UNITED STATES OF AMERICA

NUCELAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In The Matter Of: PACIFIC GAS AND ELECTRIC COMPANY (Diablo Canyon Nuclear Power Plant Units 1 and 2)	))))))	Docket Nos. 50-275(OL) 50-323(OL)

AFFADAVIT OF JAMES NEIL BRUNE

STATE OF CALIFORNIA)
) ss.
COUNTY OF SAN DIEGO)

JAMES N. BRUNE, being of legal age and duly sworn, deposes and says as follows:

1. I am Professor of Geophysics at the University of California at San Diego. My educational background includes a Bachelor of Science degree in Geological Engineering from the University of Nevada and a Ph.D. in Seismology from Columbia University. I have carried out a number of studies relating to earthquake source mechanism and strong motion in recent years. Currently I am conducting a study of the strong motion records resulting from the October 15, 1979 Imperial Valley earthquake. My study of the strong motion data resulting from the Imperial Valley earthquake is being funded by a grant from the National Science Foundation. Hence, I am very familiar with current and previous investigations of

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earthquake source mechanisms and strong motion data. My qualifications, experience, and a list of publications are described in detail in an attachment to the testimony I presented to the Atomic Safety and Licensing Board during the Diablo Canyon seismic hearings in January, 1979.

2. The purpose of my affidavit is to discuss the recent USGS Open File Report 81-365. This report attempts to define the mean and standard deviation for observed values of peak horizontal ground acceleration. To obtain estimates for large magnitudes at short distance (e.g., M $\sim$ 7.5 at distances less than 10 km) the authors had to extrapolate beyond the data base, and thus the results "should be treated with caution" (p. 15). The situation could be remedied to a certain extent if we could confidently establish some rules for extrapolating from data at lower magnitudes and larger distances, using either hypothesized shapes of extrapolation curves or theoretical and numerical calculations. At present, different investigators can get quite different answers using what appear to be reasonable assumptions.

Data Base and Standard Deviations

3. Because the IV79 earthquake is the only earthquake of magnitude greater than 6 for which there are a number of stations within 10 km of the rupture surface, there is a tendency to rely heavily upon its data. However, we have no basis for saying it is typical or that its mean accelerations are typical. In particular, there is no basis for assuming that the standard deviations estimated on the basis of our present data set represents the standard deviation of a population of different earthquakes of magnitude near 7.5 at distances near 10 km. At close distances we may find the standard deviation for a population of data from numerous earthquakes,

with different stress drop and rupture characteristics, to be considerable greater than the standard deviation of multiple observations of a single earthquake, or our present data set for only a few earthquakes, especially when most of the data is at larger distances. This could be particularly true if large earthquakes are characterized by a complex rupture process with large, high stress drop asperities, as many recent studies suggest. For this reason, I feel that the actual standard deviations could end up considerably greater than present estimates.

Magnitude "Saturation"

4. Magnitude saturation is often based on the assumption that the slip, stress drop, and energy release on a particular section of the fault near a site, assumed to control the strong motion, will not change with magnitude, i.e., that larger magnitudes will be associated only with longer rupture lengths and that the additional energy release from distant parts of the fault will not significantly change the strong motion near the site. However, it is well known that the amount of displacement on a fault increases with fault length, and magnitude, up to magnitudes greater than 7.5. For example, Slemmons' (1977) compilation of North America data indicates maximum surface fault slip of .57 m for an M = 6.5 earthquake and 5.74 m for an M = 7.5 earthquake. Scholz (1981) (attached) has cast this result in terms of stress drop and fault slip as a function of fault length and moment (for strike slip earthquakes; ~10 bars for M = 6.5 and ~50 bars for M = 7.5) (see Scholz, Figure 1). This data indicates that the amount of energy released on a given section of a fault (e.g., ±20 km from a given point) has a clear increase with magnitude. Thus, the amount of seismic energy a structure such as Diablo Canyon would be exposed to would increase with magnitude.

However, the rate at which peak acceleration increases with magnitude depends on the details and coherence of the pattern of energy release.

