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PG&E Letter HIL-05-007

U.S. Nuclear Regulatory Commission
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
Washington, DC 20555-0001

ATTN: Document Control Desk

Docket No. 72-27

Humboldt Bay Independent Spent Fuel Storage Installation
Response to NRC Request for Additional Information for the Humboldt Bay
Independent Spent Fuel Storage Installation Application (TAC NO. L23683)

Dear Commissioners and Staff:

On December 15, 2003, Pacific Gas and Electric Company (PG&E) submitted an application to the Nuclear Regulatory Commission (NRC), in PG&E Letter HIL-03-001, requesting a site-specific license for an Independent Spent Fuel Storage Installation (ISFSI) at the Humboldt Bay Power Plant (HBPP) site to store the HBPP Unit 3 spent nuclear fuel. The application included a Safety Analysis Report, Environmental Report, and other required documents in accordance with 10 CFR 72.

By letter dated July 22, 2004, the NRC staff requested additional information needed to continue their review of the Humboldt Bay ISFSI License Application. PG&E responded to the NRC's request for additional information in PG&E Letter HIL-04-007, dated October 1, 2004. As part of the NRC review of the responses, additional NRC questions were raised concerning structural issues, thermal issues, and greater than class C waste. PG&E provided a partial response to the additional NRC questions in PG&E Letter HIL-05-003, dated April 8, 2005.

Enclosed is PG&E's response to NRC questions 5-4 and 15-6 as committed to in PG&E Letter HIL-05-003.

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If you have any questions regarding this response, please contact Mr. Terence Grebel at (805) 545-4160.

Sincerely,

A handwritten signature in black ink, appearing to read 'Donna Jacobs', written over the printed name.

Donna Jacobs
Vice President Nuclear Services

emb/3522

Enclosure

cc: PG Fossil Gen HBPP Humboldt Distribution
cc/enc: James R. Hall

**PG&E Response to Request for Additional Information
Humboldt Bay Independent Spent Fuel Storage Installation (ISFSI)
License Application**

Question 5-4

The seismic analysis of the RC vault does not consider potential amplifications of acceleration forces due to soil-structure interaction, SSI (Holtec International 2003b, HI-2033013). Staff concurs that the storage vault structure can be considered "rigid" but that the response of this "rigid" structure on the supporting soil (soil-vault-cask system) has frequencies in the amplified region of the uniform hazard spectra (UHS) provided by PG&E (SAR).

In its response to RAI 5.4 (PG&E, 2004b), PG&E utilizes available literature, mainly Stewart et al (1998), to claim that the amplifications of accelerations due to SSI are not feasible, or that several factors may mitigate their impact on the response. PG&E sources, however, only provide statistical information derived from structural systems identification. The geometry of the storage vault, as well as the soil conditions and the extreme earthquake hazards of the HB site, include particularities that cannot be addressed based on general trends presented in Stewart et al (1998). Nevertheless, NRC staff agrees with PG&E in that some factors may mitigate the potential of amplifications of accelerations, particularly, the fact that the soil surrounding the vault will provide confinement in the horizontal direction. The top of the vault, however, is not restrained and the soil embedment effect does not take place in the vertical direction, which according to the UHS (SAR) is the direction with the largest spectral accelerations. Thus, NRC considers that PG&E still has to address the potential of amplifications in, at least, the vertical direction. The applicant has several options:

- i) show quantitatively that amplifications are not feasible based on PG&E UHS and the vibrational periods of the soil-vault-cask system*
- ii) carry out the pseudo-static seismic analysis using spectral accelerations of PG&E UHS corresponding to the estimated first natural periods of vibration of the soil-vault-cask system (considering reasonable uncertainties). The analysis should also address the dynamic response of partially loaded RC vault, which will lead to non-uniform mass distribution. The vault-cask interaction analysis (Holtec International, 2003c; HI-2033014) should also be based on the above spectral accelerations.*
- iii) perform a dynamic seismic analysis including SSI for the soil-vault-cask system.*

Any of these options will satisfy 10 CFR 72.122(b)

PG&E Response to Question 5-4

As stated in the Humboldt Bay ISFSI Safety Analysis Report (SAR), Section 4.5.2, the vault structure is important to safety for protection against sliding and tip-over in a design basis seismic event, and it also provides protection from missiles. This was done as part of PG&E's defense-in-depth approach to the ISFSI design. The HI-STAR 100 system has been certified under 10 CFR 71 and 10 CFR 72 by the NRC as a storage and transportation cask and the HI-STAR 100 system is designed for seismic, missiles, etc. The HB ISFSI vault provides a shielding function for normal storage conditions to maintain annual exposure to the public less than 25 mr/yr. The vault has the practical purpose to maintain the overpacks in an easily storable, monitorable, and retrievable condition.

