ADEQUACY OF SEISMIC MARGINS ASSUMING AN INCREASE IN AMPLITUDE OF THE DIABLO CANYON LONG TERM SEISMIC PROGRAM VERTICAL GROUND MOTION IN THE FREQUENCY RANGE FROM 2 TO 10 HERTZ

May 1991

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As mentioned in an NRC meeting summary dated March 22, 1991 and later requested verbally, following is a discussion of the effects on Plant structures and equipment of an assumed increase of 15 percent in the amplitude of the Long Term Seismic Program 84th-percentile site-specific vertical ground motion spectrum (PG&E, 1988) in the frequency range from 2 to 10 hertz.

STRUCTURES

The structures that could potentially be affected by an increase in the vertical ground motion amplitudes in the frequency range from 2 to 10 hertz are typically the roof and floor systems supported by structural steel beams and trusses, and some overhead cranes. At Diablo Canyon, these structures include the pipeway structure, overhead bridge cranes, and other roof and floor framing systems.

In the seismic evaluation of nuclear power plant structures, it is typically found that the effects of vertical seismic excitation are small compared with the horizontal ground motion effects, except for parts of structures such as floor beams and slabs. This is because the vertical load-carrying system of a structure usually is designed for dead and live loads, and vertical ground motion effects are minimized by the square-root-of-sum-of-squares or the 100/40/40 earthquake component combination methods. A large margin against vertical seismic loading results from the fact that structures must be designed conservatively to resist the effects of vertical dead and live loads in all cases, including a major seismic event. The full value of live load occurs so infrequently that it is highly unlikely it will occur concurrent with a major seismic event. In addition, vertical load-carrying elements such as beams and floor slabs are usually controlled by ductile bending behavior, which is accompanied by a large inelastic energy absorption capability.

As noted in our previous response on the effects of increased horizontal ground motion (April 1991), steel structures have an inherent ability to resist high seismic loading with no major structural failure, as evidenced by the performance of steel structures during past earthquakes. This is due to the inelastic energy absorption capability and redundancy of steel structures, factors that are normally not considered in the design process. The structures noted above were evaluated for load combinations including vertical Hosgri earthquake ground motions, and adequate seismic margins were obtained for each structure. These seismic margins will remain adequate for an assumed level of ground motion that is 15 percent higher than the 84th-percentile site-specific vertical input motion in the 2 to 10 hertz frequency range.

The pipeway structure is a steel structure designed to resist large loads due to pipe support and rupture restraint reactions, as well as seismic demands. Because postulated pipe rupture loads far exceed seismic loads, an increase in the vertical ground motion of 15 percent will have an insignificant effect on the seismic margin for the pipeway structure. The structure will continue to have a substantial seismic margin.

The responses of overhead cranes, such as the fuel-handling and turbine-building bridge cranes, are dominated by vertical input motions. We evaluated the fuel-handling bridge crane as part of our additional deterministic studies (Response to Question DE 7, September 1990). These studies demonstrated a large margin for the crane in the loaded condition, even though a very conservative lifted load equal to its rated capacity was used. In the unloaded condition, a very large margin against uplift also was demonstrated, because of the large input energy required to uplift the massive crane structure.

Other overhead cranes will have similar characteristics; therefore, the cranes would continue to have substantial seismic margins assuming an increase of 15 percent in the vertical ground motion.

EQUIPMENT

For those cases where the vertical fundamental frequencies of flexible floor slabs within structures are in the frequency range of 2 to 10 hertz, the postulated increase in vertical ground motion results in a new response spectrum against which we must assess the seismic margins of equipment supported on these floors. Also, any equipment or components within equipment having fundamental vertical frequencies in the 2 to 10 hertz range may also be affected by this postulated increase. The capacity of equipment is governed by two modes: structural failure, or relay chatter.

Structural Failure Mode

Past evaluations of numerous nuclear power plants have shown that horizontal excitation generally dominates the seismic response of typical plant equipment; the contribution of vertical excitation is generally small. This is because the effect of (1) the square-root-of-sum-of-squares or the 100/40/40 earthquake component combination methods minimizes the vertical contribution in fragility calculations, (2) vertical frequencies of equipment tend to be higher than the dominant frequencies of the vertical floor response spectra, and (3) the effect of dead weight usually must be overcome before the equipment is subjected to a harmful stress condition.

In Appendix D of our Response to Question 2d (January 1989), we described the procedure for the development of vertical floor response spectra used in the seismic fragility evaluation of essential equipment at the Diablo Canyon Power Plant. The vertical frequencies of all essential equipment were presented, as well as a list of components for which the seismic response due to vertical excitation exceeded 30 percent of the total seismic response. Only six components had failure modes in which the vertical contribution to overall seismic response exceeded 30 percent. Of these, none had vertical fundamental frequencies of 10 hertz or less. Therefore, based on structural failure mode considerations, essential equipment will continue to have substantial seismic margins.

Relay Chatter

Relay chatter usually occurs in the frequency range between 4 and 16 hertz. Of all the relays located in essential equipment in the Plant, only the following are sensitive primarily to the vertical excitation:

Manufacturer/Model	Location
Agastat E7012	Diesel Generator Control Panel
Agastat E7012	4.16 kV Switchgear
Westinghouse OT2 (switch)	Main Control Boards
Cutter-Hammer 10250T (switch)	Hot Shutdown Panel
General Electric IAC53	4.16 Kv Switchgear

The Agastat E7012 timing relays have a very high seismic capacity against chatter and do not control the functional failure mode of either the diesel generator control panel or the 4.16 Kv switchgear. Thus, an assumed increase of 15 percent in the vertical input would not affect the fragility estimate or the corresponding seismic margin.

The OT2 and 10250T switches are push-button type switches fitted with standard selector switch operators. The fundamental frequencies of the internal parts of these switches are greater than 10 hertz and, therefore, the switches will not be sensitive to an amplitude increase in the frequency range between 2 and 10 hertz.

The GE IAC53 relay installed in the 4.16 Kv switchgear is susceptible to chatter at frequencies near the vertical floor response spectrum peak frequency of approximately 7 hertz. Thus, a 15-percent increase in the vertical spectral acceleration in the frequency range between 2 and 10 hertz would result in a corresponding reduction in the fragility estimate governed by the relay chatter failure mode of the 4.16 Kv switchgear. However, the consequences of this relay chatter failure mode (lockout of the 4.16 Kv breakers) are recoverable by operator action. Therefore, the postulated vertical acceleration exceedance will not alter the Plant seismic margin.

REFERENCES

Pacific Gas and Electric Company, 1988, Final report of the Diablo Canyon Long Term Seismic Program, U. S. Nuclear Regulatory Commission, Docket Nos. 50-275 and 50-323.