4-6. These alternatives are based on the previously approved ASME Code alternatives for the HI-STORM 100 System CoC docketed under 72-1014 through March 7, 2002.

Additions/deletions to the previously approved ASME Code alternatives for the HI-STORM 100 System CoC are reconciled in underline/strikeout format, respectively, in Table 18-8-1 (Attachment 18-1), and as new text in Diablo Canyon ISFSI SAR Table 3.4-6. PG&E believes that these proposed changes are consistent with ASME Code alternatives previously approved. For example, the Holtec alternatives to NB-1100, NB-8000 and NG-8000 have been deleted and are now addressed under Code Subsection NCA using applicable Notes 1 through 5. Also, Holtec alternatives to NB-2000, NG-2000 and NF-2000 have been clarified (e.g., CMTR statement). These changes are necessary to reflect the issuance of a site-specific license in lieu of a CoC. This change will also allow the use of an NRC-approved quality assurance program in lieu of the specific Holtec Quality Assurance Program.

SAR Section 4.2.3.3 previously indicated that Code Case N-595-1 would be applied to the MPC pressure boundary. PG&E has further evaluated the Code Case and determined that its use is not warranted. Where appropriate, specific provisions of the Code Case have been included in the changes described above. Diablo Canyon ISFSI SAR was revised to delete references to Code Case N-595-1 and add the new tabulation of ASME Code Alternatives.

<u>*Question 18-9*</u>

Provide current manufacturer data sheet(s) for all of the coating(s) to be applied to all safety significant carbon steel components of the transfer and storage casks.

It is unclear if the approved Carboline 890 or Thermaline 450, as listed on Page 3-4 of the Holtec Safety Evaluation Report, will be used on the transfer cask. Provide documentation that the selected coating will perform as required considering expected neutron and gamma radiation and specific conditions expected during immersion in borated water. Provide temperatures for the inner and outer surfaces of the overpack that are coated and verify that these temperatures do not exceed the maximum continuous or noncontinuous recommended temperature for the coating. Provide *information that indicates the coatings used on the storage casks can be repaired. Section 4.4.3 of the Diablo Canyon ISFSI Safety Analysis Report indicates that storage cask repair and maintenance may require reapplication of corrosion inhibiting materials on accessible external surfaces. According to Carboline data (1996, 2002), the maximum surface temperature for application is 51.7° C [125 ° F]. Damage to the overpack coating may not be properly repaired if the surface temperature of the overpack exceeds the maximum temperature for the proper application of the coating.*

This information is needed to determine compliance with 10 CFR §72.122(a), §72.122(b), §72.122(c), and §72.236(g).

PG&E Response to Question 18-9

The manufacturer's data sheets for Carboguard 890, Carbozinc 11, Carbozinc 11HS, and Thermaline 450 are provided herein as Attachment 18-2 to this response. These products are used by Holtec on behalf of general licensees on the carbon steel surfaces of the HI-STORM overpacks and HI-TRAC transfer casks. These coatings are commonly used throughout the nuclear industry in wet and dry applications and in radiation environments.

For the HI-STORM overpack, Thermaline 450 (or equivalent) is used on all carbon steel surfaces (HI-STORM FSAR, Table 2.2.6). The equivalents to Thermaline for use on the HI-STORM overpack are Carbozinc 11 or Carbozinc 11HS. As can be seen from the attached data sheets, the two Carbozinc products far exceed the design performance thresholds of Thermaline 450. Therefore, the more limiting characteristics of Thermaline 450 are addressed in the response to this RAI. However, the Carbozinc products are typically used on the overpack due to their superior design characteristics and the fact that the overpack is never immersed in the spent fuel pool (SFP).

For the HI-TRAC transfer cask, Carboguard 890 is used for coating the exterior surfaces and Thermaline 450 for coating the interior surfaces (HI-STORM FSAR Table 2.2.6). Thermaline 450 is used on the interior for its higher temperature ratings. Carboguard 890 is used on the exterior due to its superior decontamination characteristics. The short-term exposure of the transfer cask to borated SFP water during fuel loading has no significant effect on the coatings or any potential nicks in the coatings that may expose the carbon steel underneath. Decontamination activities rinse the exterior surfaces to remove residual boric acid shortly after removal from the SFP. Gamma radiation dose and neutron fluence are of small enough magnitude to not have any significant degradation effect on the coating materials. After use, the HI-TRAC transfer cask is fully decontaminated, inspected, and re-coated as necessary prior to its next use.

All four coatings are resistant to chemical attack in a variety of aggressive environments including moderate acids, alkalis, solvents, and salt solutions, and possess abrasion and permeation resistance. These coatings have a history of successful prior use at several plants (e.g., Dresden, Hatch, Columbia and Fitzpatrick).

These same coatings will be used for the hardware at the Diablo Canyon ISFSI. The attached Diablo Canyon ISFSI SAR, Amendment 1, includes a new Section 4.7 to provide a discussion of these coating materials. For confirming the adequacy of the coatings to exposure to elevated temperatures in the HI-STORM system, the manufacturer recommended temperature limits (T_{lim}) are tabulated below:

Coating	Dry Temperature Resistance	Maximum Surface Temperature for Application
Carboguard 890	250°F (Continuous) 300°F (Non-Continuous)	125°F
Thermaline 450	425°F (Continuous) 450°F (Non-Continuous)	110°F
Carbozinc 11	750°F (Continuous) 800°F (Non-Continuous)	200°F
Carbozinc 11HS	750°F (Continuous) 800°F (Non-Continuous)	150°F

<u>HI-TRAC Transfer Cask</u>

There are two different operating condition scenarios evaluated for the coating on the HI-TRAC transfer cask: MPC preparation for storage and onsite transportation.

(1) MPC preparation

During MPC preparation activities after fuel loading, the MPC may be vacuum dried or the forced helium recirculation method of moisture removal may be used. Vacuum drying provides the limiting case for temperature at the inner surface of the transfer cask body during this time. During vacuum drying operations there is always water in the annulus space between the MPC and the HI-TRAC inner shell wall. Section 4.5.1.1.4 of the HI-STORM 100 FSAR states that, at lower heat loads, this water is modeled at a hypothetical limiting temperature of 232°F, slightly higher than boiling temperature at atmospheric pressure to account for the increased static head pressure at the bottom of the annulus. This temperature is less than the continuous temperature rating of the Thermaline 450 coating listed in the table above, by 193°F. The temperature at the outer shell wall surface will, by logic, be lower than 232°F and will therefore be less than the continuous temperature limit for Carboguard 890 of 250°F. At higher heat loads, the annulus water is recirculated, reducing its temperature to an assumed value of 125°F, which is less than the values just discussed and is therefore acceptable.

(2) Onsite Transportation

During onsite transportation activities, the annulus between the MPC and the overpack inner shell wall is drained of water and the MPC is filled with helium. Steady-state thermal calculations were performed for generic HI-STORM licensing, assuming design basis heat loads, 100°F ambient air and full solar insolation. This analysis is discussed in HI-STORM FSAR Section 4.5.6 with results shown in Table 4.5.2. The HI-TRAC inner shell surface temperature is computed to be 322°F, which is less than the continuous temperature rating for Thermaline 450 of 425°F. The HI-TRAC enclosure shell outer surface temperature outer surface temperature is computed as 224°F, which is less than the continuous temperature rating for Carboguard 890 of 250°F.

HI-STORM Overpack

The maximum internal and external overpack shell surface temperatures, considering design basis heat load, under normal conditions of storage, are 199°F and 145°F, respectively, as reported in Table 4.4.36 of the Holtec License Amendment Request 1014-1, revision 1, supplement 1 dated October 2000. These temperatures are less than the limiting continuous temperature rating for Thermaline 450 of 425°F by a large margin.

Off-normal and Accident Conditions

During hypothetical off-normal and accident conditions involving the HI-TRAC transfer cask or the HI-STORM overpack, such as a fire, damage to the coatings may be experienced. Coatings would be repaired, as necessary, as part of the recovery plan in response to the event.

Maintenance

Maintenance coating repairs on the HI-TRAC transfer cask would be conducted between uses of the cask in accordance with manufacturer's instructions. With no source of heat or radiation in the transfer cask, ambient conditions would control the surface temperature of the cask and all surfaces will be accessible for coating repair, as needed. The transfer cask could be coated in a paint shop or outdoors, at the discretion of the painter.

For the overpack, only the exterior surfaces of the cask are accessible for maintenance during normal operations due to the radiation emanating from the MPC. Locations having chips or scratches will be touched up on an as-needed basis. For this purpose, appropriate measures will be taken to prepare the local area by sandblasting to remove grime and dust and otherwise prepare the surface in accordance with the manufacturer's instructions. Coating repairs will likely be performed in-situ at the ISFSI. The maximum projected normal operating temperature of the outer surface of the overpack, assuming design basis fuel, full solar insolation, and other conservative assumptions described in Chapter 4 of the HI-STORM FSAR, is 145°F, which is higher than the 110°F maximum surface temperature recommended for application of Thermaline 450. The maximum surface temperatures for application of Carbozinc 11 and Carbozinc 11HS are 200°F and 150°F, respectively and bound the maximum normal overpack external surface temperature.

No single cask at the Diablo Canyon ISFSI is expected to contain design-basis heat load fuel in every storage location, nor are other design basis conditions expected to exist concurrently. For example, there will likely be breezes at the ISFSI that prompt forced convection cooling from the cask surface on almost a perpetual basis, which will reduce the exterior surface temperature. For these reasons, the actual exterior surface temperature of the overpack is expected to be much lower than the calculated bounding value. Never-the-less, for overpack maintenance coating work with Thermaline 450 (if used), exterior surface temperatures will be checked with a surface pyrometer or similar instrument and reduced, as necessary, to ensure the manufacturer's recommendations for applying the coatings are met. This could include using a portable blower or performing maintenance early in the morning or under portable shelters, if necessary. Such coating repair activities, including the prerequisite surface temperature requirement will be governed by procedure.

Question 18-10

Provide documentation that the operating procedures for cask loading and unloading include provisions for detecting the presence of hydrogen and preventing the ignition of combustible gases. Buildup of hydrogen, which may evolve as a result of corrosion reactions in borated water, may create a fire hazard.

This information is needed to determine compliance with 10 CFR §72.24(c)(3).

PG&E Response to Question 18-10

Calculations performed by Holtec International have shown that any residual hydrogen generation produced by the pre-passivated Boral neutron absorber panels when exposed to spent fuel pool water in the MPC will not result in an explosive concentration of hydrogen under the MPC lid during lid welding or cutting operations (see Section 3.4.1 of the HI-STORM FSAR, Revision 1). The operating procedures for the Diablo Canyon ISFSI will include provisions to address combustible gas control in the MPC lid area, consistent with the controls discussed in Sections 8.1.5 and 8.3.3 of the HI-STORM 100 System FSAR, Revision 1, for loading and unloading operations, respectively. Diablo Canyon ISFSI SAR was revised accordingly. Refer to the Diablo Canyon ISFSI SAR, Amendment 1, Sections 5.1.1.2 and 5.1.1.4.

<u>*Question 18-11*</u>

Provide the following information on the fabrication of the transfer and storage casks:

(a) Specifications for weld filler materials for the multiple-purpose canisters the HI-TRAC transfer casks, and the storage overpacks including associated American Welding Society classification

(b) The preheat and post weld heat treatment temperatures for the storage overpacks and the HI-TRAC transfer casks.

(c) Holtec's position paper DS 213 cited in HI-STORM Final Safety Analysis Report Chapter 9 and any additional information used to assess the critical flaw size in accordance with the American Society of Mechanical Engineers Section XI methodology.

This information is needed to determine compliance with 10 CFR §72.122(a).

<u>PG&E Response to Question 18-11</u>

The MPCs are designed, fabricated, tested, and inspected in accordance with ASME Section III, Subsection NB. The storage overpacks and transfer cask are designed, fabricated, tested, and inspected in accordance with ASME Section III, Subsection NF. PG&E is proposing code alternatives as described in Table 3.4-6 of the Diablo Canyon ISFSI SAR (please refer also to the response to RAI 18-8). Compliance with the requirements of the ASME Code will be verified by PG&E through supplier audits performed in accordance with its Quality Assurance program.

(1) Section II.C of the ASME Code provides the requirements for weld filler materials for the MPC, overpack, and transfer cask, which are incorporated into the fabricator's manufacturing procedures. Typical weld filler materials for the MPC, overpack, and transfer cask shop welds are provided below:

Component	Weld Filler Material Specification (SFA No.)
MPC	5.9 and 5.22
HI-STORM Overpack	5.17, 5.29, 5.18, 5.9, and 5.22
HI-TRAC Transfer Cask	5.18, 5.29, and 5.17

(2) The ASME Code, Subsection NF, provides the requirements for preheat and post-weld heat treatment for the overpacks and transfer cask, which are incorporated into the fabricator's manufacturing procedures. Neither Table WB-4622.1-1 nor Table WB-4622.4(c)-1 of ASME Section III, Division 3, (as referred to in the

"Fracture Control" portion of Section X.5.2.3 of ISG-15) is used to determine the pre-heat and post-weld heat treatment requirements for these components.

Based on the size of the weldments, there are no post-weld heat treatment requirements for the overpack or transfer cask (per Code Table NF-4622.7(b)-1). There are approximately 25 weld procedure specifications (WPSs) for the overpack and transfer cask, each of which includes the appropriate pre-heat requirements specified by the ASME Code. These WPSs will be made available for inspection upon request.

(3) Holtec International's Position Paper 213 was previously submitted by Holtec as a proprietary document under Docket 71-9261 on February 24, 1999. A copy was provided to the CNWRA reviewer at the meeting held on September 19, 2002.

Question 18-12

Provide the penetrant testing requirements for the multi-purpose canister closure weld.

Different penetrant testing requirements are identified in Diablo Canyon ISFSI Safety Analysis Report Section 4.4.1.2.3 and the HI-STORM Final Safety Analysis Report Drawing 1393 Sheet 1. The Diablo Canyon ISFSI Safety Analysis Report Section 4.4.1.2.3 indicates penetrant testing of the multiple-purpose canister closure weld, if used instead of ultrasonic testing, will be performed on the root pass, at ½ the weld thickness and on the final pass. However, the HI-STORM Final Analysis Report Drawing 1393 sheet 1 indicates penetrant testing will be performed after the root pass, after the final pass and twice after intermediate passes.