There is no failure mode of the storage vault that could compromise the integrity of the overpack. The vault is conservatively designed to provide confidence that the overpacks will remain easily retrievable after a seismic event. Should the vault or vault lid fail, the only consequence would be additional dose at the site boundary, but this would remain well within the 10 CFR 72.106 accident dose limits and could be mitigated by the use of temporary shielding. As seen in Holtec Report HI-2033047, Table 1, the bulk contact dose rate is less than 10 mr/hr and this reduces to 5.1 mr/hr at a distance of 1 meter. Even if the entire Holtite neutron shielding is lost (not considered credible from a seismic event) the dose rate is 123 mr/hr on contact and 45 mr/hr at 1 meter. This allows adequate time to maintain control of the 100-meter zone to limit dose to the public.

PG&E believes that even if the soil-structure interaction (SSI) effects were to result in vertical amplification, the amplified value required to impose a rigid-body deceleration in excess of 60 g on the HI-STAR HB would not be a credible event at the HB ISFSI site. However, as suggested by the NRC staff, a supplemental cask dynamic analysis was performed using a vertical amplification to establish an amplified limit where the postulated cask impact causes impact decelerations to exceed the design basis limit of 60 g. The supplemental SSI evaluation was docketed as Appendix E of Holtec Report HI-2033014, Revision 1 in PG&E Letter HIL-05-004, dated April 15, 2005. A summary of this evaluation follows.

The dynamic model of the HI-STAR HB, used in the main body of Holtec Report HI-2033014 to determine the impact forces imposed on the vault, was reevaluated with the vertical input time history amplified by 2, 3, 5, and 10. The horizontal input time histories are not altered. Seismic event DBE3 is used as the input time history, as that produced the maximum impact load in the vertical direction (refer to Holtec Report HI-2033014, page 18). The seismic event has a 40-second duration. Simulations were performed to a time that exceeded the point where maximum decelerations of the cask were obtained (approximately 23 seconds). Other than imposing an amplifier on the vertical seismic event, no other model modifications were made. For each simulation, the net acceleration of the top lid of the cask was tracked and the maximum net

acceleration recorded. The analysis did not preclude amplification of a horizontal response caused by the amplified vertical seismic event. The following table summarizes the results from the supplemental dynamic simulations:

Imposed Vertical Seismic Amplifier	Maximum Net Deceleration of HI-STAR HB Lid (g)
2	14.57
3	21.04
5	32.05
10	62.37

Based on the results of the supplemental dynamic simulations, the HI-STAR HB can withstand a postulated SSI induced amplification of its imposed vertical time history to a value of approximately 9.5 without exceeding its design basis deceleration limit. This magnitude of amplification as a result of SSI effects is not credible at the HB ISFSI site.

The maximum vertical excursion of the cask relative to the surrounding structure was determined to be 1.9 inches, and all the amplified inputs result in a vertical excursion that exceeds the cask-to-vault lid clearance, which suggests that the cask would impact the vault lid and likely lead to overstress of the lid bolts. Since maximum cask accelerations under this hypothetical amplified vertical seismic input occur if the cask is allowed to move freely within the vault, any restraint provided by the vault lid will serve to reduce the deceleration levels computed above. As stated above, the lid is only required for shielding purposes, and after any accident of this magnitude, temporary shielding could be emplaced prior to reaching any 10 CFR 100 limits.

It should be noted, SAR Section 8.2.1.2.4.1, and Holtec Report HI-2033014, Revision 0, indicate that the maximum cask deceleration was 37.1 g. Upon further evaluation, it was determined that this deceleration response (reported in data shown in Holtec Report HI-2033014, Figure 7) occurred at time equal to 0 sec and is a spurious response caused by a slight initial interpenetration of the cask lid into the adjacent body. If this spurious value at time zero is disregarded, then the maximum deceleration is well below 37.1 g. Holtec Report HI-2033014, Revision 1, corrects this result, and was submitted to the NRC in PG&E Letter HIL-05-004, dated April 15, 2005. SAR Section 8.2.1.2.4.1 will also be revised to correct this value.

