COMMONWEALTH EDISON COMPANY
Date: July 2, 1984

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
(REINSPECTION PROGRAM - WORK QUALITY)

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

II. Mr. Singh was involved in preparing the portion of the Byron Reinspection Program Report which dealt with the inferences of work quality from the Program.

III. Mr. Singh has applied principles of statistics and probability theory to the results of the engineering evaluations discussed in the testimony of Messrs. McLaughlin, Leone and French. He concludes with a 95% confidence level that, in general, the work performed by Hatfield and Hunter meets the original design basis with a greater than 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 pro-

moted 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 problem analyses, and computer program development. In 1980, I was made an associate of Sargent & Lundy.

Q.4. Are you familiar with the Byron Reinspection Program?

A.4. Yes. The reinspection program was developed by Commonwealth Edison Company to verify the effectiveness of former inspector certification practices and inspector qualification by re-examining, on a sampling basis, inspections performed by QC inspectors certified prior to 1982.

Q.5. Were you involved in the preparation of the report?

A.5. Yes. I was involved in preparing portions of the report dealing with work quality, including the section on inference of work quality from the reinspection program.

Q.6. What is the purpose of your testimony?

A.6. The purpose of my testimony is to apply principles of statistics and probability theory to the results of

the engineering evaluations discussed in the testimony of Messrs. McLaughlin, Leone and French.

Q.7. Would you summarize the results of the engineering evaluations to which you are applying your statistical analysis?

A.7. Yes. Their testimony explains that the results of engineering evaluations performed by Sargent & Lundy demonstrated that none of the 356 Hatfield Electric Company ("Hatfield") weld discrepancies analyzed or any of the 2,311 objective discrepancies analyzed had design significance. Similarly, the engineering evaluations demonstrated that none of the 109 Hunter Corporation ("Hunter") weld discrepancies or 689 Hunter objective discrepancies analyzed had design significance.

Q.8. Applying a statistical analysis to these results, what conclusions do you reach with respect to the total population of work performed by Hatfield and Hunter?

A.8. From a statistical standpoint, I conclude with a 95% confidence level that, in general, the work performed by Hatfield and Hunter meets the original design basis with a greater than 99% reliability.

Q.9. Please explain the basis for your conclusions.

A.9. 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 Hatfield welding, approximately 28,000 welds were reinspected. This resulted in approximately 2,200 observed discrepancies. This shows that 8% of the Hatfield welds do not meet the conservative specifica-

tion requirements. From this population of approximately 2,200 welds, 356 welds were evaluated for the design significance of the observed discrepancies. 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 observed discrepancies do not have any design significance.

For Hatfield objective attributes, approximately 67,000 items were reinspected. This resulted in approximately 2,300 observed discrepancies. All these observed discrepancies were evaluated for design significance. 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, in general, greater than 99% of all Hatfield objective work in the plant meets the design requirements.

The actual reliability levels for each of the 10 objective attributes reinspected are shown in Table 1. The table shows that for 8 out of 10 attributes the reliability is greater than 99%. For the remaining two attributes, the reliability is computed as 98.9 and 96.3 percent.

For Hunter welding, a total of 3,725 welds (1,007 AWS and 2,718 ASME) were reinspected. Discrepancies were observed in 60 AWS welds and 49 ASME welds. These observed discrepancies were evaluated for their design significance. 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 Hunter welds meet the design requirements.

For Hunter objective work, a total of 34,878 hardware items were reinspected. This resulted in 248 observed discrepancies. All these observed discrepancies were evaluated for their design significance. 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 more than 99% of all Hunter hardware work items meet the design requirements.

TABLE 1:
CALCULATED RELIABILITIES FOR WORK OF HATFIELD

		No. of Inspected Items	No. of Discrepancies with Design Significance	Reliability % at 95% Confidence Level
	Objective Attributes			
1.	Conduit	2,793	0	99.9
2.	Terminations	7,784	0	>99.9
3.	Equipment setting	778	0	99.6
4.	A325 bolting	295	0	98.9
5.	Equipment modification	1,850	0	99.8
6.	Conduits as-built	44,777	0	>99.9
7.	Pan hangers	4,776	0	>99.9
8.	Pan	80	0	96.3
9.	Conduit support bolting	1,008	0	99.7
10.	Concrete expansion anchor	2,840	0	99.9