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November 22, 1976

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Washington, D.C. 20555

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In the Matter of
Pacific Gas and Electric Company
(Diablo Canyon Nuclear Power Plant, Units Nos. 1 and 2)
Docket Nos. 50-275 O.L. and 50-323 O.L.

Dear Members of the Board:

In behalf of Pacific Gas and Electric Company, transmitted herewith in the captioned matter is the Applicant's testimony of Dr. G. Hoyt Whipple, Professor of Radiological Health, University of Michigan.

Sincerely,

Nancy L. Hickman

Nancy L. Hickman

encls.

cc: (w/encls.)
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50-275
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EDUCATIONAL AND PROFESSIONAL QUALIFICATIONS

G. HOYT WHIPPLE

EDUCATION:

Public Schools: Rochester, New York

College: Wesleyan University, 1935-39, B. S. in Chemistry
Massachusetts Institute of Technology Graduate School, 1939-42, no degree
University of Rochester Graduate School, 1950-53, Ph.D. in Biophysics

EXPERIENCE:

M.I.T. Division of Industrial Cooperation: 1942-47, Loran, radar, food dehydration, aerial bomb fuses, etc., government sponsored research.
General Electric Company, Hanford Works, Richland, Washington: 1947-50, research and development on health physics problems and instruments.
University of Rochester Atomic Energy Project: 1950-57, teaching in health physics and research in biophysics.
The University of Michigan, School of Public Health, Ann Arbor, Michigan: September 1957-present, Professor of Radiological Health.

For about 25 years I have taught radiation protection to graduate students specializing in this subject. For the last 20 years I have served the nuclear power industry and others as a consultant on radiation protection, both in the environment and in the work place. This teaching and consulting have required me to maintain familiarity with past and current research on the biological effects of radiation, particularly at low doses, including the induction of malignancies and of genetic mutations.

PROFESSIONAL SOCIETIES

American Industrial Hygiene Association
Health Physics Society

CERTIFICATION

American Board of Health Physics: in Health Physics
American Board of Industrial Hygiene: in Radiological Aspects of Industrial Hygiene.

TESTIMONY ON BEHALF OF
PACIFIC GAS AND ELECTRIC COMPANY
DIABLO CANYON, UNITS 1 & 2
DOCKET NOS. 50-275 and 50-323
BY

G. HOYT WHIPPLE
PROFESSOR OF RADIOLOGICAL HEALTH
SCHOOL OF PUBLIC HEALTH
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ANN ARBOR, MICHIGAN

This testimony provides an assessment of the potential health effects from expected routine releases of radioactive materials from operation of the Diablo Canyon Nuclear Generating Station and an assessment of the effects of occupational doses to plant workers. This testimony is intended to offer comments and analyses relevant to contentions 4A, 4C, and 4D.

Prior submittals of the Pacific Gas and Electric Company, as well as testimony of the Nuclear Regulatory Commission, have indicated that potential radioactive exposures from the Diablo Canyon Nuclear Generating Station satisfy design objectives of Appendix I of 10 CFR Part 50. In subsequent sections additional testimony will be provided on the effects of radioisotope buildup in the food chain, effects of routine releases on population within 50 miles, and effects of radiation exposure to plant workers.

Buildup of Radioisotopes in the Food Chain

Possible food chain pathways wherein low level radioactive releases from the Diablo Canyon may enter are described in Chapters 2 and 11 of the Final Safety Analysis Report for Units 1 and 2, Diablo Canyon Site, and in the Final Environmental Statement Related to the Nuclear Generating Station, Diablo Canyon Units 1 and 2.

The specific pathways were referenced in a response [1/] of Philip A. Crane to the Atomic Safety and Licensing Board in answer to Interrogatory 3A. Potential radiation doses from these pathways within 50 miles of the Diablo Canyon Nuclear Generating Station have been calculated by both Pacific Gas and Electric Company and the Nuclear Regulatory Commission Staff. In both sets of calculations the methods given in Regulatory Guide 1.109 [2/] were used.

Regulatory Guide 1.109 provides guidance through equations, transfer coefficients, dose conversion factors, and consumption rates. This Guide consolidates information from a wide variety of sources, including the International Commission on Radiological Protection. Among the transfer factors given in the Guide are those for Bioaccumulation Factors (Table A-8, pages 1.109-31 and 1.109-32) and for Stable Element Transfer Data (Table C-5, page 1.109-56). The table of bioaccumulation factors gives the ratio, pCi/kg of organism per pCi/liter of water, for fish, invertebrates and plants in fresh water and in sea water for 100 chemical elements (the traditional 92, plus 8 transuranic elements). The table of stable element transfer data gives transfer coefficients for soil to vegetation, for cow's diet to milk and for animal diet to meat, for all

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1/ "Responses of Pacific Gas and Electric Company to Interrogatories Propounded by Various Intervenors Dated October 19, 1976," November 12, 1976.