In order to clarify the important to safety (ITS) classification of the vault lid and lid closure bolts, SAR, Section 3.2.4, "Storage Vault Structural Analyses (Storage Mode)," Amendment 1, will be revised to read as follows:

In accordance with 10 CFR 72.103, the licensing basis Design Earthquake (DE) for the ISFSI storage vault structural analyses is a probabilistically developed uniform hazard spectrum (UHS) with a 2000-year return period (probability of exceeding the DE is $5E-4$ /yr). To provide additional margin, the ISFSI was analyzed to withstand a

deterministically developed seismic spectra (see Figure 2.6-72) that exceeds the 2000-year return period UHS at all spectral periods.

Although not part of the Humboldt Bay ISFSI design basis, PG&E performed a supplementary evaluation to determine the potential amplifications of acceleration forces on the cask due to soil-structure interaction (SSI). The details of this supplementary evaluation, which are provided in PG&E response to NRC Question 5-4 contained in PG&E Letter HIL-05-007, dated June 3, 2005 (Reference 11), concluded the following:

There is no failure mode of the storage vault that could compromise the integrity of the overpack. The vault is conservatively designed to provide confidence that the overpacks will remain easily retrievable after a seismic event. Should the vault fail, the only consequence would be additional dose at the site boundary, but this would remain well within the 10 CFR 72.106 accident dose limits and could be mitigated by the use of temporary shielding.

Based on the results of the supplemental evaluation, the HI-STAR HB can withstand an amplification of its imposed vertical time history to a value of approximately 9.5 without exceeding its design basis deceleration limit. This magnitude of amplification as a result of SSI effects is not credible at the HB ISFSI site.

The maximum vertical excursion of the cask relative to the surrounding structure is determined to result in a vertical excursion that exceeds the cask-to-vault lid clearance, which suggests that the cask would impact the vault lid and likely lead to overstress of the lid bolts. Since maximum cask accelerations under this hypothetical amplified vertical seismic input occur if the cask is allowed to move freely within the vault, any restraint provided by the vault lid will serve to reduce the deceleration levels computed above.

Based on the above evaluation and documentation provided in Reference 11, it is concluded that the ISFSI Vault lid and lid closure bolts are classified as ITS Category B, except for beyond design seismic events involving SSI, which results in vertical acceleration causing vault lid impacts. For these postulated SSI seismic events, the ISFSI Vault lid and lid closure bolts are classified as NITS since they are not relied upon in the seismic design basis accident analysis. As stated above, for these postulated SSI seismic events the lid is only required for shielding purposes, and after any accident of this magnitude, temporary shielding could be emplaced prior to reaching any 10 CFR 100 limits.

SAR Table 4.5-2 will be revised as indicated below to reflect the ITS classification of the vault lid and lid closure bolts.

IMPORTANT TO SAFETY ^(a)	NOT IMPORTANT TO SAFETY
<p>CLASSIFICATION CATEGORY A</p> <p>MULTI-PURPOSE CANISTER FUEL BASKET AND BASKET SPACERS DAMAGED FUEL CONTAINER HI-STAR 100 HB OVERPACK CASK TRANSPORTER^(b) TRANSPORTER LIFT LINKS</p> <p>CLASSIFICATION CATEGORY B</p> <p>ISFSI STORAGE VAULT^(c) FUEL SPACERS TRANSPORTER CONNECTOR PINS HELIUM FILL GAS^(b) LID RETENTION DEVICE</p> <p>CLASSIFICATION CATEGORY C</p>	<p>SECURITY SYSTEMS FENCING LIGHTING ELECTRICAL POWER COMMUNICATIONS SYSTEMS AUTOMATED WELDING SYSTEM (AWS) MPC FORCED HELIUM DEHYDRATION SYSTEM OVERPACK VACUUM DRYING SYSTEM RAIL DOLLY</p>

- (a) Major cask system components are listed according to the highest QA category of any subcomponent comprising the major component. The safety classification of the subcomponents and the determination of the ITS category of each item is administratively controlled by PG&E via design and procurement control procedures with input from the storage cask vendor.
- (b) Purchased commercial grade and qualified by testing prior to use.
- (c) ISFSI Storage Vault lid and lid closure bolts are classified as ITS Category B except for beyond design basis soil structure interaction seismic events. For these postulated SSI seismic events, the ISFSI Storage Vault lid and lid closure bolts are classified as NITS since they are not relied upon in the seismic accident analysis. Refer to SAR, Section 3.2.4, and PG&E Letter HIL-05-007, dated June 3, 2005, for details of the classification.