This information is needed to determine compliance with 10 CFR §72.24(c)(3) and §72.122(a).

PG&E Response to Question 18-12

In researching this RAI, Holtec discovered an error on the MPC-32 drawing included with Holtec License Amendment Request 1014-1. Consistent with Holtec Position Paper DS-213, the critical flaw size for the MPC lid-to-shell weld is 3/8 inch. Therefore, the liquid penetrant (PT) examination requirements on the MPC-32 drawing should include the root and final layers, as well as each approximately 3/8 inch of weld depth. Since the MPC lid-to-shell weld for the MPC-24E and MPC-32 is nominally 3/4 inch deep, it is expected that only one intermediate PT examination will be required. This is consistent with the MPC-24 and MPC–68 designs and the guidance contained in ISG-4, Revision 1. The MPC lid-to-shell weld for the MPC-24EF is 1-1/4 inch deep and will require four intermediate PT examinations. This error has been corrected on the MPC enclosure vessel drawing (3923) included in HI-STORM FSAR Revision 1, Section 1.5. The MPC enclosure vessel licensing drawing (applicable to all MPC fuel basket designs) now requires PT examinations of the MPC lid-to-shell weld after the root and final passes, and each approximately 3/8 inch of weld depth. Diablo Canyon ISFSI SAR, Amendment 1, revised Section 4.4.1.2.3 to be consistent with these requirements.

<u>*Question 18-13*</u>

Provide the coefficient of thermal expansion for bolting materials used on the HI-STORM storage overpacks and the HI-TRAC transfer casks as well as the thermal expansion coefficients for the storage overpack and transfer cask materials of construction over the entire range of temperatures expected during normal, off-normal, and accident conditions.

Differences between the thermal expansion coefficients of the bolting materials and the overpack and transfer cask materials may lead to either higher than anticipated bolt stresses or reduced mechanical integrity of the transfer cask and overpack closures.

This information is needed to determine compliance with 10 CFR §72.122(a), §72.122(b), and §72.122(c).

<u>PG&E Response to Question 18-13</u>

Coefficients of thermal expansion for bolting materials and construction materials used in the HI-STORM storage cask and HI-TRAC transfer cask are presented in the HI-STORM FSAR licensed under 10 CFR 72. The particular information for thermal expansion coefficients, over the temperature range of operation, is given in tabular form in Chapter 3 of the HI-STORM FSAR, Revision 1.

SA516-Gr. 70 – Table 3.3.2
SA-350 LF3 and SA203-E – Table 3.3.3
SA-193-B7 bolts – Table 3.3.4

<u>*Question 18-14*</u>

Provide specifications of the materials to be used for the seismic anchor. In particular, the applicant should address the following:

(a) *Compatibility of materials and coatings to be used with the Diablo Canyon ISFSI environment*

(b) *Tables with material properties and allowable stresses and strains associated with temperature, as appropriate*

(c) *Appropriate corrosion allowances used in the structural analyses*

This information is needed to determine compliance with 10 CFR §72.122(a), and §72.122(b).

PG&E Response to Question 18-14

(1) The coatings to be used in with the Diablo Canyon ISFSI environment is a 3 to 5 millimeters thick layer of Carboline 891 or Bar-Rust 235 by Devoe in accordance with PG&E Specification No. 8848. The compatibility of materials is addressed in RAI response 5-5.

(2) The seismic anchor system consists of the following components:

Cask anchor studs, embedment plate, compression coupling block, anchor rods, and anchor plates. The information for all but the cask anchor studs has been provided in response to RAI 5-5. The SA 193 B7 cask anchor studs are shown in SAR Figure 4.2-6 and the properties (size and yield/ultimate stress values) are provided in Holtec Calculation HI-2012618, Attachment A, Section 2.2 (submitted in PG&E letter DIL-01-007, December 21, 2001).

(3) No corrosion allowance was applied to the cask anchor stud material in the design because the studs and nuts will be protected from the environment by coating as outlined in response (1) above.

Question 18-15

Provide a revised Materials evaluation, to evaluate the potential reaction between the aluminum heat conduction elements, Boral, stainless steel in the MPC and the spent fuel pool water with respect to its impact on the safe operation and performance of the cask under normal, off-normal, and accident conditions. Also, revise the operating procedures to include appropriate controls for detecting the presence of hydrogen and preventing the ignition of combustible gases during cask loading and unloading.

The evaluation should consider: (1) water temperature change during loading and unloading, (2) the generation of reactive gases due to irradiation, (3) the generation of gases due to the aluminum and the stainless steel basket, and (4) the welding of the MPC lid, including pre- and post- weld heat treatments. Reaction of the heat conduction elements with the spent fuel pool water and/or steel components may produce hydrogen in concentrations close to the lower explosive limit of hydrogen.

This information is needed to determine compliance with 10 CFR §72.122(b).

PG&E Response to Question 18-15

As part of an industry event where hydrogen was observed emanating from a submerged Holtec MPC, Holtec International performed a detailed evaluation of chemical and galvanic reactions of the MPC with spent fuel pool water. The key conclusions of the evaluation have been included in the materials evaluation section that was added as new Section 4.7 to the Diablo Canyon ISFSI SAR. This new information is consistent with the information added to the generic HI-STORM 100 FSAR, Revision 1

There are no off-normal or accident conditions postulated while the MPC contains water. Please see the response to RAI 18-10 for discussion of control measures for potential combustible gas generation in the MPC.

Aluminum heat conduction elements (AHCEs) were made optional equipment for the HI-STORM 100 System in CoC Amendment 1 and are no longer installed in any future MPCs being fabricated, including those that will be deployed at the Diablo Canyon ISFSI. The "optional" designation is retained in the HI-STORM FSAR to recognize the fact that some early vintage MPC-68 and MPC-68F models do include the AHCEs.

Question 18-16

Demonstrate that the coatings to be used on all carbon steel components of the transfer and storage casks are non-reactive with the spent fuel pool water and that they will remain adherent when exposed to the various environments of the Diablo Canyon ISFSI.

The most prevalent environments include: immersion in spent fuel pool water during loading and unloading operations and the relatively high temperature (elevated temperatures cause degradation in normal coatings), high radiation (including neutrons), and dry inert gas environment encountered during storage, the potential for mechanical damage through abrasion or erosion, and environment exposure duration.

In accordance with 10 CFR §72.122 (c), non-combustible and heat resistant materials must be used whenever practical, and in accordance with §72.122 (h)(1), the spent fuel cladding must be protected from degradation that leads to gross ruptures. The concern is that any degradation of coating material, including gases or particulates that originate from a deteriorating coating, could affect the integrity of the cladding. Further, in accordance with §72.236 (h), the cask, and cask components, must be compatible with wet or dry spent fuel loading and unloading facilities. Thus, the coatings must remain intact and adherent to perform their intended functions during all loading and unloading operations.

This information is needed to determine compliance with 10 CFR §72.122(b), §72.122(c), and §72.122(h)(1).

PG&E Response to Question 18-16

Please see the response to RAI 18-9 for discussion of the coatings used on carbon steel components of the HI-STORM 100 System. Additionally, as stated in Diablo Canyon ISFSI SAR, Amendment 1, Section 4.7.1, there no coatings of any kind used inside or outside the MPC.

Question 18-17

Revise the Diablo Canyon ISFSI SAR to include section 3.4.1 from the Holtec SAR on Chemical and Galvanic Reactions.

The reference tables evaluating each component (i.e., stainless steel, concrete, neutron absorber, coatings, shielding material, etc.) should also be included in the Diablo Canyon ISFSI SAR.

PG&E Response to Question 18-17

A new Diablo Canyon ISFSI SAR section to address chemical and galvanic reactions is now SAR Section 4.7, Amendment 1. This section includes a discussion on chemical and galvanic reactions of the materials in the HI-STORM 100 System with its operating environments.

Refer to RAI response 18-15 for disposition of the chemical and galvanic reactions issue.

Chapter 19. Editorial Comments

Question 19-1

Provide a complete PGE-009-CALC-001 package. Pages 4 and 12 are missing from the PGE-009-CALC-001 package.

PG&E Response to Question 19-1

A complete package of calculation PGE-009-CALC-001 is provided as Attachment 19-1 to this letter.

Question 19-2

Revise Drawing No. 3769, Figure 4.2-6, Section A-A. The current version of that figure shows an anchor system differing from the Diablo Canyon ISFSI Safety Analysis Report description and design (e.g., no compression coupling block).

PG&E Response to Question 19-2

Diablo Canyon ISFSI SAR, Amendment 1, revised SAR Figure 4.2-6, Section A-A to refer to SAR Figure 4.2-2 for the embedment detail.

Question 19-3

Correct page 10.2-1 of the Diablo Canyon ISFSI Safety Analysis Report. The eleventh bullet states "SFSC time limitation while seated in the cast transfer facility (CTF)." Please change it to read "SFSC time limitation while seated in the cask transfer facility (CTF)."

PG&E Response to Question 19-3

Attached Diablo Canyon ISFSI SAR, Amendment 1 corrects page 10.2-1, eleventh bullet, to read: "SFSC time limitation while seated in the cask transfer facility (CTF)."

Question 19-4

Correct the title of the second column of Table 10.2-7 in the Diablo Canyon ISFSI Safety Analysis Report. The column title should read "Assembly Decay Heat" instead of "Assembly Burnup".

PG&E Response to Question 19-4

Attached Diablo Canyon ISFSI SAR, Amendment No. 1, corrects the title of the second column of Diablo Canyon ISFSI SAR, Table 10.2-7, to read: "Assembly Decay Heat."

Question 19-5

Provide a reference in the Diablo Canyon ISFSI Safety Analysis Report to the design details and analysis of the storage-pads that are contained in Pacific Gas and Electric Company Calculation Nos. 52.27.100.704 "Non-Linear Seismic Sliding Analysis of the ISFSI Pad," 52.27.100.705 "Embedment Support Structure," and 52.27.100.707 "ISFSI Cask Storage Pad Seismic Analysis."

PG&E Response to Question 19-5

Diablo Canyon ISFSI SAR, Amendment 1, contains revisions that reference the design details and analysis of the storage pads. SAR Sections 4.2.1.1.7 and 4.2.6 were revised to reference PG&E Calculation No. 52.27.100.705 (PGE-009-CALC-001), "Embedment Support Structure." SAR Sections 8.2.1.2.3.2 and 8.2.18 were revised to reference PG&E Calculation No. 52.27.100.704, "Non-Linear Seismic Sliding Analysis of the ISFSI Pad" and PG&E Calculation No. 52.27.100.707 (PGE-009-CALC-003), "ISFSI Cask Storage Pad Seismic Analysis."

Question 19-6

Provide a reference in the Diablo Canyon ISFSI Safety Analysis Report to the design and design analysis of the Cask Transfer Facility that is contained in Pacific Gas and Electric Company Calculation Nos. 52.27.100.708 "Cask Transfer Facility (Reinforced Concrete)," and OQE-10 "Structural Evaluation of Diablo Canyon Cask Transfer Facility."

PG&E Response to Question 19-6

Diablo Canyon ISFSI SAR, Amendment 1 contains revisions to reference the design and design analysis of the cask transport facility. SAR Sections 8.2.1.2.2.1 and 8.2.18 were revised to reference PG&E Calculation No. OQE-10 (HI-2012626) "Structural Evaluation of Diablo Canyon Cask Transfer Facility." SAR Sections 8.2.1.2.2.2 and 8.2.18 were revised to reference PG&E Calculation No. 52.27.100.708 (PGE-009-CALC-002), "Cask Transfer Facility (Reinforced Concrete)."

Question 19-7

Provide a reference in the Diablo Canyon ISFSI Safety Analysis Report to the design and design analysis, showing that the cask transporter will not fail by tornado or tornado missile impact, that is contained in Pacific Gas and Electric Company Calculation Nos. 52.27.100.703 "Design Basis Wind and Tornado Evaluation for DCPP," and OQE–9 "Transporter Stability on Diablo Canyon Dry Storage Travel Paths."

PG&E Response to Question 19-7

Diablo Canyon ISFSI SAR, Amendment 1 contains revisions to reference the design analysis showing that the cask transporter will not fail by tornado or tornado missile impact. SAR Sections 8.2.1.2 and 8.2.18 were revised to reference PG&E Calculation No. OQE-9 (HI-2012768), "Transporter Stability on Diablo Canyon Dry Storage Travel Paths." SAR Sections 8.2.2 and 8.2.18 were revised to reference PG&E Calculation No. 52.27.100.703 (HI-2002497), "Design Basis Wind and Tornado Evaluation for DCPP."