2/ Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, March 1976.

100 chemical elements. Table C-6 (page 1.109-57) gives transfer coefficients for goat's diet to goat's milk for 14 elements which differ from the cow transfer coefficient.

The compilation of factors described in the preceding paragraph has been used in the calculation of the buildup of the concentration of radioisotopes in the various food chains. Tables summarizing these doses were provided in Tables 3 and 4 in a letter [3/] of the NRC dated September 21, 1976.

Based on my experience in this field, I have conducted a general review of the analyses of buildup of radioisotopes in the various food chains. My conclusions are:

1. That data and methods available appear adequate to provide reasonable assessments of the effects of buildup of radioisotopes in the food chains at Diablo Canyon.
2. Both the NRC Staff and Pacific Gas and Electric have given adequate consideration to buildup of radioisotopes in their analyses, and have used appropriate data and methods.
3. That potential doses to the total body and to any organ from liquid effluents are so small that they would remain insignificant even if food chain buildup were to be much greater than estimated.

Effects of Routine Releases on Population Within 50 Miles

As indicated previously, the Diablo Canyon Nuclear Generating Station expected exposures have been shown to be below the applicable

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3/ Letter of E.G. Ketchen to J. Geocaris, September 21, 1976.

design objectives of Appendix I, 10 CFR Part 50. The somatic effects, including potential incidences of human cancers, leukemia, infant mortalities, and genetic defects were considered and given extensive analyses during the federal studies and proceedings which led up to the establishment of these regulations and their associated guides for implementation. In an attempt to provide additional response to the contentions of the intervenors, however, the calculated somatic and genetic effects of the calculated radiation exposures to persons within 50 miles of the Station are discussed in this testimony. These calculations were made using the BEIR Report [4/] and assuming a linear damage response with no threshold for radiation damage. These bases, including the use of some of the data in the BEIR Report, are considered conservative.

The projected 1980 population within 50 miles of the Diablo Canyon Nuclear Generating Station is 252,540. [5/] For purposes of this response, a population of 260,000 will be used.

The projected annual integrated dose to this population is 0.30 man-rem per year as given in reference 3. Assuming a 40-year life for the Diablo Canyon Nuclear Generating Station, the population would accumulate 12 man-rem.

4/ "The Effects on Population of Exposure to Low Levels of Ionizing Radiation", National Academy of Sciences, National Research Council, November 1972.

5/ Figure 2.8, Final Environmental Statement relative to Nuclear Generating Station, Diablo Canyon Units 1 and 2, May 1973.

From the BEIR Report coefficients, based on the linear, no threshold hypothesis, the estimated somatic and genetic effects in populations exposed to low levels of ionizing radiation can be obtained. For somatic effects (cancer deaths), the BEIR coefficient is 172 cancer deaths per million man-rem (BEIR Report, page 2). For genetic effects in the first generation, the BEIR coefficient is 42 genetic effects per million man-rem (BEIR Report, Table 4, page 57, using the geometric mean of the given range).

Application of these coefficients to an assumed 40-year population dose of 12 man-rem gives 0.00206 additional cancer deaths and 0.000504 additional genetic effects.

Since, for these calculations the Diablo Canyon Nuclear Generating Station is assumed to operate for about 40 years, it is appropriate to use the first generation estimate for genetic effects. The estimate for equilibrium effects is appropriate only when a number of generations are exposed to the same level of radiation. For illustration, however, the equilibrium estimate is 0.0031 additional genetic effects per generation.

The somatic and genetic effects estimated above from the BEIR coefficients should be compared to the number of effects which arise spontaneously.

Some data on the incidence of cancer deaths are listed below:

U.S. average 6/	1974	170.5 per 100,000
California average 6/	1974	160.9 per 100,000
San Luis Obispo County: 7/		
	1970	162.7 per 100,000
	1973	160.4 per 100,000
	1974	182.1 per 100,000

The current incidence of spontaneous genetic effects is taken to be 0.06 per live birth (BEIR Report, Table 4, page 57). If, as seems likely, the population of 260,000 within 50 miles of the Diablo Canyon Nuclear Generating Station reproduces itself during the 40 years of station life, there will be some 15,600 children who bear a spontaneous genetic effect.

The addition of the estimated 0.00206 cancer deaths after 40 years of plant operation to about 16,640 cancer deaths which would occur spontaneously during this period in San Luis Obispo County is insignificant. The addition of the estimated 0.000504 genetic effects after 40 years of plant operation to the 15,600 spontaneous genetic effects in the same population is also insignificant.

