UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
GENERAL ELECTRIC CO.	)	
	)	Docket No. 50-70
(Vallecitos Nuclear Center -	)	(Show Cause)
General Electric Test Reactor,	)	
Operating License No. TR-1)	)	

NRC STAFF TESTIMONY OF WILLIAM J. HALL

Q.1. Please state your name and present occupation.

A.1. My name is William J. Hall. My position is that of Professor of Civil Engineering at the University of Illinois at Urbana-Champaign, and I am also an independent consulting engineer.

Q.2. Please summarize your educational background and relevant work experience.

A.2. B.S. in Civil Engineering, University of Kansas, Lawrence 1948 M.S. and Ph.D. in Civil Engineering, University of Illinois at Urbana-Champaign, 1951 and 1954, respectively.

As the University of Illinois I have been involved in teaching and research in structural engineering and structural dynamics for over 30 years. In recent years I have been principal investigator on several large research programs concerning earthquake engineering sponsored by the National Science Foundation. In addition, my consulting activities in structural and seismic engineering have included, among many assignments, the following: (a) nuclear

power plants since 1964, (b) trans-Alaska Pipeline since 1970, (c) Canadian sector of the Alaska-Canada gas line since 1980, and (d) the uranium hexafluoride gas centrifuge enrichment plant since 1973. I was a member of the Applied Technology Council projects ATC-3 and ATC-6 dealing with the development of seismic design criteria for buildings (1974-1977) and bridges (1978-1981), and have consulted on military system design in the area of structural dynamics since 1958. A summary of my educational and professional background is attached and is made a part of this testimony.

Q.3. Please describe the scope of your participation in the review of the General Electric Test Reactor for this proceeding.

A.3. At the time of the initial Show Cause review, the Staff contracted with N. M. Newmark Consulting Engineering Services to recommend the proper seismic design criteria to be used for the GETR and to provide a recommendation, based on a review and evaluation of analyses submitted by General Electric, as to the seismic adequacy of the GETR facility to meet the appropriate criteria. During this review period, I carried major responsibility for reviewing the GETR seismic issues. My recommendations and evaluations have provided the basis for certain portions of the Staff's SERs.

Q.4. Please summarize the results of your review.

A.4. After discussion with a number of persons and a review of reports, documents, and letters from NRC, the U.S. Geological Survey, and the TERA Corporation, studies for Diablo Canyon, and recognizing the lack of correlation of damage to structures and equipment in relation to peak acceleration, in the light of our judgment and experience Dr. Newmark and I recommended the

use of the criteria described below for the seismic evaluation of the GETR site and participated in the review of safety-related structures and equipment at the site.

On the basis of considerations of the type noted, we recommended that the most reasonable value of acceleration to use for anchoring the spectra for effects arising from the Calaveras fault would correspond to 0.6 g (consistent with a magnitude in the range of 7.0 to 7.5), but for design or review conservatism we suggested a value of 0.75 g. This value reflects the fact that there is some degree of uncertainty in estimating such motions and that the hazard specified by the USGS corresponded to a magnitude 7.5 earthquake. We noted that we did not expect fault motion of significance to be transferred to the site from activity on the Calaveras fault.

In a similar manner, in the case of the Verona Fault, we stated that, from the information available, an acceleration value of about 0.40 g (consistent with a magnitude in the range of 5.0 to 6.0) was the most reasonable value for anchoring the response spectra, but for conservatism we recommended use of a value of 0.6 g. The margin between the most likely value and the recommended value here is larger to account for a greater degree of uncertainty as to the nature of the seismic motion and for the fact that the USGS specified the hazard to be that associated with a magnitude 6.5 earthquake. Also we noted that the motion was to be taken as acting simultaneously with a fault motion of not more than 1 meter, interpreted to be the resultant (net) motion in any arbitrary direction.

With regard to effective acceleration, the instruments that are used for free-field ground motion measurements are strong motion accelerographs for

the most part. Acceleration, as a measure of ground motion, can be interpreted as an item of engineering interest in the sense of force, through Newton's second law, namely that pertaining to mass and acceleration. Of equal interest to the earthquake engineer are the velocities and displacements arising from the excitation which can be obtained on a time basis through integration of the acceleration record. Reliable instruments do not exist at present for recording velocity and displacement as a function of time in the frequency ranges that are associated with earthquake excitation.

Actually, extremely high accelerations can occur on a localized basis with no damage to structures or equipment. Many types of structures as well as equipment are designed to resist very high frequency accelerations in the range of hundreds to thousands of gravities, as for example in the case of military structures and equipment (submarines, missiles, ground vehicles and underground structures). If one strikes a building with a structural wrecking ball, localized damage and high accelerations occur in the region where the ball strikes the building; generally, such localized loading for a well engineered structure does not lead to building collapse or even any type of gross damage. Accordingly, earthquake excitation with a few high frequency acceleration peaks, characterized for design and analysis purposes by Reg. Guide 1.60 spectra, would not be expected to produce significant damage.