LIST OF ATTACHMENTS

ATTACHMENT NO.	TITLE
2-1	Development of Lateral Bearing Capacity for DCPP CTF Stability Analysis (GEO.DCPP.01.06) – Calculation 52.27.100.716
2-2	Boring Log: Landslide Investigation, Diablo Canyon Site, San Luis Obispo county, California, 1970
2-3	Boring Log: Assessment of Slope Stability Near the Diablo Canyon Power Plant (Response to NRC Request of January 31, 1997), 1997
2-4	Letter from Norm Abrahamson to Rich Klimczak, subject: Ground Motion Along the Proposed Transport Route
2-5	Seismic Stability Analysis of Transporter on Soil - OQE-14
2-6	Probabilistic Risk Assessment – Probabilistic Evaluation of Seismically Induced Cask Drop, Overturn of the Transporter, or Sliding of the Transporter off the Transport Route – PRA02-10
2-7	Boring Log: DCPP Patton Cove Landslide Boring PC-1, 2000
3-1	Cask Transfer Facility Seismic Restraint Configuration - M-1058
4-1	Excerpts From Wind Effects on Structures: Fundamentals and Applications to Design
5-1	Determination of Thermal and Shrinkage Values for the ISFSI Concrete Pad Design – Calculation 52.27.701
5-2	ISFSI Cask Storage Pad Concrete Shrinkage and Thermal Stresses – Calculation PGE-009-CALC-006
6-1	Daily Solar Radiation from CIMIS for SLO
6-2	Monthly Weather Data for Station #52 San Luis Obispo in Region CCV-Central Coast/Valley
15-1	Minimum Separations Between Gas Truck and Cask – Calculation M-1046

ATTACHMENT NO.	TITLE
15-2	Holtec letter from Evan Rosenbaum to Eric Lewis, dated February 15, 2001, Justification of 50-gallon Transporter Fire Bounding Other Fires
15-3	Probabilistic Risk Assessment – Risk Assessment of Dry Cask/Spent Fuel Transportation within the DCPP Owner Controlled Area – PRA01-01
17-1	Sheet 1: Annual Wind Roses for the Diablo Canyon Site
	Sheet 2: Wind Roses for the Dry Season (May through September)
	Sheet 3: Wind Roses for the Wet Season (November through March)
	Sheet 4: Wind Roses for the Transitional Months (April and October)
	Sheet 5: Annual Wind Roses for the Nighttime and Daytime
18-1	List of ASME Code Alternatives for HI-STORM 100 System
18-2	Sheet 1 & 2: Product Data Carboguard 890
	Sheet 3 & 4: Product Data Carbozinc 11
	Sheet 5 & 6: Product Data Carbozinc 11HS
	Sheet 7 & 8: Product Data Thermaline 450
19-1	Embedment Support Structure – Calculation PGE-009-CALC-001

ATTACHMENT

2-1

NUCLEAR POWER GENERATION
CF3.ID4
ATTACHMENT 7.2

ORIGINAL

Index No. 402
Binder No. 201Y

TITLE: CALCULATION COVER SHEET

Unit(s): 1 & 2 File No.: 52.27

Responsible Group: Civil Calculation No.: 52.27.100.716

No. of Pages 3 Cover pages + Index (4 pages) + 1 Attachment (19 pages) = 26 Design Calculation YES [x] NO [ ]

System No. 42C Quality Classification Q (Safety-Related)

Structure, System or Component: Independent Spent Fuel Storage Facility

Subject: Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses (GEO.DCPP.01.06)

Electronic calculation YES [ ] NO [x]

Computer Model	Computer ID	Program Location	Date of Last Change

Registered Engineer Stamp: Complete A or B

A. Insert PE Stamp or Seal Below	B. Insert stamp directing to the PE stamp or seal
Expiration Date:	*REGISTERED ENGINEERS' STAMPS AND EXPIRATION DATES ARE SHOWN ON DWG 063618*

NOTE 1: Update DCI promptly after approval.
NOTE 2: Forward electronic calculation file to CCTG for uploading to EDMS.

CF3.ID4
ATTACHMENT 7.2

TITLE: CALCULATION COVER SHEET

CALC No. 52.27.100.716, R0

RECORD OF REVISIONS

Rev No.	Status	Reason for Revision Remarks	Prepared By: Initials/ LAN ID/ Date	LBIE Screen Yes/ No/ NA	LBIE Yes/ No/ NA	Check Method*	LBIE Approval PSRC Mtg. No.	 PSRC Mtg. Date	Checked Initials/ LAN ID/ Date	Supervisor Initials/ LAN ID/ Date	Registered Engineer Signature/ LAN ID/ Date
0	F	Acceptance of Geosciences Calc. No. GEO.DCPP.01.06, Rev. 1. Calc. is in support of 10CFR72, DCPP License Application (ISFSI Dry Cask) to the NRC prior to implementation. Note: Prepared per CF3.ID17 requirements	NJ NXJ1/ 11/15/01	[ ] Yes [ ] No [x] NA	[ ] Yes [ ] No [x] NA	[ ] A [ ] B [x] C	N/A	N/A	AT 11/15/01 AFT2/	[signature] LJS2/ 11/15/01	[signature] LJS2/ 11/15/01
				[ ] Yes [ ] No [ ] NA	[ ] Yes [ ] No [ ] NA	[ ] A [ ] B [ ] C					
				[ ] Yes [ ] No [ ] NA	[ ] Yes [ ] No [ ] NA	[ ] A [ ] B [ ] C					

*Check Method: A: Detailed Check, B: Alternate Method (note added pages), C: Critical Point Check

RMS

Pacific Gas and Electric Company
Engineering - Calculation Sheet
Project: Diablo Canyon Unit ( )1 ( )2 (x) 1&2

SUBJECT Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses
MADE BY NJ DATE 11/15/01 CHECKED BY [illegible] DATE [illegible]

Table of Contents:

SUBJECT Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses

MADE BY NJ DATE 11/15/01 CHECKED BY M DATE 11/15/01

1- Cross reference between Geo Sciences calculation Numbers and DCPP (Civil Group's) Calculation Numbers: This section is For Information Only.

Cross-Index

(For Information Only)

Item No.	Geosciences Dept. Calc. No.	Title	DCPP, Civil Calc. No.	Comments
1	GEO.DCPP.01.01	Development of Young's Modulus and Poisson's Ratios for DCPP ISFSI Based on Field Data	52.27.100.711	
2	GEO.DCPP.01.02	Determination of Probabilistically Reduced Peak Bedrock Accelerations for DCPP ISFSI Transporter Analyses	52.27.100.712	
3	GEO.DCPP.01.03	Development of Allowable Bearing Capacity for DCPP ISFSI Pad and CTF Stability Analyses	52.27.100.713	
4	GEO.DCPP.01.04	Methodology for Determining Sliding Resistance Along Base of DCPP ISFSI Pads	52.27.100.714	
5	GEO.DCPP.01.05	Determination of Pseudostatic Acceleration Coefficient for use in DCPP ISFSI Cutslope Stability Analyses	52.27.100.715	
6	GEO.DCPP.01.06	Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses	52.27.100.716	
7	GEO.DCPP.01.07	Development of Coefficient of Subgrade Reaction for DCPP ISFSI Pad Stability Checks	52.27.100.717	
8	GEO.DCPP.01.08	Determination of Rock Anchor Design Parameters for DCPP ISFSI Cutslope	52.27.100.718	
9	GEO.DCPP.01.09	Determination of Applicability of Rock Elastic Stress-Strain Values to	52.27.100.719	Calculation to be replaced by letter

Pacific Gas and Electric Company
Engineering - Calculation Sheet
Project: Diablo Canyon Unit ( )1 ( )2 (x) 1&2

69-392(10/92)
Engineering

CALC. NO. 52 27 100.716
REV. NO. 0

SUBJECT Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses
MADE BY NJ DATE 11/15/01 CHECKED BY [illegible] DATE [illegible]

Cross-Index

(For Information Only)

Item No.	Geosciences Dept. Calc. No.	Title	DCPP, Civil Calc. No.	Comments
		Stress-Strain Values to Calculated Strains Under DCPP ISFSI Pad		
10	GEO.DCPP.01.10	Determination of SSER 34 Long Period Spectral Values	52.27.100.720	
11	GEO.DCPP.01.11	Development of ISFSI Spectra	52.27.100.721	
12	GEO.DCPP.01.12	Development of Fling Model for Diablo Canyon ISFSI	52.27.100.722	
13	GEO.DCPP.01.13	Development of Spectrum Compatible Time Histories	52.27.100.723	
14	GEO.DCPP.01.14	Development of Time Histories with Fling	52.27.100.724	
15	GEO.DCPP.01.15	Development of Young's Modulus and Poisson's Ratio Values for DCPP ISFSI Based on Laboratory Data	52.27.100.725	
16	GEO.DCPP.01.16	Development of Strength Envelopes for Non-jointed Rock at DCPP ISFSI Based on Laboratory Data	52.27.100.726	
17	GEO.DCPP.01.17	Determination of Mean and Standard Deviation of Unconfined Compression Strengths for Hard Rock at DCPP ISFSI Based on Laboratory Tests	52.27.100.727	
18	GEO.DCPP.01.18	Determination of Basic Friction Angle Along Rock Discontinuities at DCPP ISFSI Based on Laboratory Tests	52.27.100.728	

SUBJECT Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses
MADE BY NJ DATE 11/15/01 CHECKED BY KI DATE 11/15/01

Cross-Index

(For Information Only)

Item No.	Geosciences Dept. Calc. No.	Title	DCPP, Civil Calc. No.	Comments
19	GEO.DCPP.01.19	Development of Strength Envelopes for Jointed Rock Mass at DCPP ISFSI Using Hoek-Brown Equations	52.27.100.729	
20	GEO.DCPP.01.20	Development of Strength Envelopes for Shallow Discontinuities at DCPP ISFSI Using Barton Equations	52.27.100.730	
21	GEO.DCPP.01.21	Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site	52.27.100.731	
22	GEO.DCPP.01.22	Kinematic Stability Analysis for Cutslopes at DCPP ISFSI Site	52.27.100.732	
23	GEO.DCPP.01.23	Pseudostatic Wedge (SWEDGE) Analyses of DCPP ISFSI Cutslopes	52.27.100.733	
24	GEO.DCPP.01.24	Stability and Yield Acceleration Analysis of Cross-Section I-I'	52.27.100.734	
25	GEO.DCPP.01.25	Determination of Seismic Coefficient Time Histories for Potential Sliding Masses Along Cut Slope Behind ISFSI Pad	52.27.100.735	
26	GEO.DCPP.01.26	Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses on DCPP ISFSI Slope	52.27.100.736	
27	GEO.DCPP.01.27	Cold Machine Shop Retaining Wall Stability	52.27.100.737	
28	GEO.DCPP.01.28	Roadway Capacity with Transporter	52.27.100.738	

SUBJECT Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses

MADE BY NJ DATE 11/15/01 CHECKED BY m DATE 11/15/01

Cross-Index

(For Information Only)

Item No.	Geosciences Dept. Calc. No.	Title	DCPP, Civil Calc. No.	Comments
29	GEO.DCPP.01.29	Determination of Seismic Coefficient Time Histories for Critical Slides on DCPP ISFSI Transport Route	52.27.100.739	
30	GEO.DCPP.01.30	Determination of Potential Earthquake-Induced Displacements of Critical Slides Along DCPP ISFSI Transport Route	52.27.100.740	
31	GEO.DCPP.01.31	Development of Strength Envelopes for Clay Beds	52.27.100.741	
32	GEO.DCPP.01.32	Verification of Computer Program SPCTLR.EXE	52.27.100.742	
33	GEO.DCPP.01.33	UTEXAS3 Computer Program Verification	52.27.100.743	
34	GEO.DCPP.01.34	Verification of Computer Code QUAD4M	52.27.100.744	
35	GEO.DCPP.01.35	Verification of Computer Program DEFORMP	52.27.100.745	
36	GEO.DCPP.01.36	Determination of Design Parameters for ISFSI Fill Slope	52.27.100.746	Calculation to be delayed – retaining wall to be shown on drawing
37	GEO.DCPP.01.37	Development of Freefield Ground Motion Storage Cask Spectra and Time Histories for the Used Fuel Storage Project	52.27.100.747	

NJ 11/15/01
M 11/15/01

PG&E
Geosciences Department
Departmental Calculation Procedure
Attachment 5.2

Number: GEO.001
Revision: 04
Page: 1 of 1

Title: Design Calculation Cover Sheet

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.06
Revision: 1
Date: 11/6/01
Calc Pages: 17
Verification Method: A
Verification Pages: ~~1~~ (SEE GEOSCIENCES ORIGINAL FILES) NJ 11/15 M 11/15/01

TITLE: Development of lateral bearing capacity for DCPP CTF stability analyses

PREPARED BY: Robert K White DATE 11/6/01

Robert K. White — Printed Name
Geosciences — Organization

VERIFIED BY: Joseph I. Sun DATE Nov. 14 '01

Joseph I. Sun — Printed Name
Geosciences — Organization

APPROVED BY: LS Cluff DATE 11/14/01

Lloyd S. Cluff — Printed Name
Geosciences — Organization

STATE OF CALIFORNIA REGISTERED GEOLOGIST
CERTIFIED ENGINEERING GEOLOGIST
NO. EG567
LLOYD S CLUFF

EXPIRES 12/31/02

Development of lateral bearing capacity for DCPP CTF stability analyses

Calc Number GEO.DCPP.01.06

Rev. No.	Reason for Revision	Revision Date
00	Initial Issue	10/18/01
01	Revised references and attachments; clarified applicable depth ranges for the recommended lateral capacity	11/14/01
02		11/14/01
03		
04		

DCPP ISFSI GEOTECHNICAL CALCULATION PACKAGE

Title: Development of lateral bearing capacity for DCPP CTF stability analyses

Calc Number: GEO.DCPP.01.06

Revision: Rev. 1

Author: Robert K. White

Date: November 6, 2001

Verifier: Joseph I. Sun

PURPOSE

As required by Geosciences Work Plan GEO 2001-03, Appendix D, develop values of allowable static and dynamic lateral resistance of rock mass surrounding DCPP ISFSI cask transfer facility (CTF) in terms of lateral stresses. Values are to be used in static and dynamic stability analyses by others.

ASSUMPTIONS

1. When a cask is located in the CTF, the CTF can be modeled as a short rigid pile as it transfers lateral loads to the surrounding rock. This is a realistic assumption, as the CTF dimensions (about 24 feet high and 27 feet in diameter). as shown in Klimczak, 9/27/01 (Drawing UFSP-SK-00, page 7, attached) by inspection meet the short pile criteria, as described in Prakash and Sharma, 1989, page 9, attached.
2. Rock mass lateral resistance is defined by Brinch Hansen, as presented in Prakash and Sharma (1989), page 10, attached, for short rigid piles in soil. This is a conservative assumption, as the rock mass strength properties are likely much higher than those assigned.

DESIGN INPUTS

1. Boring summaries at CTF defining rock types, from Witter, 11/5/01, Data Report B.

2. Friction angle for sandstone and dolomite rock mass of 50 degrees, from Geosciences calculation package GEO.DCPP.01.19.
3. Friction angle of 50 degrees for non-jointed (altered) rock from Geosciences calculation package GEO.DCPP.01.16.
4. Rock unit weight of 140 pcf for rock mass beneath pads, from Witter, 11/5/01, Data Report I.
5. Depth of dilated zone in rock mass of about 3 feet, from Geosciences Calculation GEO.DCPP.01.21.

