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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In The Matter of	)	
	)	
COMMONWEALTH EDISON COMPANY	)	Docket Nos. 50-454-OL
	)	50-455-OL
(Byron Nuclear Power Station, Units 1 & 2)	)	
	)	

SUMMARY OF THE TESTIMONY OF
ANAND K. SINGH
ON CONTENTION 1 .

I. Anand K. Singh is the Assistant Head of the Structural Analytical Division of Sargent & Lundy.

II. Mr. Singh has applied principles of statistics and probability theory to the results of the engineering evaluations performed by Sargent & Lundy discussed in the testimony of Mr. Kostal. He concludes with a 95% confidence level that in the area of cable tray hanger connections, solid bottom tray stiffener welds and ladder tray weld connections, the work performed by System Control Corporation meets the original design basis with 99% reliability.

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TESTIMONY OF ANAND K. SINGH

Q.1. Please state your full name and place of employment for the record.

A.1. Anand K. Singh, Sargent & Lundy, 55 East Monroe Street, Chicago, Illinois.

Q.2. Please describe your job responsibilities.

A.2. I am Assistant Head of the Structural Analytical Division. In this capacity, I supervise and coordinate the work of the Stress and Probabilistic Analysis and the Dynamic Analysis Sections in preparation of analytical studies, special problem analyses, and computer program development.

Q.3. Please describe your educational background and work experience.

A.3. I have a Doctor in Philosophy and a Master of Science degree in Structural Engineering from the University of Illinois at Champaign-Urbana. These degrees were awarded in 1972 and 1970, respectively. I am a registered professional engineer and a registered structural engineer in the State of Illinois. I am a member of the American Society of Civil Engineers (ASCE), and a member of the Seismic Analysis Committee of the ASCE Nuclear Structures and Materials Committee, a member of the Working Group on the Seismic Analysis of Safety of Class Structures of the ASCE Nuclear Standards Committee and a member of the ASCE Committee on Turbine Foundations. I have published numerous technical papers in the area of probabilistic analysis, seismic analysis and dynamic analysis of structures and piping. A list of my publications is attached to my testimony.

I joined Sargent & Lundy in 1972 as a Senior Engineering Analyst. I was responsible for the development and maintenance of computer programs for seismic and dynamic analyses of structures and piping and for performing and/or reviewing seismic analyses of nuclear power plant structures. In 1975, I was promoted to the position of Supervisor of the Dynamic Analysis Section responsible for seismic and dynamic analysis of structures and the development of computer programs for dynamic and seismic analysis. In 1979, I was promoted to the position of Assistant Division Head. In that capacity, I supervise and coordinate the work

of the Stress and Probabilistic analysis and the Dynamic Analysis Sections in preparation of analytical studies, special program analyses, and computer program development. In 1980, I was made an associate of Sargent & Lundy.

Q.4. What is the purpose of your testimony?

A.4. The purpose of my testimony is to apply principles of statistics and probability theory to the results of certain engineering evaluations performed by Sargent & Lundy discussed in the testimony of Mr. Kostal, specifically evaluations of discrepancies in cable tray hanger connections, solid bottom tray stiffener welds and ladder tray weld connections.

Q.5. Would you summarize the results of the engineering evaluations to which you are applying your statistical analysis?

A.5. Yes. The results of engineering evaluations performed by Sargent & Lundy demonstrated that none of the 106 Systems Control Corporation (SCC) cable tray hanger connection discrepancies analyzed out of 358 inspected had design significance. Similarly, the engineering evaluations demonstrated that none of the 227 solid bottom tray stiffener weld discrepancies analyzed out of 227 stiffeners inspected or the 199 ladder tray weld connection discrepancies analyzed out of 300 inspected had design significance.

Q.6. Applying a statistical analysis to these results, what conclusions do you reach with respect to the total population of work performed by SCC for these attributes.

A.6. From a statistical standpoint, I conclude with a 95% confidence level that the work performed by SCC for these attributes meets the original design basis with 99% reliability.

Q.7. Please explain the basis for your conclusions.

A.7. The reliability for a work attribute can be defined as the proportion of work items in the total population of work for that attribute which has no discrepancies with design significance. A generally accepted statistical method for calculating such reliabilities is to compute reliabilities at 95% confidence level from the sampled data. Such a reliability represents a conservative estimate of the true reliability. It is conservative in the sense that there is a 95% chance that the true reliability is greater than the estimate. In the case where no discrepant items are observed in a random sample from a large population, the reliability at 95% confidence level can be calculated

from the formula

$$R = 1 - \frac{2.9955}{n}$$

where

R = Reliability at 95% confidence level,

n = number of inspections in the random sample.

For cable tray hanger connections, a sample of 358 was reinspected. All the observed discrepancies were evaluated for design significance. As stated in Answer 5, this evaluation showed that none of the observed discrepancies had any design significance. By applying the above formula, this sampling evaluation establishes with 95% confidence that greater than 99% of all SCC cable tray hanger connections in the plant meet the design requirements.