The concept of effective acceleration has been defined by Dr. Newmark in the following manner:

> It is that acceleration which is most closely related to structural response and to damage potential of an earthquake. It differs from and is less than the peak free-field acceleration. It is a function of the size of the loaded area, the frequency content of the excitation, which in turn depends on the closeness to the source of the earthquake, and to the weight, embedment, and stiffness of the structure and its foundation.

This definition of effective acceleration describes the term as used by Dr. Newmark and myself during our review of the GETR.

As employed herein for nuclear plant design and review analysis, the term effective acceleration is associated with the significant part of the ground motion as characterized by the repetitive motion portions which possess strong energy content. This portion of the ground motion obviously is of primary importance in evaluating the response and behavior of the structure or equipment elements, and thereby of importance in design and in assessing damage potential. In this sense, the , in accordance with the definition given by Dr. Newmark, the effective acceleration normally is not that value connected with the high spikes of instrumentally recorded high frequency accelerations commonly found to occur close to the source of seismic energy release, such as in the case with GETR with respect to the Verona and Calaveras faults. On the other hand, the effective acceleration would be expected to be very close to the peak instrumental acceleration for locations at significant distances from the source, zones where such high frequency acceleration peaks normally are not encountered. Accordingly, for design purposes, the effective acceleration value is used to anchor the design response spectrum. As indicated, for GETR we would expect an effective design acceleration value of 0.75 g, consistent with the NRC Staff position for peak vibratory ground motion of slightly in excess of 1.0 g.

The results of our review, as well as our conclusions regarding the earthquake ground motion design critiera are contained in Section C and Appendix A of the Staff's May 23, 1980 SER and Appendix A of the October 27, 1980 SER.

November 1980

BIOGRAPHICAL DATA

William J. Hall

William J. Hall, Professor of Civil Engineering at the University of Illinois, Urbana, Illinois, has been a member of the faculty at the University since 1949. During this time he has been engaged in research and instruction in structural engineering, structural dynamics and materials.

He was born on 13 April 1926 in Berkeley, California. After attending the University of California at Berkeley in 1943 and 1944, he entered the U.S. Merchant Marine Cadet Corps and served in the Pacific War Zone and at Kings Point until September 1945. He received the degree of Bachelor of Science in Civil Engineering from the University of Kansas, Lawrence, Kansas, in June 1948. While a senior student he held a teaching assistantship and worked summers for the Kaw Valley Drainage District and the Phillips Petroleum Company Kansas City Refinery. Upon graduation he received the ASCE Kansas Section Award for the Outstanding Civil Engineering Graduate of 1948.

From July 1948 through August 1949 he worked as an engineer in the field and operation sections of the Sohio Pipe Line Company, a subsidiary of the Standard Oil Company of Ohio. He joined the staff of the Civil Engineering Department, University of Illinois in September 1949, holding successively the positions of Research Assistant (1949-52), Research Associate (1952-54), Assistant Professor (1954-57), Associate Professor (1957-59), and Professor of Civil Engineering from 1959 to date. He undertook graduate study at the University of Illinois and received the degrees of Master of Science in Civil Engineering in 1951 and Doctor of Philosophy in Civil Engineering in June 1954.

He received the A. Epstein Memorial Award in 1958, the Walter L. Huber ASCE Research Award in 1963, the Adams Memorial Membership Award of the American Welding Society in 1967, and the Halliburton Engineering Education Leadership Award of the University of Illinois College of Engineering for 1980. He was appointed an Associate Member of the Center for Advanced Study, Graduate College, University of Illinois for 1963-64.

On 1 April 1968 he was elected to membership in the National Academy of Engineering and in 1979-80 served as Chairman of the Membership Committee.

At the University of Illinois his duties have involved teaching and research in structural engineering and structural mechanics; he carried major departmental responsibility for graduate student and research affairs (1958-1973) and serves on many high-level university policy committees and boards. Specific areas of formal research have included such topics as fatigue machine design; effects of blast forces on model submarine hulls; design, construction, and test operation of protective structures at the AEC Nevada Test Site; static and dynamic response of beams and connections; shear strength of steel beams; brittle fracture behavior of welded steel plates; properties of metals under static and dynamic loadings; seismic hazard evaluation and earthquake engineering.

He is currently principal investigator of a large research program sponsored by the National Science Foundation in the area of earthquake engineering with application to improvements in analysis and design of structures and equipment.

He is the author or co-author of over 115 formal publications (books and articles) in the fields of structural engineering, structural mechanics and dynamics, soil dynamics, earthquake engineering, plasticity, fatigue, brittle fracture mechanics, civil defense and education. He is the co-author with H. Kihara, W. Soete and A. A. Wells of a book entitled "Brittle Fracture of Welded Plate" published by Prentice-Hall in October 1967. In addition he is the author or co-author of over 150 major consulting reports, many of public record and wide distribution.