METHODOLOGY

1. Obtain rock strength parameters appropriate for the assumed failure mechanism and rock mass type at CTF site.
2. Determine ultimate lateral resistance of surrounding rock mass using Brinch Hansen method.
3. Define equivalent uniform ultimate lateral resistance from ultimate lateral resistance.
4. Reduce equivalent uniform ultimate lateral stress by an appropriate safety factor to determine allowable static lateral stress in surrounding rock mass.
5. Increase allowable static lateral stress by an appropriate amount to determine allowable dynamic lateral stress in surrounding rock mass.

SOFTWARE

No software is used for this calculation.

ANALYSIS

1. Rock types as shown on boring log summaries 00BA-3 and CTF-A from Witter, 11/5/01, Data Report B indicate sandstone, dolomite, and altered sandstone are all found in the rock surrounding the proposed CTF. The design friction angle for all these rock types is 50 degrees, as described in GEO.DCPP.01.16 and GEO.DCPP.01.19.
2. The ultimate lateral resistance as defined by Brinch Hansen (as described in Prakash and Sharma, 1989) is a function of the depth at which resistance is being calculated. The ultimate resistance is defined by:

$$p_{xu} = \sigma_{vx} K_q \quad (1)$$

where:
p_{xu} = ultimate resistance
σ_{vx} = effective vertical overburden pressure at depth x
K_q = coefficient determined from Prakash and Sharma, 1989, page 10, attached.

In this case, for x ~ 24 feet and B ~ 27 feet (depth and diameter of CTF opening from Klimczak, 9/27/01 (Drawing UFSP-SK-00, page 7, attached), x/B ~ 1. Then, from page 10, and extrapolating a curve for a friction angle equal to 50 degrees, $K_q \sim 30$. Then for σ_{vx} = 24 feet · 0.140 kcf = 3.36 ksf, p_{xu} = 30 · 3.36 ksf = 100.8 ksf, say 100 ksf at base of CTF, as shown on page 7. The total ultimate resistance per foot of CTF width, is then:

$$P_u = \tfrac{1}{2} \cdot 100 \text{ ksf} \cdot 24 \text{ feet} = 1200 \text{ kips.}$$

3. For analysis purposes, an equivalent uniform ultimate lateral resistance along the side of the CTF can be derived by dividing the maximum ultimate lateral resistance at the base by two, or $p_{u(equiv)}$ = 100 ksf / 2 = 50 ksf. However, it is recommended that the rock mass resistance be reduced in the apparent zone of dilation/disturbance to zero at ground surface. This zone is about 3 feet deep (GEO.DCPP.01.21) so the equivalent uniform resistance should be reduced from 50 ksf to 0 ksf starting at 3 feet below the surface. The total ultimate resistance per foot of CTF width, using this equivalent profile, is then:

$$P_u = 50 \text{ ksf} \cdot 21 \text{ feet} + \tfrac{1}{2} \cdot 50 \text{ ksf} \cdot 3 \text{ feet} = 1125 \text{ kips} < 1200 \text{ kips.}$$

4. The equivalent uniform ultimate lateral resistance can be reduced by a customary safety factor of 2 (Bowles, 1988, page 12, attached) to arrive at an allowable static lateral resistance:

$$p_{allow(static)} = 50 \text{ ksf} / 2 = 25 \text{ ksf}$$

5. An allowable dynamic lateral resistance can be determined by increasing the allowable static resistance by 33% (per ICBO (1997), Section 1612.3.2, page 15, attached), as follows:

$$p_{allow(dynamic)} = 25 \text{ ksf} \times 1.33 = 33 \text{ ksf}$$

RESULTS

An allowable static lateral resistance of 25 ksf and dynamic lateral resistance of 33 ksf within the rock mass surrounding the CTF are provided for use in CTF stability analyses. These values are applicable for the given range of potential CTF dimensions. These values should be reduced to 0 ksf at the ground surface starting at 3 feet below the surface, to account for dilation and construction disturbance within the rock mass which tends to reduce the lateral capacity.

CONCLUSIONS

Values of allowable static and dynamic lateral resistance of rock mass surrounding DCPP ISFSI CTF have been developed in terms of lateral stresses for use in static and dynamic stability analyses by others.

REFERENCES

1. Geosciences Calculation GEO.DCPP.01.16, rev. 1, Development of strength envelopes for non-jointed rock at DCPP ISFSI based on laboratory data.
2. Geosciences Calculation GEO.DCPP.01.19, rev. 1, Development of strength envelopes for jointed rock mass at DCPP ISFSI using Hoek-Brown equations.
3. Geosciences Calculation GEO.DCPP.01.21, rev. 0, Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI site..
4. ICBO (1997), Uniform Building Code, International Conference of Building Officials, USA.
5. Bowles, J. E., 1988, Foundation Analysis and Design, 4th edition, McGraw-Hill.
6. Prakash, S., and Sharma, H. D., 1989, Pile Foundations in Engineering Practice, John Wiley and Sons, Inc.
7. Klimczak (9/27/01): letter from Richard Klimczak to Robert White, entitled "Transmittal of ISFSI Site and Vicinity Plans for the DCPP Used Fuel Storage Project," dated 9/27/01.
8. Geosciences Work Plan GEO 2001-03, Development of Engineering Properties for ISFSI and CTF Foundation Design, ISFSI Slope Analyses, and ISFSI Cut and Fill Slope Reinforcement Design for The DCPP ISFSI Site, rev. 1.

9. Witter (11/5/01): letter from Rob Witter to Rob White, entitled "Completion of Data Reports," dated 11/5/01, and accompanying Data Report B, Borings in ISFSI Site Area, rev. 0.
10. Witter (11/5/01): letter from Rob Witter to Rob White, entitled "Completion of Data Reports," dated 11/5/01, and accompanying Data Report I, Rock Laboratory Test Data, rev. 0.

ATTACHMENTS

1. Klimczak (9/27/01): letter from Richard Klimczak to Robert White, entitled "Transmittal of ISFSI Site and Vicinity Plans for the DCPP Used Fuel Storage Project," dated 9/27/01, and Drawing UFSP-SK-00, attached as pages 6 and 7.
2. Prakash, S., and Sharma, H. D., 1989, Pile Foundations in Engineering Practice, John Wiley and Sons, Inc., cover sheet and pp. 324 through 327, attached as pages 8 through 10.
3. Bowles, J. E., 1988, Foundation Analysis and Design, McGraw-Hill, cover sheet and page 232. attached as pages 11 and 12.
4. ICBO (1997), Uniform Building Code, International Conference of Building Officials, USA, cover sheet and pages 2-4 and 2-5, attached as pages 13 through 15.
5. Witter (11/5/01): letter from Rob Witter to Rob White, entitled "Completion of Data Reports," dated 11/5/01 (without attachments), pages 16 to 17.

GEO.DCPP.01.16 ~~Rev. 0~~ Rev. 1

Memorandum

Date: September 27, 2001 File #: 72.10.05

To: Robert K. White Phone: (415) 973-0544
PG&E Geosciences Dept

From: Richard L. Klimczak, Project Engineer

Subject: Diablo Canyon Units 1 and 2
Transmittal of ISFSI Site and Vicinity Plans for the DCPP Used Fuel Storage Project

Pacific Gas and Electric Company

Dear Rob,

Attached are copies of three site plan drawings and a sketch of the cask transfer facility.

PG&E Drawing 471124 is a plant site plot plan. Fig. 2.1-2 is a site plan showing the ISFSI and Transport Route. UFSP-SK-004 is a sketch of the Cask Transfer Facility.

PGE-009-SK-001 is the ISFSI site plot plan showing the cask storage pads, Cask Transfer Facility and the near vicinity of the ISFSI site. The drawing was prepared by Enercon Services Inc. Per Holtec calculation HI-2012618, Rev. 3, the weight of each loaded cask is 360,000 pounds.

This transmittal is per requirements of DCPP Procedure CF3.ID17.

If you have comments or questions please contact me at (805) 595-6320 or A. Tafoya at (805) 595-6392.

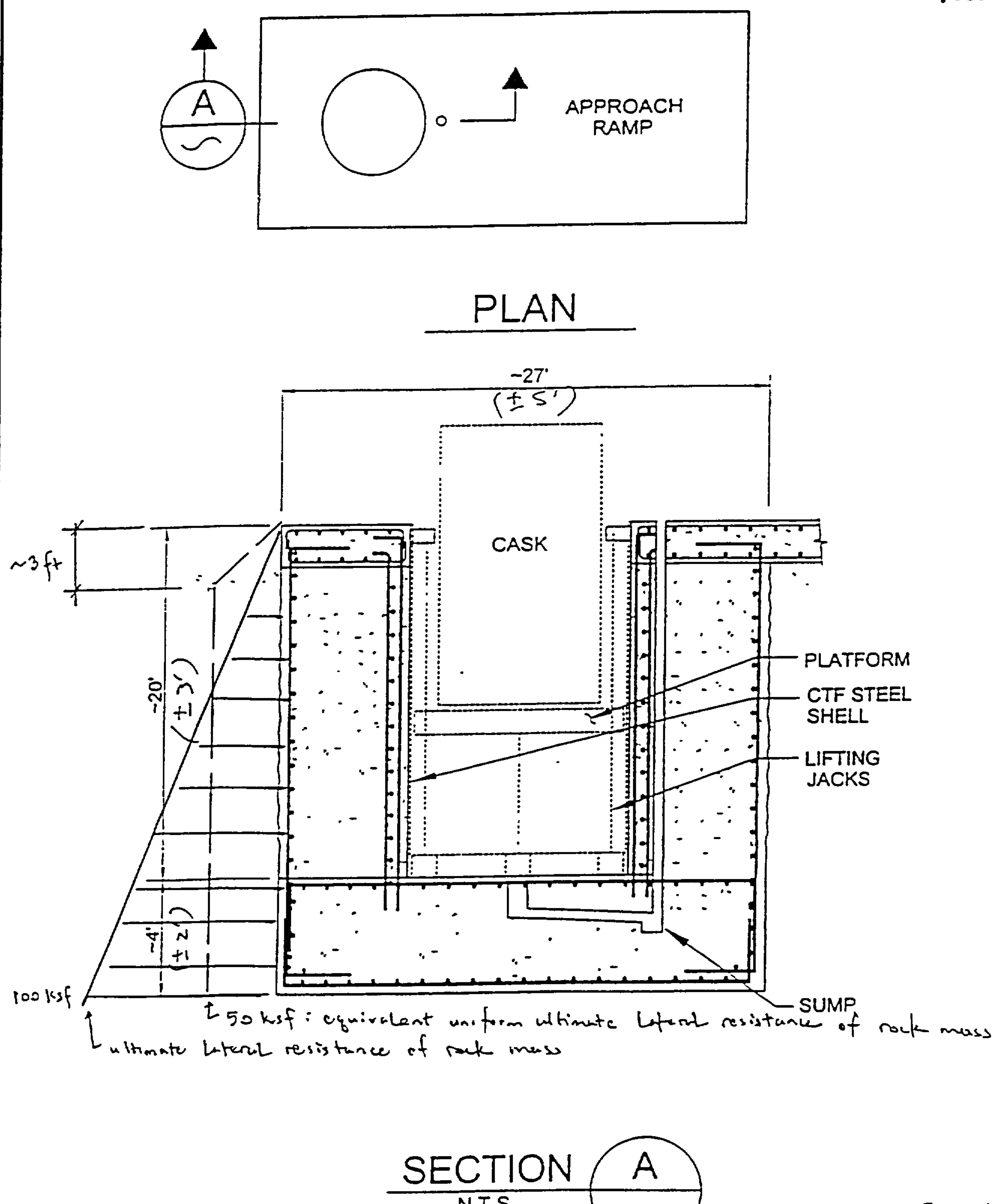
Richard L. Klimczak

Richard L. Klimczak
Project Engineer
Diablo Canyon Used Fuel Storage Project

Attachments: Dwg 471124, Fig. 2.1-2, PGE-009-SK-001, UFSP-SK-004

cc: LJStrickland	SLO B3	w/o	WPage	245 Market N4C 418B w/o
BHPatton	SLO BB	w/o	DCPP RMS	DCPP 119/1
NJahangir	DCPP 201/112	w/o	DCPP Chronological File	
AFTafoya	SLO B10		DCPP File No.72.10.05	

GEO.DCPP.01.16 ~~Rev. 0~~ Rev-1



BY: A. ZAFLYA 9/27/01

CHKD: N. JAHANGIR 9/27/01

NOTE: DIMENSIONS SHOWN ARE APPROXIMATE.

