UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING APPEAL BOARD

In the Matter of	)	
	)	
CLEVELAND ELECTRIC ILLUMINATING COMPANY, ET AL.	)	Docket Nos. 50-440 OL 50-441 OL
	)	
(Perry Nuclear Power Plant, Units 1 and 2)	)	

AFFIDAVIT OF ARNOLD J. H. LEE

I, Arnold J. H. Lee, being duly sworn do depose and state as follows:

I am employed as a mechanical engineer in the Boiling Water Reactor Division, Engineering Branch, in the Nuclear Regulatory Commission. A statement of my professional qualifications is attached.

The purpose of my affidavit is to respond to assertions concerning the seismic design of the Perry Nuclear Power Plant (PNPP) contained in a Motion to Reopen the Record filed on February 3, 1986 by Ohio Citizens for Responsible Energy (OCRE).

1. On the day following the Ohio earthquake on January 31, 1986, an inspection team consisting of members of NRC Staff went to the Perry plant to review preliminary seismic recordings and to conduct a walk-through inspection of buildings and equipment. No damage of any significance was observed at the plant. Another inspection team consisting of myself and the staff consultant from EG&G, Idaho, who is the original SQRT (seismic qualification review team) member performing the

SQRT plant site audit in August, 1985, conducted another site audit on February 6, 1986 to investigate the effect of the earthquake on the safety-related equipment of the station. During the above audit, the applicants and its architect engineers, indicated that some exceedance of the recorded response spectra over the Perry SSE and OBE had occurred at high frequencies ($\geq$ 15 Hz).

2. In view of the short duration (strong motion portion is less than one second), high frequency characteristics of the recorded motion, the initial view of applicants and Staff was that the impact of the high frequency exceedances on the plant would be insignificant. This is because high frequency short duration accelerations do not contain significant energy. However the Staff sought information about the effect of high frequency accelerations on equipment. The Staff inspected some representative equipment which was subjected to a previous detailed audit in August, 1984. Among the equipment inspected was H13-680 Unit Control Console, Division 1 Battery and Rack, Motor Control Center, and RCIC Turbine and its related pipings and accessories. No apparent damage was observed on the equipment itself, the support, or the mounting configuration which could be attributed to the Ohio earthquake. Neither was any apparent structural damage observed.

3. Subsequently, a technical report was submitted by the applicants on February 12, 1986 which summarizes the earthquake event, the applicants' follow-up activities and the evaluation of safety impact. The applicants provided the Staff with information concerning qualification of equipment of three types located on Elevation 568 ft. of Auxiliary Building, namely, instrument racks; pressure and flow transmitters; and

pumps and motors. This report, supplemented by additional information provided by the applicants on February 28, 1986 indicates that conservatism exists in the original seismic and dynamic qualification for these types of equipment which is more than adequate to accommodate the recorded event. For the instrument racks and transmitters which were qualified to some generic load requirements, the test response spectra are an order of magnitude greater than the corresponding recorded response spectra. For the pumps and motors which were qualified by analyses, although the resulting stresses and deflections at critical locations may slightly exceed the original calculated values, there remains a significant margin of safety compared to the allowables.

4. The applicants provided additional information for the equipment located on elevation 686' of Reactor Building where high peak acceleration at around 20 Hz was recorded. The components selected were the purge and vacuum relief system and containment isolation valves and actuator assemblies. Since the valves and motor operators are supported from the piping systems, the response at the valves is modifed by the piping system. There is a short length of piping for the purge system (M14) and the fundamental frequency of the system is 41.6 Hz. At this high frequency, the accelerations are comparable between the recorded spectra and the design spectra. Similarly, for the vacuum relief system (M17) the fundamental frequency is 33 Hz. In this case, the combined response spectrum value at this elevation envelops the recorded spectrum value.

5. The applicants indicated that the acceleration at the valve assembly as determined by the piping analysis for both the M14 and M17 systems bounds the recorded data at this fundamental frequency. The

resultant acceleration at the valve associated with the recorded earthquake data was extrapolated based on the ratios of recorded spectrum to design spectrum times the valve design acceleration values. This shows that the estimated valve accelerations for M14 and M17 systems due to the recorded earthquake are well within the qualification levels of the valve and actuator. Comparisons of the qualification spectra with estimated floor response spectra for other types of equipment in different buildings at different elevations were also performed by the applicants. The results reconfirmed the adequacy of the original qualification.