For solid bottom tray stiffeners, all welds on a sample of 227 stiffeners were reinspected. All the observed discrepancies in the sample were evaluated for design significance. As stated in Answer 5, this evaluation showed that none of the observed discrepancies had any design significance. By applying the above formula, this sampling evaluation establishes with 95% confidence that 98.7% of all SCC solid bottom tray stiffeners in the plant meet the design requirements.

For ladder type tray welding, a sample of 300 welds was reinspected. The observed weld discrepancies in the sample were evaluated for their design significance.

As stated in Answer 5, none of the observed discrepancies had any design significance. By applying the above formula, this sampling evaluation establishes with 95% confidence that more than 99% of all SCC ladder type tray weld connections meet the design requirements.

Publications

"A Stochastic Model for Predicting Seismic Response of Light Secondary Systems" (coauthor A. H. S. Ang), Proceedings of the Fifth World Conference on Earthquake Engineering, Rome, 1973

"Influence of Closely Spaced Modes in Response Spectrum Method of Analysis" (coauthors S. L. Chu and S. Singh), Proceedings, ASCE Specialty Conference on Structural Design of Nuclear Plant Facilities, Chicago, Illinois, December 1973

"Stochastic Prediction of Maximum Seismic Response of Light Secondary Systems" (coauthor A. H. S. Ang), Nuclear Engineering and Design 29, pp. 218-230, 1974

"Reliability Assessment of ASME Code Equations for Nuclear Components" (coauthor M. K. Ravindra), Reliability Engineering in Pressure Vessels and Piping, ASME, June 1975

"Seismic Response of Pipelines on Friction Supports," (coauthor J. C. Anderson), Journal of the Engineering Mechanics Division, ASCE, EM2, pp. 275-291, April 1976

"Inelastic Response of Nuclear Piping Subjected to Rupture Forces" (coauthor J. C. Anderson), Journal of Pressure Vessel Technology, ASME, pp. 98-104, May 1976

"A Probabilistic Model for Seismic Analysis of Nuclear Plant Structures" (coauthor S. Singh), Paper K3/3, 4th International Conference on Structural Mechanics in Reactor Technology, San Francisco, California, August 15-19, 1977

"Dynamic Analysis of Piping Systems Using Substructures" (coauthor V. Kumar), presented at the ASME Design Engineering Technical Conference, Chicago, Illinois, Preprint No. 77-DET-144, September 26-30, 1977

"Technical Bases for the Use of the Square Root of the Sum of Squares (SRSS) Method for Combining Dynamic Loads for Mark II Plants" (coauthors S. W. Tagart and C. V. Subramanian), General Electric Company Report NEDE 24010, July 1977

"Dynamic Analysis Using Modal Synthesis," Journal of the Power Division, ASCE, PO2, pp. 131-140, April 1978

"Response Analysis Using Dynamic Influence Coefficients" (coauthors T. P. Khatua, N. A. Holmes and S. L. Chu),

Publications, Continued

Proceedings of the 7th Conference on Electronic Computation, American Society of Civil Engineers, St. Louis, Missouri, August 1979

"Structural Building Response Review" (coauthors T. I. Hsu and T. P. Khatua), NUREG/CR 1423, Vol. II, U.S. Nuclear Regulatory Commission, Washington, D.C., May 1980

"Prevention and Control of Vibrations," (coauthor D. E. Olson), presented at the General Engineering Conference, Chicago, Illinois, March 1980

"Vibration in Power Plant Structures and Piping" (coauthor D. E. Olson), Proceedings of the American Power Conference, Chicago, Illinois, April 1980

"Soil Structure Interaction Using Substructures" (coauthors T. I. Hsu and N. A. Holmes), Proceedings of the ASCE Specialty Conference, Civil Engineering and Nuclear Power, Knoxville, Tennessee, September 1980

"Evaluation of Soil Structure Interaction Methods" (coauthors T. I. Hsu, T. P. Khatua and S. L. Chu), presented at the second ASCE Engineering Mechanics Division Specialty Conference on Dynamic Response of Structures, Atlanta, Georgia, January 1981

"Seismic Analysis - Changing Considerations," Proceedings of the American Power Conference, Chicago, Illinois, April 1981

"An Integrated and Interactive Piping Analysis and Design Information System" (coauthor C. A. Podczerwinski), Proceedings of the General Engineering Conference, Chicago, Illinois, March 1982

"Modeling Considerations for Pool Dynamic Analysis," (coauthor D. C. Gupta), paper to be presented at the International Workshop on Soil Structure Interaction: Practical Solutions for Static and Dynamic Loading, Durkee, India, October 10-14, 1983

"Use of Sampling in Nuclear Power Plant Applications," (coauthors M. Amin and P. Y. Wang), paper to be presented at the ASCE Speciality Conference on Probabilistic Mechanics and Structural Reliability, Berkeley, California, January 11-13, 1984