UNIT page 7 of 51	DIABLO CANYON POWER PLANT	
CASK TRANSFER FACILITY STRUCTURE (SCHEMATIC)	PG&E CO. SHEET 1 OF 1 SHEETS	DRAWING NUMBER UFSP-SK-00 REV. A

GEO.DGPP 01.06 ~~Rev. 0~~ Rev. 1

PILE FOUNDATIONS IN ENGINEERING PRACTICE

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Attachment "A" to Calc. # 52.27.100.716 Rev. 0 Page 11 of 19

1. Methods of calculating ultimate lateral resistance
2. Methods of calculating acceptable deflection at working lateral load

I. Methods of Calculating Lateral Resistance of Vertical Piles

A. Brinch Hansen's Method (1961) This method is based on earth pressure theory and has the advantage that it is
   1. Applicable for $c - \phi$ soils
   2. Applicable for layered system

   However, this method suffers from disadvantages that it is
   1. Applicable only for short piles
   2. Requires trial and error solution to locate point of rotation

B. Broms' Method (1964a, b) This also is based on earth pressure theory, but simplifying assumptions are made for distribution of ultimate soil resistance along the pile length. This method has the advantage that it is.
   1. Applicable for short and long piles
   2. Considers both purely cohesive and cohesionless soils
   3. Considers both free-head and fixed-head piles that can be analyzed separately

   However, this method suffers from disadvantages that:
   1. It is not applicable to layered system
   2. It does not consider $c - \phi$ soils

II. Methods of Calculating Acceptable Deflection at Working Load

A. Modulus of Subgrade Reaction Approach (Reese and Matlock, 1956) In this method it is assumed that soil acts as a series of independent linearly elastic springs. This method has the advantage that
   1. It is relatively simple
   2. It can incorporate factors such as nonlinearity, variation of subgrade reaction with depth, and layered systems
   3. It has been used in the practice for a long time

   Therefore, a considerable amount of experience has been gained in applying the theory to practical problems. However, this method suffers from disadvantages that
   1. It ignores continuity of the soil
   2. Modulus of subgrade reaction is not a unique soil property but depends on the foundation size and deflections

B. Elastic Approach (Poulos, 1971a and b) In this method, the soil is assumed as an ideal elastic continuum. The method has the advantage that.
   1. It is based on a theoretically more realistic approach,
   2. It can give solutions for varying modulus with depth and layered system. However, this method suffers from disadvantages that.
   1. It is difficult to determine appropriate strains in a field problem and the corresponding soil moduli

6

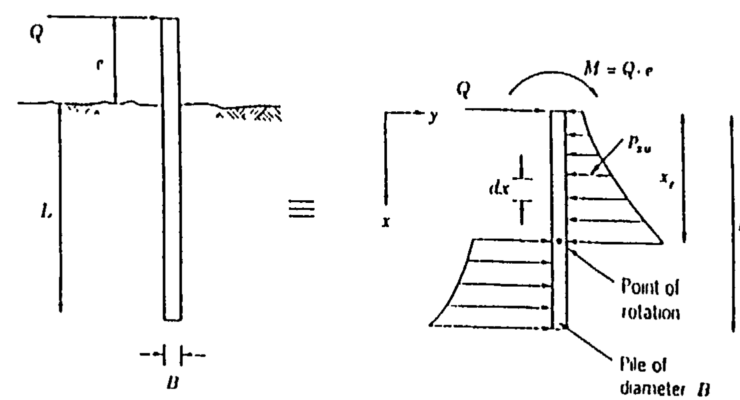

Figure 6.2 Mobilization of lateral resistance for a free head laterally loaded rigid pile.

2. It needs more field verification by applying theory to practical problems

Ultimate Lateral Resistance Figure 6.2 shows the mechanism in which the ultimate soil resistance is mobilized to resist a combination of lateral force Q and moment M applied at the top of a free-head pile. The ultimate lateral resistance Q_u and the corresponding moment M_u can then be related with the ultimate soil resistance p_u by considering the equilibrium conditions as follows

Sum of Forces in horizontal direction $= \Sigma F_y = 0$

$$Q_u - \int_{x=0}^{x=x_r} p_{xu} B\,dx + \int_{x=x_r}^{x=L} p_{xu} B\,dx = 0 \qquad (6.1)$$

Σ Moments $= 0$

$$Q_u e + \int_{x=0}^{x=x_r} p_{xu} B x\,dx - \int_{x=x_r}^{x=L} p_{xu} B x\,dx = 0 \qquad (6.2)$$

where

B = width of pile
x_r = depth of point of rotation

If the distribution of ultimate unit soil resistance p_{xu} with depth x along the pile is known, then the values of x_r (the depth of the point of rotation) and Q_u (the ultimate lateral resistance) can be obtained from equations (6.1) and (6.2)

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This basic concept has been used by Brinch Hansen (1961) and Broms (1964a, b) to determine the ultimate lateral resistance of vertical piles

Brinch Hansen's Method For short rigid piles, Brinch Hansen (1961) recommended a method for any general distribution of soil resistance. The method is based on earth pressure theory for c–ϕ soils. It consists of determining the center of rotation by taking moment of all forces about the point of load application and equating it to zero. The ultimate resistance can then be calculated by using equation similar to equation (6.1) such that the sum of horizontal forces is zero. Accordingly, the ultimate soil resistance at any depth is given by following equation

$$p_{xu} = \bar{\sigma}_{vx} K_q + c K_c \qquad (6.3)$$

where

$\bar{\sigma}_{vx}$ = vertical effective overburden pressure
c = cohesion of soil
K_c and K_q = factors that are function of ϕ and x/B as shown in Figure 6.3

The method is applicable to both uniform and layered soils. For short term loading conditions such as wave forces, undrained strength c_u and $\phi = 0$ can be used. For long-term sustained loading conditions, the drained effective strength values (c', ϕ') can be used in this analysis

Broms' Method The method proposed by Broms (1964a, b) for lateral resistance of vertical piles is basically similar to the mechanism outlined above. The following simplifying assumptions have been made in this method

1. Soil is either purely cohesionless ($c = 0$) or purely cohesive ($\phi = 0$). Piles in each type of soil have been analyzed separately
2. Short rigid and long flexible piles are considered separately. The criteria for short rigid piles is that $L/T \leq 2$ or $L/R < 2$

where

$$T = \left(\frac{EI}{n_h}\right)^{1/5} \qquad (6.4a)$$

$$R = \left(\frac{EI}{k_h}\right)^{1/4} \qquad (6.4b)$$

E = modulus of elasticity of pile material
I = moment of inertia of pile section
$k_h = n_h x$ for linearly increasing soil modulus k_h with depth(x)

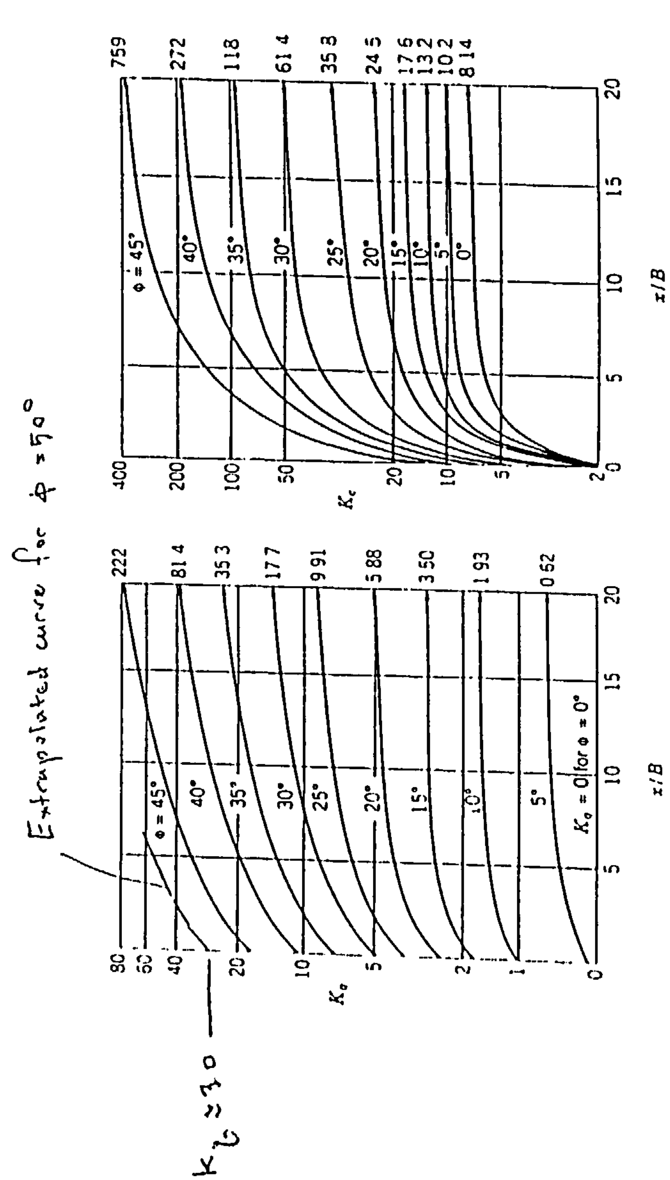

Figure 6.3 Coefficients K_q and K_c (Brinch Hansen 1961)

Geo.DCPP.01.01 Rev. 1

FOUNDATION ANALYSIS AND DESIGN

Fourth Edition

Joseph E. Bowles, P.E., S.E.
Consulting Engineer Software Consultant
Engineering Computer Software
Peoria, Illinois

McGraw-Hill Book Company

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14 of ~~15~~ 17

GEO.DEVP.01.06 ~~Rev. 0~~ Rev. 1

4-1(

TABLE 4-9 Values of customary safety factors

Failure mode	Foundation type	SF
Shear	Earthworks	
	Dam fills, etc	1 2–1 6
Shear	Retaining structure	
	Walls	1 5–2 0
Shear	Sheetpiling cofferdams	1 2–1 6
	Braced excavations. (temporary)	1 2–1 5
Shear	Footings	
	Spread	2–3
	Mat	1.7–2 5
	Uplift	1 7–2.5
Seepage	Uplift heaving	1 5–2 5
	Piping	3–5

Using the load term abbreviations of Table 4-10, and code amplification factors R_i the following might be investigated

$$\text{Design load} = R_D DL + R_L LL + R_S S + HS \qquad (SF = 3\,0)$$

$$\text{Design load} = R_D DL + R_L LL + R_W W + HS \qquad (SF = 2\,0)$$

$$\text{Design load} = R_D DL + R_L LL + R_E E + R_S S \qquad (SF = 2\,0)$$

A number of other possible load combinations including 0.5LL and E, E and HS, etc., are commonly investigated It is usual to use smaller safety factors for transitory loads such as wind and earthquake but is not an absolute requirement.

We should especially note that the geotechnical consultant will make a recommendation for an allowable strength (bearing capacity, etc) which has the

TABLE 4-10 Foundation loads

Load	Includes
Dead load (DL)	Weight of structure and all permanently attached material
Live load (LL)	Any load not permanently attached to the structure, but to which the structure may be subjected
Snow load (S)	Acts on roofs; value to be used generally stipulated by codes
Wind load (W)	Acts on exposed parts of structure
Earthquake (E)	A lateral force (usually) which acts on the structure
Hydrostatic (HS)	Any loads due to water pressure and may be either (+) or (−)
Earth pressure (EP)	Any loads due to earth pressures—commonly lateral but may be in other directions

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STRUCTURAL ENGINEERING DESIGN PROVISIONS

GEO.DCPP.01.06 Rev. 0 Rev. 1

walls under a load of 5 psf (0.24 kN/m²) shall not exceed 1/240 of the span for walls with brittle finishes and 1/120 of the span for walls with flexible finishes. See Table 16-O for earthquake design requirements where such requirements are more restrictive.

EXCEPTION: Flexible, folding or portable partitions are not required to meet the load and deflection criteria but must be anchored to the supporting structure to meet the provisions of this code

1611.6 Retaining Walls Retaining walls shall be designed to resist loads due to the lateral pressure of retained material in accordance with accepted engineering practice Walls retaining drained soil, where the surface of the retained soil is level, shall be designed for a load, *H*, equivalent to that exerted by a fluid weighing not less than 30 psf per foot of depth (4.71 kN/m²/m) and having a depth equal to that of the retained soil Any surcharge shall be in addition to the equivalent fluid pressure

Retaining walls shall be designed to resist sliding by at least 1.5 times the lateral force and overturning by at least 1.5 times the overturning moment, using allowable stress design loads

1611.7 Water Accumulation. All roofs shall be designed with sufficient slope or camber to ensure adequate drainage after the long-term deflection from dead load or shall be designed to resist ponding load, *P*, combined in accordance with Section 1612.2 or 1612.3. Ponding load shall include water accumulation from any source, including snow, due to deflection. See Section 1506 and Table 16-C, Footnote 3, for drainage slope See Section 1615 for deflection criteria.

1611.8 Hydrostatic Uplift. All foundations, slabs and other footings subjected to water pressure shall be designed to resist a uniformly distributed uplift load, *F*, equal to the full hydrostatic pressure.

1611.9 Flood-resistant Construction. For flood-resistant construction requirements where specifically adopted, see Appendix Chapter 16, Division IV

1611.10 Heliport and Helistop Landing Areas. In addition to other design requirements of this chapter, heliport and helistop landing or touchdown areas shall be designed for the following loads, combined in accordance with Section 1612.2 or 1612.3:

1. Dead load plus actual weight of the helicopter.

2 Dead load plus a single concentrated impact load, *L*, covering 1 square foot (0 093 m²) of 0 75 times the fully loaded weight of the helicopter if it is equipped with hydraulic-type shock absorbers, or 1.5 times the fully loaded weight of the helicopter if it is equipped with a rigid or skid-type landing gear

3 The dead load plus a uniform live load, *L*, of 100 psf (4 8 kN/m²) The required live load may be reduced in accordance with Section 1607.5 or 1607.6

1611.11 Prefabricated Construction.

1611.11.1 Connections. Every device used to connect prefabricated assemblies shall be designed as required by this code and shall be capable of developing the strength of the members connected, except in the case of members forming part of a structural frame designed as specified in this chapter. Connections shall be capable of withstanding uplift forces as specified in this chapter

1611.11.2 Pipes and conduit. In structural design, due allowance shall be made for any material to be removed for the installation of pipes, conduits or other equipment

1611.11.3 Tests and inspections. See Section 1704 for requirements for tests and inspections of prefabricated construction.

SECTION 1612 — COMBINATIONS OF LOADS

1612.1 General. Buildings and other structures and all portions thereof shall be designed to resist the load combinations specified in Section 1612.2 or 1612.3 and, where required by Chapter 16, Division IV, or Chapters 18 through 23, the special seismic load combinations of Section 1612.4

The most critical effect can occur when one or more of the contributing loads are not acting All applicable loads shall be considered, including both earthquake and wind, in accordance with the specified load combinations

1612.2 Load Combinations Using Strength Design or Load and Resistance Factor Design.

1612.2.1 Basic load combinations. Where Load and Resistance Factor Design (Strength Design) is used, structures and all portions thereof shall resist the most critical effects from the following combinations of factored loads

$$1.4D \quad (12\text{-}1)$$

$$1.2D + 1.6L + 0.5 (L_r \text{ or } S) \quad (12\text{-}2)$$

$$1.2D + 1.6 (L_r \text{ or } S) + (f_1L \text{ or } 0.8W) \quad (12\text{-}3)$$

$$1.2D + 1.3W + f_1L + 0.5 (L_r \text{ or } S) \quad (12\text{-}4)$$

$$1.2D + 1.0E + (f_1L + f_2S) \quad (12\text{-}5)$$

$$0.9D \pm (1.0E \text{ or } 1.3W) \quad (12\text{-}6)$$

WHERE:

f_1 = 1 0 for floors in places of public assembly, for live loads in excess of 100 psf (4 9 kN/m²), and for garage live load.