6/ Monthly Vital Statistics Report, National Center for Health Statistics, U.S. Department of HEW, February 3, 1976.

7/ Based on 1970 census population and deaths as reported in Vital Statistics of the U.S., Volume 2, Part B, Mortality, U.S. Department of HEW for years 1970, 1973 and 1974.

Effects of Radiation Exposure to Workers

The most recent data on occupational radiation exposure at nuclear power plants are those presented by the NRC.[8/] [9/] Table 1 summarizes the data from tables 1 and 2, pages 5 and 6 of reference 8. It is evident from Table 1 that there has been considerable variation from year to year in the average number of man-rem per reactor year for all light water reactors (LWRs), or for pressurized water reactors (PWRs) and for boiling water reactors (BWRs) separately. This variation is a function of several factors (reactor age, repair, maintenance, and in-service inspection), but not for power level with PWRs.[10/]

In view of the variation in man-rem per year averages, one cannot predict accurately the exposure to the entire work force at a particular station for future years. However, for purposes of estimating the effects at Diablo Canyon Nuclear Generating Station, a figure of 450 man-rem per reactor year was assumed. A value of 0.8 rem per year to the average work is appropriate for estimation purposes based on data of Table 1.

8/ T.D. Murphy, N.J. Dayem, J.S. Bland, W.J. Pasciak, "Occupational Radiation Exposure at Light Water Cooled Power Reactor," NUREG-0109, August 1976.

9/ B.G. Brooks, "Eighth Annual Occupational Radiation Exposure Report 1975, "NUREG-0119, October 1976.

10/ C.A. Pelletier, et al, "Compilation and Analysis of Data on Occupational Radiation Exposure Experienced at Operating Nuclear Power Plants," Atomic Industrial Forum, Inc., National Environmental Studies Project Report, September 1974.

Under the above assumptions, a person who worked at the Diablo Canyon Nuclear Generating Station for the full 40-year life of the Station at an average exposure rate of 0.8 rem per year would accumulate 32 rem. According to the BEIR Report, this exposure will increase the chance that he will develop a fatal cancer by 0.0054.

The California rate for cancer deaths in 1974 was 160.9 per 100,000 per year, somewhat lower than the average U.S. rate of 170.5 per 100,000 per year. The life-time probability that an individual will die of cancer is about 70 times these annual rates; hence, for California the probability is 0.113. (For the average person in the U.S. it is 0.119.)

Thus, one can calculate that the individual who works at the Diablo Canyon Nuclear Generating Station for the 40-year assumed life of the Station at the average exposure rate increases the likelihood that he will die of cancer from the spontaneous risk of 0.113 to 0.119, an increase of about 4.5%, according to the BEIR coefficient, which in my opinion represents an overly conservative approach.

With regard to the genetic effects, under the same assumption the 40-year operation of the station will result in 36,000 man-rem of exposure. The BEIR extrapolation of 42 genetic effects in the first generation per million man-rem multiplied by 36,000 man-rem results in 1.5 additional genetic effects.

If the plant workers all live within 50 miles of the Diablo Canyon Nuclear Generating Station, these 1.5 calculated effects will be added to the 15,600 effects which will arise spontaneously in this area during the period under consideration resulting in an increase of about 0.01%.

Conclusions

On the basis of my review of the contentions raised by the intervenors and accepted by the Board, and a review of the relevant sections of the analyses performed by the Pacific Gas & Electric Company and the NRC Staff, I have the following conclusions:

1. Buildup of radioisotopes in the food chains significant at Diablo Canyon has been given adequate consideration and the resulting exposures will not be significant contributors at Diablo Canyon.
2. Somatic and genetic effects on the surrounding population have been given adequate consideration and will be insignificant compared to spontaneous effects of the same kind which occur in the population.
3. Somatic and genetic effects on plant personnel, based on experience at similar facilities and using a number of conservative assumptions, will be small compared to the spontaneous occurrence of similar effects in individuals.

Table 1. Occupational Radiation Exposure [1/]

YEAR	AVERAGE MAN-REM PER REACTOR-YEAR			AVERAGE INDIVIDUAL EXPOSURE, REM PER YEAR
	ALL LWRs	PWRs	BWRs	
1969	178	165	195	1.1
1970	365	599	130	1.0
1971	294	340	255	1.0
1972	364	463	286	1.2
1973	534	772	330	0.9
1974	427	364	507	0.8
1975	457	309	670	0.8

1/ Murphy, Dayem, Bland, and Pasciak, "Occupational Exposure at Light Water Cooled Power Reactors," NUREG-0109, August 1976.