He serves (or has served) as a consultant to a number of industrial organizations and governmental agencies, including for example the U.S. Army Office of the Chief of Engineers, the U.S. Army Waterways Experiment Station, the U.S. Army Construction Engineering Research Laboratory, Naval Civil Engineering Laboratory, the U.S. Navy Bureau of Ships, Stanford Research Institute, Union Carbide Corporation, Alyeska Pipeline Service Co., Foothills Pipelines (Yukon) Ltd., Woodward-Clyde Consultants, and Structural Mechanics Associates, Inc. On his own, and as an associate with N. M. Newmark, he has carried major consulting engineering responsibility for projects in such areas as development of design criteria for hardened protective structures, including missile facilities, physical vulnerability studies, vibration studies of missile test stands, reactor containment structural design and analysis, nuclear field test studies, review of structural criteria and designs for nuclear power plants and equipment for seismic loading for the U.S. Atomic Energy Comission and the Nuclear Regulatory Commission, and development of seismic design criteria for the uranium hexafluoride gas centrifuge plant. He has been a principal consultant since 1970 on the trans-Alaska pipeline and since 1980 on the Alaska-Canada gas line. He is currently a member of the M-X Nuclear Hardness and Survivability Audit Group, an independent panel charged with technical oversight review of M-X system development.

In 1964 he participated in Project HARBOR, a study of the national civil defense posture, and in 1967 participated in the Little Harbor review. In 1964 he was selected as one of the five U.S. scientists and engineers to participate in the first Seminar on Brittle Fracture held in Tokyo, Japan under auspices of the U.S. - Japan Cooperative Science Program. In 1965 he was selected as one of 30 scientists and engineers to participate in the Meet Modern Sweden science tour held under auspices of the Royal Swedish Academy of Science and Royal Swedish Academy of Engineering. In 1966 he served as a member of the Commerce Technical Advisory Board Panel on High Speed Ground Transportation and was Chairman of the Panel on Guideways, Suspension, and Aerodynamics. From 1970 to 1973 he was Chairman of the Materials and Fabrication Subcommittee of the Ship Research Committee, NRC. In 1974-76 he served as Chairman of the NMAB Ad Hoc Committee on Application of Fracture Mechanics Analysis Techniques to Marine Systems. In 1975-76 he was a member of the Panel on Earthquake Prediction of the NRC Committee on Seismology. From 1974-77 he was a member of two committees (seismic ground motions, and structural design provisions) of the ATC-3 project of the Applied Technology Council, a group working to develop national comprehen-

sive seismic design provisions; currently he is a member of project ATC-6, studying the seismic design of bridges. He was a member of the Committee on Seismology, NAS/NRC in 1976-1979 and was Chairman of the NAS/NAE/NRC Committee to provide recommendations for improving the siting of critical facilities. Currently he is a member of the NSF Advisory Committee on Earthquake Engineering.

He was a member of the U.S. delegation on Earthquake Engineering and Hazards Reduction that visited the People's Republic of China July 24-August 13, 1973 under auspices of the National Academy of Sciences.

He is active as officer and member of many professional and scientific groups and societies: Fellow, American Society of Civil Engineers; Member, Structural Division Executive Committee, 1971-75 (Chairman 1973-74); Chairman, Structural Division Research Committee, 1960-64; Awards Committee 1975-79; Member and past Chairman, Committee on Plasticity, EMD; Member, Committee on Dynamic Forces, and Committee on Nuclear Structures and Materials, 1975-79; Member, Committee on Gas and Liquid Fuel Pipelines, TCLEE, 1976-; Member, Executive Committee TCLEE, ASCE, 1980-; Secretary-Treasurer, Central Illinois Section, 1956-59; Vice President, President and Director, Central Illinois Section, 1965-68; Fellow, American Association for the Advancement of Science; Earthquake Engineering Research Institute Director, 1979; American Concrete Institute; American Society of Mechanical Engineers; American Welding Society; American Society of Engineering Educators; the International Institute of Welding, 1959-74, Expert on IIW Commissions IX and X; Seismological Society of America; American Society for Testing and Materials; Society for Experimental Stress Analysis; International Association for Bridge and Structural Engineering (Reporter, 1968); Illinois Society of Professional Engineers; National Society of Professional Engineers; Structural Engineers Association of Illinois (Chairman of Seismology Committee, 1973-77); Honorary society memberships include Tau Beta Pi, Sigma Tau, Phi Kappa Phi, Sigma Xi, and Chi Epsilon. He is an editor for a series of texts in civil engineering and engineering mechanics for Prentice-Hall, Inc.

He is a Registered Structural Engineer and Professional Engineer in the State of Illinois, and is a Registered Professional Engineer (Civil) in the State of California. He is listed in Who's Who in America, Who's Who in Engineering, Who's Who in the Midwest, Who's Who in Metals, Personalities of the West and Midwest, American Men of Science, Engineers of Distinction and Who's Who in Engineering.

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