6. Discussions were held between the staff and the applicants as to whether the recorded motion at the top of the foundation mat of the reactor building was suitable to use as a free-field input motion, even though structures usually reduce or amplify free-field motion. The phenomenon which could lead to a different foundation motion compared to the free-field is soil-structure interaction (SSI). All Category I structures except the diesel generator building and the off-gas building are constructed on very stiff rock (shear wave velocity of 4900 ft/sec) or fill concrete of similar shear wave velocity. These very stiff materials are generally thought to preclude significant SSI effects. In addition, the reactor building was analyzed by the staff consultant as a fixed-base structure subjected to the recorded foundation motions (three translations). Good correlation of calculated and measured in-structure responses was observed, explained below in ¶ 8. This good correlation implies that rocking of the foundation was not significant, whereas, rocking of the foundation is an important SSI phenomenon. Hence, it is judged that the recorded foundation motions are similar to the free-field ground

motion in frequency content; both are characterized by a very short strong motion duration (less than 1 sec) and significant frequency content at high frequencies (near 20 Hz).

7. The staff consultant performed an eigenvalue analysis for the model which included soil springs and found that the result checked with those of the original Perry analysis. A fixed-base eigenvalue extraction was then performed in the model and the modes interrogated to determine whether a mode of frequency near 20 Hz. had high importance to response of the containment vessel at a location near the recording. Such modes do exist in both the N-S and E-W directions and they are the second most important modes for the containment vessel's response.

8. Further verification of the ability of the model to amplify the recorded motion was derived by performing a fixed-base time history analysis using the recorded foundation acceleration time histories as input. The response spectra for the recorded foundation motions were compared with the calculated containment vessel response at approximately elevation 688'. In addition, comparison was also made for response spectra of the recorded motions on the foundation and on the containment vessel at elevation 686'. Both comparisons show clearly the amplification of the 20 Hz. motion from the foundation to the point on the containment vessel. The magnitude of the calculated amplification is less than that of the recorded motion. However, this preliminary analysis simply assumed a design damping value of 4% of critical value. In the case of this earthquake, an analysis performed with a lower damping value may have produced a result closer to that actually measured. Also, peak spectral amplification is widely recognized to be uncertain.

9. Low overall energy content, and thus low damage potential of earthquakes of short duration and high frequencies can be demonstrated by use of scale factors by which earthquake records must be scaled to induce specified levels of nonlinear deformation. A ductility level of about 1.85 was found to represent a best estimate of the inelastic deformations which would occur in a shear wall designed for static lateral loads to the ACI-349 Code capacity. Two records of past earthquakes of short duration and somewhat higher frequency content (less than 10 Hz.) were considered in calculating the dynamic response for a structure of fundamental frequency of 3.20 Hz. (near that of the Perry reactor building). It was found that the two recorded earthquake motions would need to be scaled by factors of 1.6 to 2.2 to achieve deformations corresponding to the design level forces. Alternatively, a measure of the effective peak ground acceleration of these records would be the instrumental peak divided by these factors. If a similar procedure were applied to the recorded foundation motions at Perry, the scale factors are expected to be significantly higher than 2 and, consequently, a measure of the effective peak ground acceleration of the Perry motions would be perhaps 1/3 of the instrumental peak acceleration or less. These analyses demonstrate the low energy content of the January 31 earthquake. Excitations of this type have limited energy and, hence, little damage potential.

10. To further demonstrate the insignificance of high frequency acceleration on the structural design, the applicants noted that the conventional seismic stress analysis applies the inertial load as equivalent static load which ignores the effects of small relative displacements. A comparison was made between the design stresses for the containment

building as calculated using the inertia load and the dynamic stresses obtained directly from a time history analysis using the time history recorded at the top of reactor building foundation mat as input. For the three elevations investigated, i.e. 592'-3", 644'-6", and 688'-6", it was found that the design was controlled by the maximum stress at elevation 592'-3". At this elevation, the design stress of 1.32 Ksi is 2.6 times higher than the dynamic stress of 0.51 Ksi. The applicants pointed out that the containment material, ASME SA516 Grade 70, has a yield stress of 38 Ksi which is more than 74 times higher than the dynamic stress of 0.51 Ksi. The staff concluded that the dynamic stresses due to the recorded earthquake are substantially lower than the corresponding design stresses and, therefore are not of any safety significance.

11. For the diesel generator building and the off-gas building which are founded on soil, the fundamental frequencies are very low compared to the high frequency content of the Ohio earthquake. Therefore, their seismic designs are governed by the broadband design basis earthquakes, not the Ohio earthquake.

12. In summary, based on the detailed inspections and investigations conducted by the staff and its consultants which resulted in no finding of equipment or structural damage that could be attributed to the Ohio earthquake, and on the reassessment of the seismic capability of some sample equipment types and the containment building as previously discussed, it is my opinion that the earthquake does not raise a significant safety question concerning the operation of the Perry plant or its safety-related equipment. Although the design basis earthquakes for the plant may have been exceeded at some high, narrow frequency region,

the plant seismic design is not affected. Therefore, the staff concludes that the previous SER conclusion regarding the adequacy of the applicants' seismic qualification program and the seismic design of Category I structure remains valid, and continues to support operation of the plant. However, as an added precaution the applicant has been requested to provide additional confirmatory information concerning equipment qualification and structures.