5. A recent Hanks and McGuire (1981) study has superceded the previous Hanks and Johnson (1979) study, often cited in discussions of magnitude saturation. Hanks and McGuire (1981) studied more than 300 horizontal components of ground acceleration from recent earthquakes and obtained the following result for the increase in average peak acceleration with magnitude: $\log a_{max} \sim 0.30\,M$ for $4 \leq M = M_L \leq 6.5$, "remarkably close to that recently determined empirically by Joyner *et al.*, (1981) for $5.0 \leq M \leq 7.7$, their coefficient on M (moment magnitude) being 0.28 ± 0.04." Thus, in the magnitude range 5.5 to 6.5 there is no longer any indication of "saturation.".

6. As Scholz (1981) has pointed out, the dependence of high frequency energy release per unit fault length with increasing fault length (and magnitude) depends on the mechanism causing the increase in fault displacement with fault length (and magnitude) and this is not understood at present. Thus, one cannot confidently assume that "magnitude saturation" of peak ground acceleration will occur at some magnitude below 7.5, although it could begin to be effective at M = 6.5 or M = 7.0. It is even possible, given the uncertainty about the mechanism responsible for the large increase in average slip between M = 6.5 and M = 7.5, that the average peak accelerations could increase somewhat faster with increasing magnitude between 6.5 and 7.5 than between 5.5 and 6.5, i.e., even faster than the Hanks and McGuire and Joyner, Boore and Porcella results.

Conclusion

7. The recent USGS Open File Report 81-365 represents an extrapolation based on one set of assumptions, but as the authors point out, "for distances less than 40 km from earthquakes with M greater than 6.6 the prediction equations are not constrained by data and the results should be treated with caution." The same applies to other attempted extrapolations. Whether mean peak horizontal accelerations increase with magnitude above $M_s = 6.5$ at the same rate they do below $M_s = 6.5$ depends on how the effects of increased energy release per unit fault length balance the near field tendency toward saturation due to fault size. No definitive conclusions can be reached on this matter without more data and a better understanding of the physics of large earthquakes.

8. The recent Hanks and McGuire results for M of 6.5 at a distance of 10 km are higher, by a factor of about 1.4, than the results of USGS Open File Report 81-365 (.36 g vs .50 g) and indicate about the same rate of increase with magnitude up to M = 6.5. Hanks and McGuire state that "On the other hand, a_{max} need not increase by much above $\sim$1/2 g for M > 6.5 at close distances, and we expect it will not, the linear increase in log a_{max} above M = 6.5 assumed in the empirical relations of Donovan (1973) and Joyner *et al.*, (1981) notwithstanding." In a recent personal communication, Hanks has explained that this could include increases ranging, on the one extreme, from a continuous linear increase at the same slope as between 5.5 and 6.5 giving accelerations of about .9g at M = 7.5 and R = 10, to on the other extreme, a corner and flattening at 1/2 g. Hanks indicated that a reasonable guess for the most likely extrapolation would be about 0.75 g at M = 7.5 and R = 10, but at this

time, such a guess is quite uncertain due to the lack of data (personal communication, 5/22/81).

9. The above discussion refers to curves for mean accelerations. If we multiply the mean value of .75 g by a factor of 1.5 to obtain a mean plus one standard deviation value, we obtain 1.13 g.

10. Thus, the considerations I have outlined above, with the new results in the Scholz (1981) and Hanks and McGuire (1981) indicate that the values for peak acceleration indicated in USGS Open File Report 81-365 for M = 7.5 and distances of less than 10 km are reasonable extrapolations given the limitations in the data base.

James N Brune

TO 1944 CA (8-74)
(Individual)

TITLE INSURANCE AND TRUST
ATICOR COMPANY

STATE OF CALIFORNIA
COUNTY OF San Diego } SS.

On May 22, 1981 before me, the undersigned, a Notary Public in and for said State, personally appeared James N. Brune, known to me to be the person whose name is subscribed to the within instrument and acknowledged that he executed the same.

STAPLE HERE

WITNESS my hand and official seal.

Signature Sharon A. Fritz

OFFICIAL SEAL
SHARON A. FRITZ
NOTARY PUBLIC - CALIFORNIA
Principal Office in San Diego County
My Commission Exp. March 9, 1984

(This area for official notarial seal)