Additional question from NRC staff on April 11, 2005:

The applicant has substituted a soil-structure-interaction (SSI) analysis of the soil-cask-vault system by directly increasing the magnitude of the vertical ground motion input. The staff considers that this approach provides reasonable confidence for establishing structural integrity of the vault.

The applicant has reevaluated the dynamic model of the HI-STAR HB cask-vault system using vertical input time history amplified by factors of 2, 3, 5, and 10. The horizontal input time histories are not altered. Based on uniform hazard spectra (UHS) provided by the applicant in Chapter 2 of the SAR (Figures 2.6-66 to 2.6-72), the peak spectral acceleration (Sa) is 3-4 times larger than the corresponding peak ground acceleration (PGA) for the deterministic and the 2000-year probabilistic UHS. Therefore, the staff considers that the amplification range provided by the applicant is satisfactory. There are additional sources of conservatism that enhance the staff's confidence with respect to the applicant's analysis.

The applicant has used seismic event DBE3 as the input time history for the reevaluation of the dynamic analyses, claiming that this event produced the maximum impact load in the vertical direction. The staff's review of the revised report HI-2033014 indicates that the applicant needs to provide additional clarification, as follows:

The staff considers that if only one DBE is used for the reevaluation, it should correspond to the ground motion that produces the maximum resultant impact load, instead of the maximum vertical impact load. Studies of dynamic impact on fuel assemblies indicate that bending (caused by lateral impact) and not axial failure controls the performance of these components (Chun et al, 1987). The staff has reviewed the resulting decelerations under the original ground motion events (Figures 5 thru 12 in Holtec report HI-2033014). The justification presented by the applicant for selecting DBE-3 is not consistent with the information of HI-2033014. For instance, Figures 7 and 9 of this report indicate that the maximum acceleration of the top restraint in the vertical ("Az") direction is larger for DBE-2 ($1690 \text{ in/sec}^2 = 4.4 \text{ g's}$) than for DBE-3 ($926.5 \text{ in/sec}^2 = 2.4 \text{ g's}$). Also, the maximum resultant acceleration at the top restraint is larger for DBE-2 than for DBE-3. The staff acknowledges that some of these accelerations may correspond to the spurious large decelerations at the beginning of time history. However, Figures 5 thru 12 of HI-2033014, indicate that the maximum decelerations (or contact forces) do not take place at the beginning of the time history, but always close to the peak ground acceleration. Therefore, the staff needs a clarification for using DBE-3, rather than DBE-2 as the basis for the analyses of Appendix E of HI-2033014.

PG&E Response to additional question of April 11, 2005

The Staff has questioned the use of the seismic event DBE3 instead of DBE2 as the input seismic event for the evaluation of the effect of increased vertical earthquake. The NRC suggested that the net acceleration experienced by the cask would be a more appropriate measure of the "bounding" seismic event rather than the maximum vertical impact force at the base of the vault, which was the measure used by the applicant to justify the use of DBE3 in the study.

To address this question, the archived results for both the DBE2 and the DBE3 events were exported to an Excel spreadsheet and the net acceleration, defined as:

$$\text{Net A} = (A_X^2 + A_Y^2 + A_Z^2)^{1/2}$$

computed and plotted over the strong motion duration of both events. Figures 1 and 2 to this response present the results obtained at the base of the cask for the DBE2 and DBE3 event, respectively. Figures 3 and 4 to this response present the results at the top of the cask. The largest magnitude of the net acceleration is found at the base of the cask for the DBE3 event. The net accelerations at the top of the cask for both events were significantly lower, although the DBE2 event gave a peak value that did exceed the peak for the DBE3 event.

From the results of the evaluation, if the largest magnitude of the net acceleration is used as the criterion to define the "bounding" event for the study investigating the effect of vertical amplification, then the DBE3 seismic event is the proper event to provide the input for the study. Using as a criterion either the maximum net acceleration of the cask, or the maximum impact load at the base, results in the DBE3 seismic event as being the "most limiting event". Thus, the submitted results using the DBE3 event are appropriate for the dynamic simulations performed to respond to the RAI question of the effect of amplification of the vertical seismic event.