= 0.5 for other live loads.

f_2 = 0.7 for roof configurations (such as saw tooth) that do not shed snow off the structure.

= 0.2 for other roof configurations.

EXCEPTIONS: 1 Factored load combinations for concrete per Section 1909 2 where load combinations do not include seismic forces

2 Factored load combinations of this section multiplied by 1 1 for concrete and masonry where load combinations include seismic forces

3 Where other factored load combinations are specifically required by the provisions of this code

1612.2.2 Other loads. Where *F*, *H*, *P* or *T* are to be considered in design, each applicable load shall be added to the above combinations factored as follows: 1.3*F*, 1.6*H*, 1.2*P* and 1 2*T*.

1612.3 Load Combinations Using Allowable Stress Design.

1612.3.1 Basic load combinations. Where allowable stress design (working stress design) is used, structures and all portions thereof shall resist the most critical effects resulting from the following combinations of loads

$$D \quad (12\text{-}7)$$

$$D + L + (L_r \text{ or } S) \quad (12\text{-}8)$$

$$D + \left(W \text{ or } \frac{E}{1.4}\right) \quad (12\text{-}9)$$

$$0.9D \pm \frac{E}{1.4} \quad (12\text{-}10)$$

$$D + 0.75\left[L + (L_r \text{ or } S) + \left(W \text{ or } \frac{E}{1.4}\right)\right] \quad (12\text{-}11)$$

No increase in allowable stresses shall be used with these load combinations except as specifically permitted by Section 1809.2.

1612.3.2 Alternate basic load combinations. In lieu of the basic load combinations specified in Section 1612.3.1, structures and portions thereof shall be permitted to be designed for the most critical effects resulting from the following load combinations. When using these alternate basic load combinations, a one-third increase shall be permitted in allowable stresses for all combinations, including W or E.

$$D + L + (L_r \text{ or } S) \quad (12\text{-}12)$$

$$D + L + \left(W \text{ or } \frac{E}{1.4}\right) \quad (12\text{-}13)$$

$$D + L + W + \frac{S}{2} \quad (12\text{-}14)$$

$$D + L + S + \frac{W}{2} \quad (12\text{-}15)$$

$$D + L + S + \frac{E}{1.4} \quad (12\text{-}16)$$

EXCEPTIONS: 1. Crane hook loads need not be combined with roof live load or with more than three fourths of the snow load or one half of the wind load.

2. Design snow loads of 30 psf (1.44 kN/m²) or less need not be combined with seismic loads. Where design snow loads exceed 30 psf (1.44 kN/m²), the design snow load shall be included with seismic loads, but may be reduced up to 75 percent where consideration of siting, configuration and load duration warrant when approved by the building official.

1612.3.3 Other loads. Where F, H, P or T are to be considered in design, each applicable load shall be added to the combinations specified in Sections 1612.3.1 and 1612.3.2. When using the alternate load combinations specified in Section 1612.3.2, a one-third increase shall be permitted in allowable stresses for all combinations including W or E.

1612.4 Special Seismic Load Combinations. For both Allowable Stress Design and Strength Design, the following special load combinations for seismic design shall be used as specifically required by Chapter 16, Division IV, or by Chapters 18 through 23:

$$1.2D + f_1L + 1.0E_m \quad (12\text{-}17)$$

$$0.9D \pm 1.0E_m \quad (12\text{-}18)$$

WHERE:

f_1 = 1.0 for floors in places of public assembly, for live loads in excess of 100 psf (4.79 kN/m²), and for garage live load.

= 0.5 for other live loads.

SECTION 1613 — DEFLECTION

The deflection of any structural member shall not exceed the values set forth in Table 16-D, based on the factors set forth in Table 16-E. The deflection criteria representing the most restrictive condition shall apply. Deflection criteria for materials not specified shall be developed in a manner consistent with the provisions of this section. See Section 1611.7 for camber requirements. Span tables for light wood-frame construction as specified in Chapter 23, Division VII, shall conform to the design criteria contained therein. For concrete, see Section 1909.5.2.6; for aluminum, see Section 2003; for glazing framing, see Section 2404.2.

$U = 0.9D \pm E/1.4$

GEO.DCPP.01.06 Rev.1

WLA

William Lettis & Associates, Inc.

1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
Voice. (925) 256-6070 FAX: (925) 256-6076

Mr. Robert White
Geosciences Department
Pacific Gas & Electric Company
245 Market Street, Rm. 421-N4C
San Francisco, CA 94105

November 5, 2001

Re: Completion of Data Reports (formerly appendices)

Dear Rob:

This letter transmits to Geosciences the following Diablo Canyon ISFSI Data Reports (formerly called appendices) that were prepared under the WLA Work Plan, Additional Geologic Mapping, Exploratory Drilling, and Completion of Kinematic Analyses for the Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site, Rev. 2 (11/28/00) using data collected under that Work Plan and a second WLA Work Plan, Additional Exploratory Drilling and Geologic Mapping for the ISFSI Site, Rev. 1 (9/21/01).

Diablo Canyon ISFSI Data Report A - Geologic Mapping in the Plant Site and ISFSI Site Areas, Rev. 0, November 5, 2001, November 5, 2001, prepared by J. Bachhuber, 42 p.

Diablo Canyon ISFSI Data Report B - Borings in ISFSI Site Area, Rev. 0, November 5, 2001, prepared by J. Bachhuber, 244 p.

Diablo Canyon ISFSI Data Report C - 1998 Geophysical Investigations at the ISFSI Site Area, (Agbabian Associates and GeoVision), Rev. 0, November 5, 2001, prepared by J. Bachhuber, 84 p.

Diablo Canyon ISFSI Data Report D - Trenches in the ISFSI Site Area, Rev. 0, November 5, 2001, prepared by J. Bachhuber, 66 p.

Diablo Canyon ISFSI Data Report E, - Borehole Geophysical Data (NORCAL Geophysical Consultants, Inc.), Rev. 0, November 5, 2001, prepared by C. Brankman, 303 p.

Diablo Canyon ISFSI Data Report F - Field Discontinuity Measurements, Rev. 0, November 5, 2001, prepared by J. Bachhuber and C. Brankman, 85 p.

Diablo Canyon ISFSI Data Report G - Soil Laboratory Test Data (Cooper Testing Laboratory), Rev. 0, November 5, 2001, prepared by J. Sun, 63 p.

Diablo Canyon ISFSI Data Report H - Rock Strength Data and GSI Sheets, Rev. 0, November 5, 2001, prepared by J. Bachhuber, 37 p.

GEO.DCPP.01.06 Rev. 1

WLA

Diablo Canyon ISFSI Data Report I - Rock Laboratory Test Data (GeoTest Unlimited), Rev. 0, November 5, 2001, prepared by J. Sun, 203 p.

Diablo Canyon ISFSI Data Report J – Petrographic Analysis and X-Ray Diffraction of Rock Samples (Spectrum Petrographics, Inc.), Rev. 0, November 5, 2001, prepared by J. Bachhuber, 204 p.

Diablo Canyon ISFSI Data Report K - Petrographic and X-Ray Diffraction Analyses of Clay Beds (Schwein/Christensen Laboratories, Inc.). Rev. 0. November 5, 2001, prepared by J. Bachhuber, 36 p.

In addition to the revisions of those reports required under the various Work Plans, Mr. Scott Lindvall, the WLA ITR for the ISFSI project, has performed independent technical reviews of the Diablo Canyon ISFSI Data Reports as part of his review of Calculation Package GEO.DCPP.01.21, Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site. He finds that the reports clearly and accurately compile and organize the data.

Mr. Albert Tafoya from the Diablo Canyon ISFSI Project Office in San Luis Obispo, Mr. Dale Marcum, NQS Technical Oversight for the project, and William Page of your office provided comments on the August versions of the Diablo Canyon ISFSI Data Reports (formerly called appendices) and their comments have been addressed.

These reports are submitted to you as per the PG&E Geosciences Department Calculation Procedure GEO.001, Rev. 04 (10/10/01).

We look forward to any comments you may have.

Sincerely,
WILLIAM LETTIS & ASSOCIATES, INC.

Robert C. Witter
Project Manager

CC: William Page

ATTACHMENT

2-2

LOG OF BORING 1

Equipment: 24" Diameter Bucket Auger

Elevation: 111.8 Date: 2/17/70

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Moisture Content (%)	Dry Density (pcf)	Depth (ft)
		0
		5
		10
26.0	86	
		15
25.8	94	
		20
		25
		30
		35
		40

DARK BROWN SANDY CLAY (CH)
soft, damp, with occasional angular gravel

LIGHT BROWN SANDY SILT (ML)
stiff, dry, with occasional angular gravel
change to hard at 5', with occasional caliche cementation
increased gravel up to 8" from 9 to 10.5'
change to soft, wet at 10.5'

LIGHT BROWN SANDY SILTY CLAY (CL) - soft, wet, with occasional angular gravel

change to stiff at 22.5'

GRAY BROWN SILTY SAND (SM)
dense, wet, with abundant angular gravel

YELLOW BROWN SANDY CLAY (CL)
stiff, wet, with occasional gravel and shell fragments

MOTTLED YELLOW GRAY SILTY CLAY (CL) - stiff, wet, with abundant weathered rock fragments

MOTTLED YELLOW GRAY TUFF
friable, low hardness, sheared, altered and deeply weathered
change to gray, weak at 44'

water level 2/18/70

HARDING, MILLER, LAWSON & ASSOCIATES
Consulting Engineers

Job No: 569,010.04 Appr: SRK/jw Date 3/18/70

LOG OF BORING 1
Landslide
PG&E - Diablo Canyon

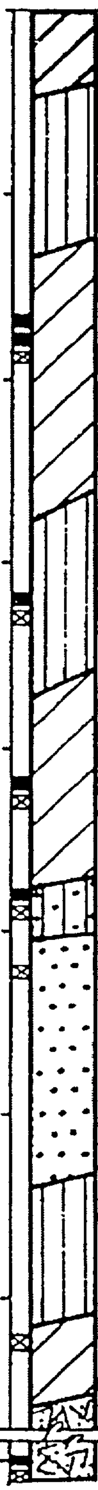
PLATE
6

LOG OF BORING 2

Equipment: 24" Diameter Bucket Auger

Elevation: 110.8 Date: 2/17/70

Shear Strength (lbs/sq ft): 5000 4000 3000 2000 1000 0



Depth (ft)	Moisture Content (%)	Dry Density (pcf)	Shear Strength (lbs/sq ft)	Description
0				DARK BROWN SANDY CLAY (CH) soft, damp, with occasional angular gravel
				LIGHT BROWN SANDY SILT (ML) stiff, damp, with abundant angular gravel with occasional gravel up to 6" at 5'
~9	25.4	93		LIGHT BROWN SANDY CLAY (CL) soft, wet, with occasional gravel change to firm at 9.5' change to soft at 11'
~16	27.9	87		LIGHT BROWN SANDY CLAYEY SILT (ML) - soft to medium stiff, wet, with occasional angular gravel
				LIGHT BROWN SILTY CLAY (CL) stiff, moist, with slight porosity
				LIGHT BROWN SILTY SAND (SM) dense, wet
				BROWN GRAVELLY SAND (SP) medium dense, moist, with silt binder
				MOTTLED GRAY BROWN CLAYEY SILT (ML) - soft, moist, with occasional angular gravel
				MOTTLED ORANGE GRAY GRAVELLY CLAY (CL) - firm, moist, with abundant rock fragments
41	33.0	87	UU 4320	MOTTLED ORANGE GRAY TUFF soft to friable, low hardness, sheared, altered and moderately weathered

water level 2/19/70 at 40.5'

HARDING, MILLER, LAWSON & ASSOCIATES
Consulting Engineers

Job No: 569,010.04 Appr: SEK/jw Date 3/18/70

LOG OF BORING 2
Landslide
PG&E - Diablo Canyon

PLATE 7

LOG OF BORING 3

Equipment: 24" Diameter Bucket Auger

Elevation: 100.8 Date: 2/18/70

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
			0		DARK BROWN SANDY CLAY (CH) soft, damp, with occasional angular gravel
			5		LIGHT BROWN SANDY SILT (ML) firm, damp, with occasional angular gravel; up to 4" gravel at 7'; grading clayey at 8', with caliche cementation
			10		
					slightly porous and moist at 14'
			15		
					BROWN SILTY SAND (SM) medium dense, moist, with occasional gravel
	20.0	83	20		
					ORANGE BROWN SANDY CLAY (CL) stiff, damp, with abundant rock fragments
			25		OPANGE BPOWN TUFFACEOUS SILTSTONE - weak, moderately hard, closely fractured, moderately weathered
			30		
					(no free water observed)
			35		
			40		

HARDING, MILLER, LAWSON & ASSOCIATES
Consulting Engineers

Job No: 569,010.04 Appr: RL/jw Date 3/18/70

LOG OF BORING 3
Landslide
PG&E - Diablo Canyon

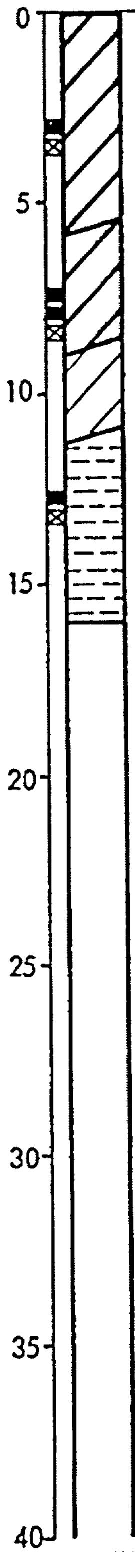
PLATE 8

LOG OF BORING 4

Equipment: 24" Diameter Bucket Auger

Elevation: 90.4 Date: 2/19/70

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample
	24.8	77		



BLACK SANDY CLAY (CH)
soft, moist, with occasional angular gravel

MOTTLED YELLOW BROWN SILTY CLAY (CH) - soft, wet, with occasional rock fragments
change to stiff at 8'