13. Finally, I have read "Motion to Reopen the Record and to Submit a New Contention," dated February 3, 1986 filed by OCRE and find nothing in the motion which raises a significant safety question concerning the Perry plant.

I attest that the foregoing is true and accurate to the best of my knowledge and belief.

Arnold J. H. Lee

Subscribed and sworn to before me
this 7th day of March, 1986.

Notary Public

My commission expires: My Commission Expires July 1, 1986

PROFESSIONAL QUALIFICATIONS

OF

ARNOLD J. H. LEE

EDUCATION

B.S. - July 1964, Agricultural Engineering, National Taiwan University
M.S. - Jan. 1967, Agricultural Engineering, Rutgers University
Ph.D. - Mar. 1971, Engineering Mechanics, Penn State University

NUCLEAR EXPERIENCE

December 1985 to present: Engineering Branch, Division of BWR Licensing, U.S. Nuclear Regulatory Commission

Position: Mechanical Engineer

April 1980 to December 1985: Equipment Qualification Branch, Division of Engineering, U.S. Nuclear Regulatory Commission

Position: Mechanical Engineer

January 1979 to April 1980: Engineering Branch, Division of Operating Reactors, U.S. Nuclear Regulatory Commission

Position: Senior Mechanical Engineer

January 1978 to January 1979: Plant Apparatus Division, Westinghouse Corporation

Position: Senior Engineer

March 1971 to January 1978: Gilbert/Commonwealth Associates, Inc.

Position: Senior Research Structural Engineer

March 1970 to March 1971: The Pennsylvania State University

Position: Instructor in Engineering Mechanics

January 1967 to March 1971: The Pennsylvania State University

Position: Research Assistant

September 1965 to January 1967: Rutgers University

Position: Research Assistant

PUBLICATION

A.J.H. Lee, W. Jaunzemis," A General Theory of Interaction of Discrete Elastic Defects," AFOSR-TR-71-0479, The Pennsylvania State University, February, 1971.

A.J.H. Lee, "Buckling Criteria of Shells Under Various Types of Loadings," Gilbert Associates, April, 1971.

A.J.H. Lee, "Tornado Missiles and Spent Fuel Pool Protection," Gilbert Associates, GAI Report No. 1772, October, 1972.

A.J.H. Lee, "Dynamic Analyses of Missile Impact Protection for Reinforced Concrete Plates," Proceeding of the Symposium on Structural Design of Nuclear Power Plant Facilities, Pittsburgh,PA., April, 1972.

A.J.H. Lee, "A General Study of Tornado-Generated Missiles," Nuclear Engineering and Design, Vol. 30,No. 3, September, 1974.

Y.Z. Lee, R. Shan, A.J.H. Lee, "Design Criteria of Crane Wall-Plate System of OHI Nuclear Power Station," Gilbert Associates, GAI Report No. 1843, July, 1974.

A.J.H. Lee, "Design Parameters of Tornado Missiles," U.S. Nuclear Regulatory Commission Topical Report, TR-102, Rev. 1, Jan.,1975.

A.J.H. Lee, "A Case Study of Soil-Structure Interaction for Nuclear Plant Structures," Presented at 3rd International Conference on Structural Mechanics in Reactor Technology, London, England, September, 1975.

A.J.H. Lee, "On the Interaction of Elastic Defects," Proceeding of 12th Annual Meeting of American Society of Engineering Science, Austin, Texas, October, 1975.

A.J.H. Lee, "Trajectory of Tornado Missiles and the Design Parameters," presented at Second Specialty Conference on Structural Design of Nuclear Plant Facilities, New Orleans, LA.,December,1975.

A.J.H. Lee, G. Bagchi, V. Noonan, "A Regulatory Overview of Equipment Seismic Qualification," presented at Annual IEEE/ASCE/ASME Joint Power Conference, Indiannapolis, Indianna, 1983.

PAST AND PRESENT COMMITTEE ACTIVITY

Member of task group of compressive allowables under ASME working group of containment.

Member of IEEE working group 2.5, responsible for revision of IEEE Standard 344-1975, Recommended Practice for Seismic Qualification of Class IE Equipment for Nuclear Power Generating Stations.

LICENSE

Registered professional structural engineer in Pennsylvania.

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CERTIFICATE OF SERVICE

I hereby certify that copies of "NRC STAFF RESPONSE TO MOTION TO REOPEN THE RECORD FILED BY OHIO CITIZENS FOR RESPONSIBLE ENERGY" in the above captioned proceeding have been served on the following by deposit in the United States mail, first class, or, as indicated by an asterisk, by deposit in the Nuclear Regulatory Commission's internal mail system, this 5th day of March, 1986:

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Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, DC 20555

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Colleen P. Woodhead
Counsel for NRC Staff