Base of HI-STAR Net Accel, DBE2

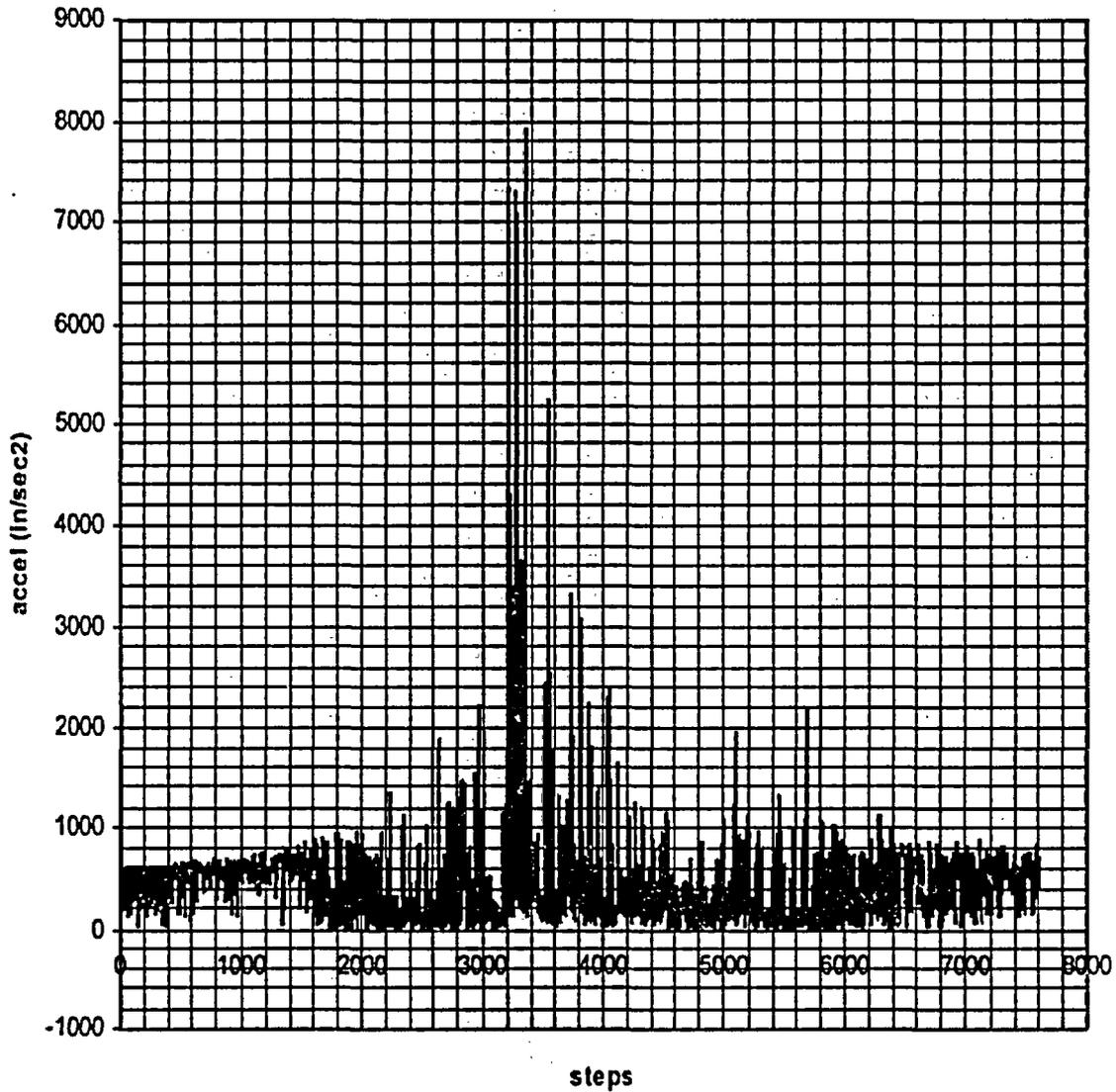


FIGURE 1:
NET ACCELERATION AT BASE OF HI-STAR HB USING DBE2

Net Accel at HI-STAR Base - DBE3

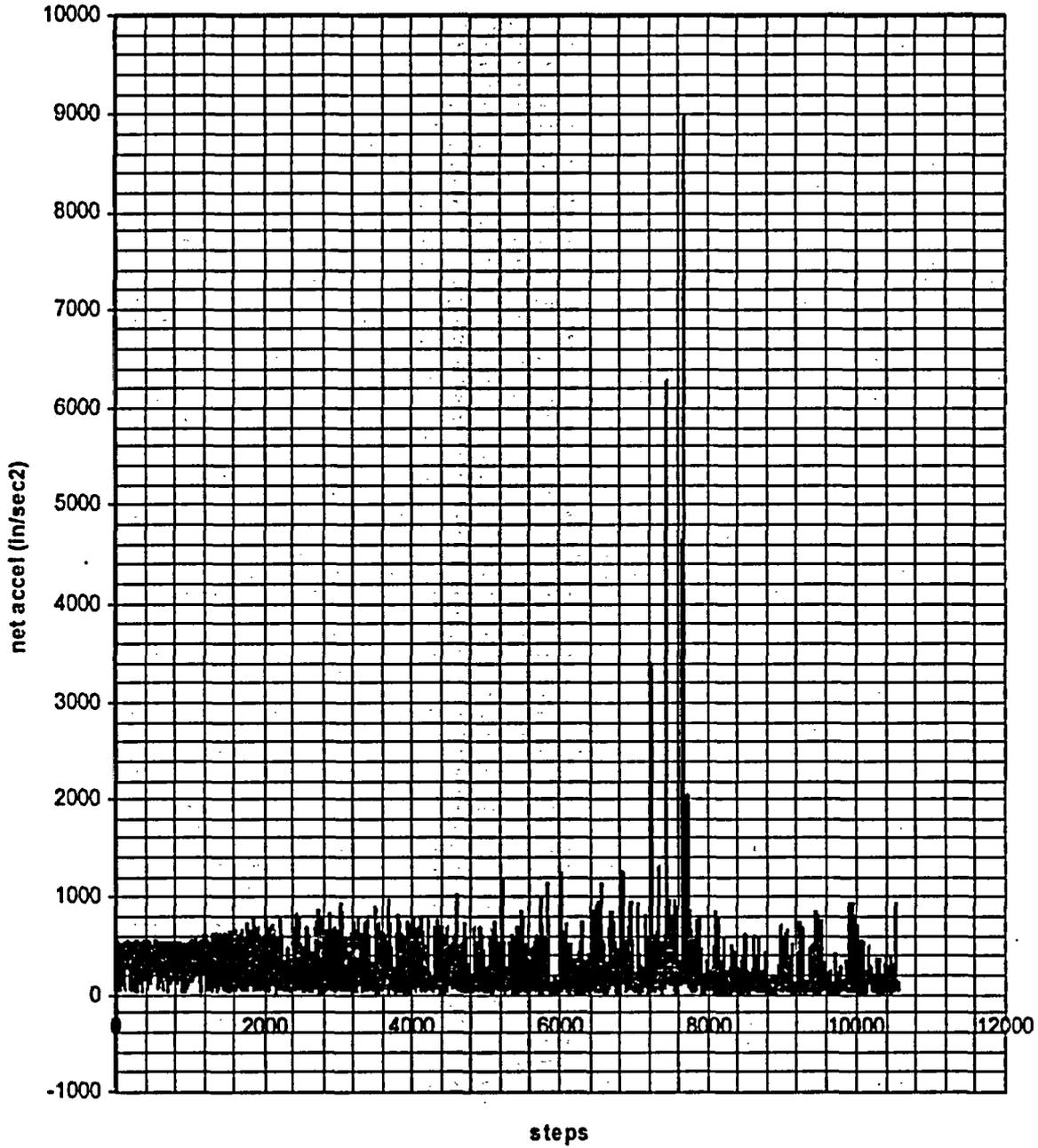


FIGURE 2:
NET ACCELERATION AT BASE OF HI-STAR HB USING DBE3

Net Top of Restraint Accel -dbe2

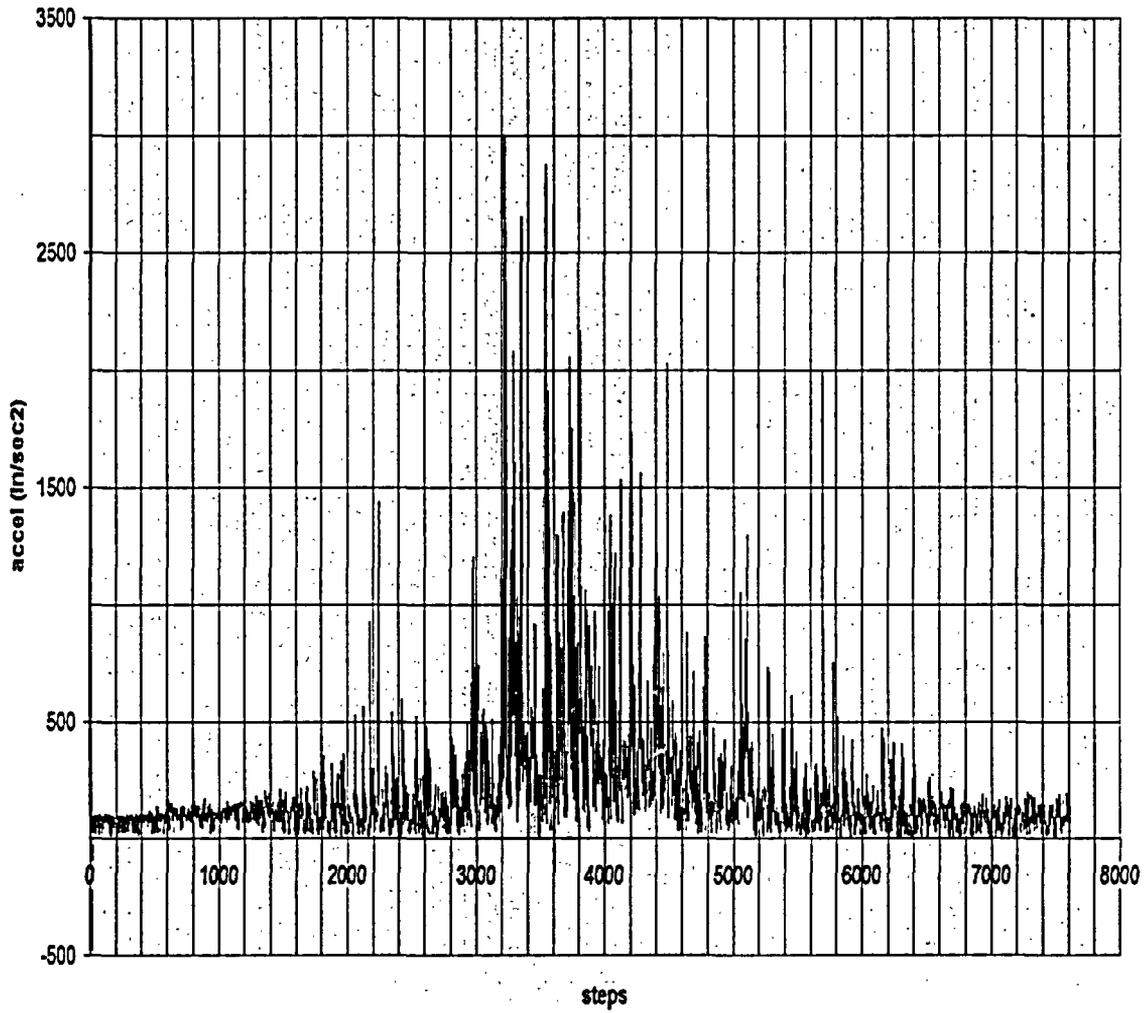


FIGURE 3:
NET ACCELERATION AT TOP LID OF HI-STAR HB USING DBE2

Top of H-STAR Accel - DBE3

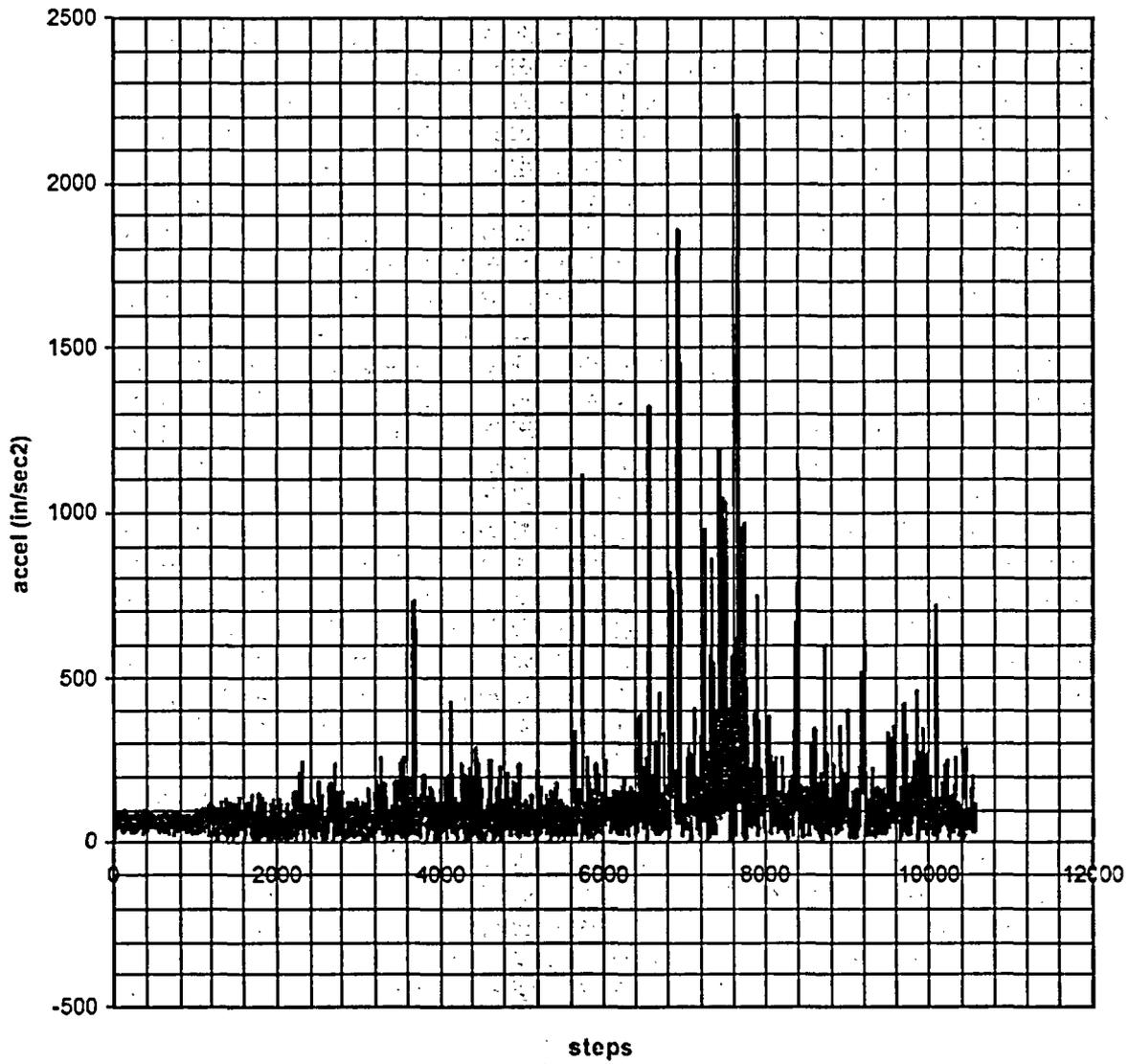


FIGURE 4:
NET ACCELERATION AT TOP LID OF HI-STAR HB USING DBE3

Revised Question 15-6

Provide adequate basis for assuming 95 percent of the aircraft approaching or departing Eureka-Arcata Airport would use the V 607 route and need not be considered