BROWN GRAVELLY SANDY CLAY (CL) - firm, moist, with abundant rock fragments

BLACK SHALE
moderately strong, hard, closely fractured, slightly weathered
change to strong, very hard at 15'
auger refusal at 16'

(no free water observed)

HARDING, MILLER, LAWSON & ASSOCIATES
Consulting Engineers

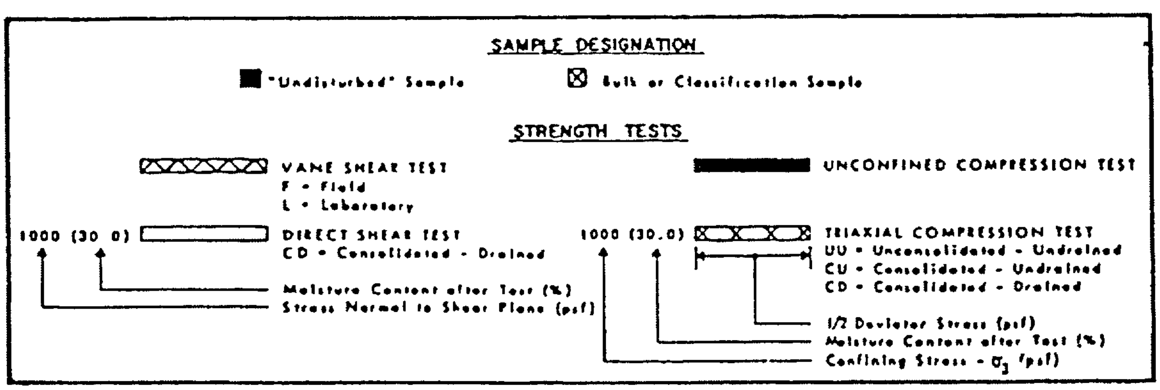
Job No: 569,010.04 Appr: SRH/jw Date 3/18/70

LOG OF BORING 4
Landslide
PG&E - Diablo Canyon

PLATE
9

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS (MORE THAN HALF IS LARGER THAN #200 SIEVE)	GRAVELS — MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL - SAND - SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL - SAND - CLAY MIXTURES
	SANDS — MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, POORLY GRADED SAND - SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND - CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN HALF IS SMALLER THAN #200 SIEVE)	SILTS AND CLAYS — LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS — LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

UNIFIED SOIL CLASSIFICATION SYSTEM



KEY TO TEST DATA

HARDING, MILLER, LAWSON & ASSOCIATES *Consulting Engineers*	SOIL CLASSIFICATION CHART AND KEY TO TEST DATA	PLATE 10
Job No: 569,010 04 Appr: SRK Date 5/14/75	PG&E - Diablo Canyon	

ATTACHMENT

2-3

WLA

BORING LOG

Project	Job No	Boring No
DCPP Dry Cask Storage Facility Siting Study	WLA 1081-28	DCSF96-1

Type & Diameter of Boring	Boring Location	Total Depth
8"ø Hollow Flight Augers through overburden	South Portion of Parking Lot 7	39.3 ft

Sampling Method	Sample Driving Hammer and Drop	Elevation @ Top of Hole
2.0" and 3.0"ø O.D. split spoon drive samplers; 3.0"ø Shelby (Pitcher) Tubes hydraulically pushed	140 lb. safety w/ 30" drop	100 ft. ±

Drilling Contractor and Rig	Date Started	Date Completed	Logged By
PC Exploration Puntell MX600	7/9/1996	7/10/1996	J. Bachhuber

Uncorrected Blows per 6-inch drive	SPT $N_1(60)$ (0–60)	Depth (feet)	Soil Type (USCS)	Sampler Type	Recovery (inches)	Pocket Pen. (TSF)	Description	Remarks
		0					3" Asphalt 3" Angular gravel baserock	Easy augering, clay cuttings
		2	CL-CH	2.5-inch I.D. split spoon	bag		Sandy (fine), silty CLAY, with some gravel (<5%); brown (7.5 YR 4/3); moist, stiff; plastic; light tan veins/streaks (carbonate?); gravels are small (<1/8"), orange-red-tan, angular. (Old fan deposits, Qpf1)	
		3–5.5		Pitcher tube	21			
2 5 10	19	5.5–7		SPT	10	2.0 2.5	Same as above.	
		6–7	CL				Silty CLAY with gravel (<10%); light brown (7.5 YR 4/3); moist; stiff; abundant tan-gray zones(carbonate?); sparse black carbon flecks; thin clay films around gravel. (Old fan deposits, Qpf2)	Easy augering, clay cuttings with <5% gravel
		9–11.5		Pitcher tube	10.5			
3 4 4	10	11.5–13	CL-CH	SPT		2.0-2.5	Same as above - moisture content increasing; less stiff.	
		13				<1.0	Same as above - very moist (almost wet); soft; very plastic (can repeatedly role 1/16" ø thread). @ ~13 ft. - 1" tan (7.5 YR 4/3) siltstone gravel in shoe.	
		14.5–15	CL-CH	Pitcher tube	6		Description on next page.	

Legend: 3.0-inch Pitcher tube sampler; 2.5-inch I.D. split spoon sampler; Standard Penetration Test (SPT) sampler

![WLA logo]

BORING LOG

Project	Job No	Boring No
DCPP Dry Cask Storage Facility Siting Study	WLA 1081-28	DCSF96-1

Uncorrected Blows per 6-inch drive	SPT N1(60) (0 10 20 30 40 50 60)	Depth (feet)	Soil Type (USCS)	Sampler Type	Recovery (inches)	Pocket Pen (TSF)	Description	Remarks
13, 50/2"	68►►	15–16	CL/CH	SPT	8	3.5->4	Silty CLAY, with some gravel (<5%); dark gray brown (10 YR 4/2); damp; very stiff; plastic; blocky structure; gravels are tan (7 5 YR 5/6) angular siltstone / claystone. (Old fan deposits, Qpf3)	Slow, stiff augering, clay cuttings with some rock fragments
6, 24, 50/4"	73►►	18–19		SPT	12	3.0-3 5	Same as above. Sampler wet 1" zone ▼ 7/9/96 Groundwater. Siltstone/Claystone in shoe.	Drill rods wet below 19'
15, 38, 25/2"	84►►	22–23	CL/CH	SPT	84		Same as above. Tan Siltstone in shoe. Bouldery -Clay	Slow augering with harder zones
		24					Gravelly cuttings ↓	
41, 44, 53	89►►	25–26	SC-SW	SPT	14	3.5	Silty, CLAYEY SAND, with weathered rock fragments (shale/siltstone) (<25%); brown (7.5 YR 4/2), damp, very stiff to hard; plastic; blocky structure. (Completely weathered bedrock, Saprolitic)	Hard, slow yet smooth augering, no cuttings
10, 17, 50/3"	70►►	30–32	bedrock	SPT	10		SILTSTONE/SHALE; severely weathered; very dark gray (7.5 YR 3/1); low hardness; yellow sulfer staining. Switch from auger to rotary coring.	Hard augering

See page 3

Legend: 3 0-inch Pitcher tube sampler; 2.5-inch I.D. split spoon sampler; Standard Penetration Test (SPT) sampler

ROCK BORING LOG

Project	Job Number	Boring Location	Boring No.
DCPP - DCSF Siting Study	WLA 1081-28	South portion of parking lot 7.	DCSF96-1

Type & Diameter of Boring	Drilling Method	Total Depth
3.5"ø HQ Wireline Coring	HQ Wireline w/double-tube C. B	39.3'

Drilling Contractor and Rig	Drillers	Depth to Bedrock
PC Exploration Puntell MX-600	PC Exploration	30.25'

Casing Size and Depth	Logged By	Date Started
8"ø Hollow Stem Augers	J. Bachhuber	7/9/96

Length of Core Barrel and Bit	Borehole Inclination	Ground Water Depth	Elevation and Datum	No of Core Boxes	Date Completed
7.6'	vertical	18 75	100'± top of hole	1	7/10/96

WLA

Depth (feet)	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
30–32									See page 2.		
32									Begin HQ Coring @ bottom of auger boring after reaming		
32–33.5	1:15, 4.10	1	1.6/1.6	100	0	Mo	VC	Lo	SILTSTONE, dark gray (2.5 YR 4/1), moderately weathered, subhorizontal partings; brittle; low hardness.	Fragments <0.2', avg. 0 05'	100% circulation medium brown return water
33.5–35.5	4:15, 3:40	2	2.0/2.0	100	65	Mo	Cl-Mo	Lo		Jo,40; Jo,45; Jo,40; Jo,30 — Wa, Sm, Op-Ti, JRC4-8 Jo,40; Jo,60 — Wa-Pl, Sm, Ti, JRC 2-4 Jo,40 — thin white coatings	
35.5–39.5	4 39, 5 17, 3:20, 3.10	3	3 8/3 8	100	21	Se-Mo	VC	Lo	CLAYSTONE; very dark gray (2.5 YR 3/1); pervasively sheared and jointed; very soft, fissile; mineralized zones (Shear) (Bedrock unit 96-1b) ≡ CLAY gouge - sheared rock.	Fo,20; Jo,30; Jo,50; Fo,20 — Wa Sm, Ti, JRC 2-4 Shaley Jo,40; Jo,70 — No Sm - Slickensides Fo (sheared), 50-70, Wa, mineralized Jo, 30	100% circulation dark brown return water
39–39.8						Mo	Cl	Lo	SILTSTONE; dark gray; mod. weathered. (Bedrock unit 96-1c)		
40									BOH @ 39.3'	Installed 2"ø Piezometer in hole: 0-19' – casing 13-19' bentonite seal 19-39' – 0.02" screen Groundwater @ 19' during drilling. Measured at 17.8' in piezometer on 7/19/96.	

Weathering Fr-Fresh, Sl-Slight, Mo-Moderate Se-Severe, and VS-Very Severe Fracture Spacing: VW -Very Wide (>3') Wi-Wide (1'-3'), Mo-Moderate (2"-12") Cl-Close (0 5"-2"), and VC-Very Close (<0.5") Strength: VH-Very High, Hi-High, Mo-Moderate Lo-Low Fr-Friable, and So-Soft. Lithologic Description Rock type color, texture, grain size, etc. Discontinuities Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint Me-Mechanical break Sh-Shear and Ve-Vein Joint descriptions Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth Sl-Slightly Rough, Ro-Rough, and VR-Very Rough) Aperture (Fi-Filled, He-Healed Op-Open and Ti-Tight), type and amount of infilling slickensides etc Remarks Drill water return and losses, drill water color drill cuttings, rapid or slow drilling, etc

WLA

BORING LOG

Project	Job No	Boring No.
DCPP Dry Cask Storage Facility Siting Study	WLA 1081-28	DCSF96-3

Type & Diameter of Boring	Boring Location	Total Depth
8"ø Hollow Flight Augers through overburden	Western Portion of Parking Lot 7	39.5 ft

Sampling Method	Sample Driving Hammer and Drop	Elevation @ Top of Hole
2.0" and 3.0"ø O.D. split spoon drive samplers; 3.0"ø Shelby (Pitcher) Tubes hydraulically pushed	140 lb. safety w/ 30" drop	100 ft. ±

Drilling Contractor and Rig	Date Started	Date Completed	Logged By
PC Exploration Puntell MX600	7/10/1996	7/11/1996	J. Bachhuber, P. Drouin

Uncorrected Blows per 6-inch drive	SPT N_1(60) (0 10 20 30 40 50 60)	Depth (feet)	Soil Type (USCS)	Sampler Type	Recovery (inches)	Pocket Pen. (TSF)	Description	Remarks
		0–1					3" Asphalt 6" Angular gravel baserock	
		1–2	CL-CH		bag		Silty CLAY, with some rock fragments (5%); dark brown; moist; firm to stiff; plastic; rocks are small (<1/2") and angular; (fill)	Easy augering, brown clayey cuttings
		4	CL-CH	3.0-inch Pitcher tube	14			
3 2 1	4	6–7		SPT	6	1 0-2 0	Same as above, lighter, soft	
		8					– – – ?– – – – – ?– – – – – ?– – – –	
		9	CL				Silty CLAY with some rock fragments (5-10%); black (7.5YR 3/1), organic; moist to damp; stiff; small carbonate veins; sparse black carbon flecks; severely to mod weathered, yellow-red(5YR 5/6) siltstone rocks; (fan deposit, Qhf)	
		10–11		3.0-inch Pitcher tube	12	1.5-2 0		
3 3 4	8	12–13	CL	SPT	6	1 5	Same as above	Continued easy augering
		14–15						

3.0-inch Pitcher tube sampler

Standard Penetration Test (SPT) sampler

WLA

BORING LOG

Project	Job No	Boring No
DCPP Dry Cask Storage Facility Siting Study	WLA 1081-28	DCSF96-3

Columns: Uncorrected Blows per 6-inch drive; SPT $N_1(60)$ (0 10 20 30 40 50 60); Depth (feet); Soil Type (USCS); Sampler Type; Recovery (inches); Pocket Pen. (TSF); Description; Remarks

Depth (feet)	Blows per 6-inch drive	SPT $N_1(60)$	Soil Type (USCS)	Sampler Type	Recovery (inches)	Pocket Pen. (TSF)
15–16.5			CL	3.0-inch Pitcher tube	16	2.0
16.5–18	2, 14, 18	29	CL	2.5-inch I.D. split spoon	11	>4.0
18–19.5	8, 14, 16	29		SPT	9	>4 5
20–21.5	6, 13, 44	49	CL	2.5-inch I.D. split spoon	18	4.0
21.5–23	43, 35, 17	49		SPT	14	
25–26.5	8, 19, 27	38	CL-ML	2.5-inch I.D. split spoon	16	>4 0
26.5–28	12, 17, 21	34		SPT	8	>4.0
30–31.5	10, 19, 21	32		2.5-inch I.D. split spoon	16	
31.5–32	21, 50/2"	>100		SPT	9	3.5->4.5