in estimating the crash hazard frequency. Alternatively, provide an estimated annual crash frequency of aircraft using the airway V 607.

Basis for this assumption, as given in Calculation File PRA-03-14, revision 1, is that all commercial aircraft currently are required to fly ILR flight plans. This would bring them on V 607 because of the instrument landing capabilities. However, as stated in Calculation File PRA-03-14, revision 1, general aviation and military aircraft flights are less regulated. Consequently, they may not always use V 607 airway. <http://airnav.com/airports/kcav> show that on average 207 daily operations take place at Eureka-Arcata Airport. Out of these, 83 percent or 172 operations are by general aviation and military aircraft. Calculation File PRA-03-14, revision 1, has estimated the daily traffic on air corridor V 607 to be approximately 207 flights as V 607 is the main approach corridor for flights into the Eureka-Arcata Airport. Therefore, it has not been established that the assumption of 95 percent of the daily flights will use the airway V 607, as they are commercial aircraft, is conservative. It is not clear what would be the estimated number of flights in V 607 and other secondary approach and departure patterns.

Additionally, Section 3.5.1.6 of NUREG-0800 provides three proximity criteria to determine by inspection whether the annual crash hazard to a given site is less than 10^{-7} if the site meets all three criteria; otherwise, a detailed review of aircraft hazards must be performed. Note that NUREG-0800 provides a quick way to estimate whether the annual crash hazard to a particular site is below 10^{-7} or not. It does not state that the hazard is zero and need not be considered further in estimating the cumulative crash hazard. This is also true for other flights activities assumed to zero based on NUREG-0800 proximity criteria.

PG&E Response to Revised Question 15-6

Based on a telephone conversation with the NRC staff on April 20, 2005, PG&E was informed that the response to the previous NRC Question 15-6, which was provided in HIL 04-007, dated October 1, 2004, was adequate, and no further response was required by PG&E.