Depth (feet)	Description	Remarks
15–16.5	Silty black CLAY (see page 1) (Qhf)	
16.5–20	Silty CLAY with rock fragments (25%+); carbonate rich; mottled white (N8), gray (10YR 6/1), yellow (10YR 5/6); damp to moist; very stiff to hard; slightly plastic; blocky structure; (Paleosol-Carbonate)	Smooth, slow augering. Bouldery, clayey, gravelly cuttings.
20–25	Silty CLAY to weathered CLAYSTONE; uniform gray (10YR 6/1) with yellow (10YR 7/6) sulfer staining; damp to moist; very stiff to hard; slightly plastic; (completely weathered bedrock, saprolitic)	
25–29.5	Same as above. Switch from auger to rotary coring.	Smooth, slow augering
29.5–	Continued on page 3	No groundwater encountered in auger boring

Legend: 3.0-inch Pitcher tube sampler; 2.5-inch I.D. split spoon sampler; Standard Penetration Test (SPT) sampler

ROCK BORING LOG

Project: DCPP - DCSF Siting Study	Job Number: WLA 1081-28	Boring Location: West portion of parking lot 7.	Boring No: DCSF96-3
Type & Diameter of Boring: 3.5"ø HQ Wireline Coring		Drilling Method: HQ Wireline w/double-tube C. B.	Total Depth: 39.5'
Drilling Contractor and Rig: PC Exploration Puntell MX-600		Drillers: PC Exploration	Depth to Bedrock: 31.7'
Casing Size and Depth: 8"ø Hollow Stem Augers		Logged By: J. Bachhuber, P. Drouin	Date Started: 7/10/96
Length of Core Barrel and Bit: 7.6'	Borehole Inclination: vertical	Ground Water Depth: not measured	Elevation and Datum: 100'± top of hole
		No. of Core Boxes: 1	Date Completed: 7/11/96

WLA

Depth (feet)	Log	Drill Rate (min/ft)	Run No.	Recovery/Cut	% Recovery	RQD	Weathering	Fracture Spacing	Strength	Lithologic Description	Description of Discontinuities	Remarks
29.5–31.7	loss	2:25, 3:40, 2:20 (part)	1	1.3/3.5	37	0	Completely weathered	Soil	Soil	Silty CLAY; white, mottled; (Completely weathered bedrock, saprolitic)	31.7: Jo,50, Pl-Wa, Sm, JRC 2-3 FeO coating	100% circulation, light brown return water
31.7–33.0	loss	2:20, 2:00					Se-Mo	Cl-VC	Lo	SILTSTONE; gray (7.5YR 5/1); low to moderate hardness; blocky; pervasive oxidation; (bedrock unit 96-3a)		
33.0–34.5	loss	6:00, 2:21	2	0/1.5	0	0						No recovery, resent core barrel
34.5–36.4		5:15, 5:00	3	1.7/2.0	85	0	Mo	Cl-VC	Lo	SILTSTONE/SHALE; very dark gray (2.5YR 3/1); low hardness; crushed zones; (bedrock unit 96-3b)		Clear mud added to water
36.4–39.5	loss	4:45, 3:05, 6:40	3	1.0/3.0	33	0	Mo	Cl-VC	Lo	SILTSTONE; gray (2.5YR 5/1); low hardness (bedrock unit 96-3c); Silty clay shear (~39)		100% circulation, dark brown return water

BOH @ 39.5'

Groundwater level not determined in boring

Weathering: Fr-Fresh, Sl-Slight, Mo-Moderate, Se-Severe, and VS-Very Severe. Fracture Spacing: VW-Very Wide (>3'), Wi-Wide (1'-3'), Mo-Moderate (2"-12"), Cl-Close (0.5"-2"), and VC-Very Close (<0.5") Strength: VH-Very High, Hi-High, Mo-Moderate, Lo-Low, Fr-Friable, and So-Soft. Lithologic Description: Rock type, color, texture, grain size, etc. Discontinuities: Be-Bedding, Fa-Fault, Fo-Foliation, Jo-Joint, Me-Mechanical break, Sh-Shear, and Ve-Vein. Joint descriptions: Dip, Surface shape (Pl-Planar, St-Stepped, or Wa-Wavy), Roughness (Sm-Smooth, Sl-Slightly Rough, Ro-Rough, and VR-Very Rough). Aperture (Fi-Filled, He-Healed, Op-Open and Ti-Tight), type and amount of infilling, slickensides, etc. Remarks: Drill water return and losses, drill water color, drill cuttings, rapid or slow drilling, etc.

ATTACHMENT

2-4

DCPP Transport Route Ground Motions

September 13, 2002

To: R. Klimczak

From: N. Abrahamson

ITR: J. Sun

Subject: Ground Motion Along the Proposed Transport Route

A/R Number: A0564589

This letter addresses work request #1 in A/R A0564589 which asks us to determine if the 5 sets of ILP ground motion time histories developed for the DCPP ISFSI project are applicable to the complete transport route (fuel handling building to ISFSI).

Subsurface Conditions

The subsurface soil profile along the transport route is evaluated using boring information and cross sections BB′, CC′, DD′, EE′, FF′, and L-L' presented in the DCPP ISFSI SAR Section 2.6.1.9. The transport route will traverse basement rock similar to the power block and ISFSI site (T_{ofb}) and Pleistocene fan deposits (Q_{pf}) overlying Tof_b, and shale and claystone (Tof_c). Basement rocks (T_{ofb}) are encountered within a few feet on the El. 115 ft. bench east of the Auxiliary Building of the power block, under a ramp of engineered fill between the El. 115' bench to the level of Plant View Road (Stations 0+00 to 5+00), and between Stations 34+00 (Reservoir Road at Hillside Road) and 49+00 (along Reservoir Road) on the hill behind the power block and toward the end of the transport route near the ISFSI. In between, the transport route is covered by consolidated to overconsolidated Pleistocene fan deposits that consist of stiff clays with thickness varying from 0 to about 60 feet. The thickest section is near the U-turn at the southern end of the route and near Warehouse B and the firing range. The thickness of the Pleistocene fan deposits measured at the points where the transport route intersects the cross-sections are listed in Table 1.

Table 1. Thickness of Pleistocene Fan Deposits Along the Transport Route

Cross-Section	Thickness of Non-rock material
CC' (western intersection with transport route)	0 ft
DD' (western intersection with transport route)	20 ft (marine terrace deposit)
EE' (western intersection with transport route)	40 ft (marine terrace deposits or fan deposits)
FF' (projected 40 ft south)	60 ft
EE' (eastern intersection with transport route)	60 ft
DD' (eastern intersection with transport route)	20 ft
CC' (eastern intersection with transport route)	25 ft
LL'	0 ft
BB'	0 ft

The shear-wave velocity profile is a key parameter in evaluating potential amplification of ground motion. Three methods were used to evaluate the shear-wave velocity of the Pleistocene fan deposits: direct measurements of shear-wave velocities from boreholes, correlation of shear-wave velocities with blow counts, and correlation of shear-wave velocities with Gmax/Su in which Gmax represents the maximum shear modulus under small strains and Su stands for the undrained shear strength. The results of these three approaches are described below.

In-situ shear-wave velocity measurements were made in borehole WLA 96-4 using conventional downhole method (Redpath, 1996). The measured shear-wave velocity was 1,075 ft/sec for the Pleistocene fan deposits.

At parking lot 7, standard penetration test blowcounts were measured in the Pleistocene fan deposits which is comprised mostly of stiff clays (WLA, 1996a). The median SPT blowcounts for this material is 32. Using the empirical correlation developed by Seed et al., (1983), Vs (ft/sec) =185 $N_1^{1/2}$, the shear-wave velocity for a blowcount of 32 is 1,050 ft/sec.

The median undrained shear strength was measured from samples of the Pleistocene fan deposits located on the hill slope behind the power block (HML, 1968, and HLA 1973). The median undrained shear strength was found to be between 3,000 to 3,500 psf. Based on the empirical correlation of Egan and Ebeling. 1985, Gmax/Su is 1,500 to 2,000. Using this correlation, the estimated shear-wave velocity of the fan deposit is estimated to be between 1,200 to 1,300 ft/sec.

Based on the velocity measurements and estimates described above, the shear-wave velocity of the Pleistocene fan deposits ranges from 1,050-1,300 ft/sec.

Site Classification for Ground Motion

In developing ground motion attenuation relations, the observed ground motion data are typically divided into broad site categories such as "rock" and "soil". The main separation is between deep soil sites and rock/shallow soil sites. (The shallow soil excludes soft-soil sites). The LTSP spectrum (PG&E, 1988) is based on "rock" and "rock-like" sites. The term "rock-like" refers to weathered rock and shallow stiff soil sites.

The LTSP ground motion study was conducted by Geomatrix. Subsequent to the LTSP, Geomatrix has developed a more formal site classification scheme that quantifies shallow soil sites. This classification scheme is listed in Abrahamson and Silva (1997). In this scheme, site class A, called rock, corresponds to sites with less than 6 m of soil and site class B, called shallow soil, corresponds to sites with between 6 and 20 m of soil or weathered rock. The LTSP term "rock-like" corresponds to Geomatrix site class B. Since the thickest Pleistocene fan deposit along the transport route is 60 ft all of the transport route is considered to be Geomatrix class A or class B. That is, all of the transport route would be classified as either rock or rock-like. Therefore, the site response effects for shallow soil are already included in the standard deviation of the LTSP attenuation relation which combined ground motions from rock and rock-like site conditions.

The shear-wave velocity profiles of sites classified as either Geomatrix class A or Geomatrix class B which have been used in developing attenuation relations are summarized in Figure 1. This figure shows the median, 16^{th},and 84^{th} percentile shear-wave profile for rock and rock-like (class A and class B) sites. Also shown on this figure is the range of velocities and depths for the Pleistocene fan deposits along the transport route and one downhole measurement in Parking Lot 7 in close proximity to the transport route. The velocities from the Pleistocene fan deposits are consistent with the velocity profiles measured at rock and rock-like sites.

Conclusions

Based on the thickness and velocities of the Pleistocene fan deposits along the transport route, the entire transport route falls into rock and rock-like site category. Therefore, the LTSP spectrum, which is applicable to both rock and rock-like sites, is applicable to the entire transport route. Since the ILP spectrum envelops the LTSP spectrum, it is also applicable to the entire transport route.

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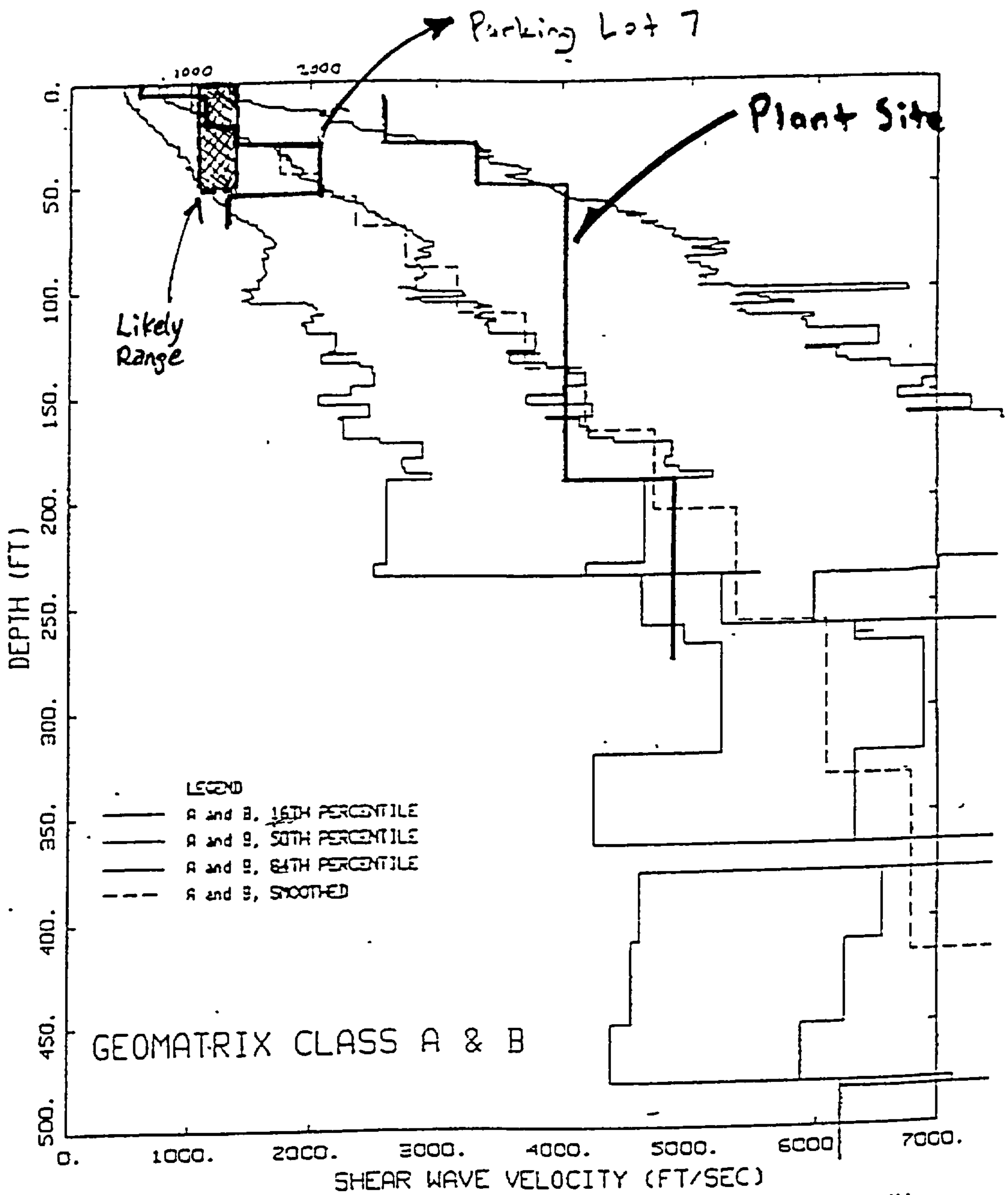

Figure 1 Comparison of Rock and Rock-like Shear wave velocity Profiles with Pleistocene Deposits Velocity Profile along Transport Route