UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION



BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| In the Matter of | ) | |
| | ) | |
| COMMONWEALTH EDISON COMPANY | ) | Docket Nos. 50-454-OL |
| | ) | 50-455-OL |
| (Byron Station, Units 1 and 2) | ) | |

TESTIMONY OF BRADLEY F. MAURER

Q.1. State your name.

A.1. Bradley F. Maurer

Q.2. What is your business address?

A.2. P. O. Box 355, Pittsburgh, Pennsylvania 15230.

Q.3. By whom are you employed?

A.3. Westinghouse Electric Corporation ("Westinghouse").

Q.4. Describe your education after you graduated from high school.

A.4. I graduated from Kansas State University with a B. S. degree in Mechanical Engineering.

Q.5. Describe your employment by Westinghouse.

A.5. In July 1973, I joined Westinghouse in the Nuclear Safety Department of the Water Reactors Division. My duties included evaluation and application of safety criteria to various nuclear power plant systems and components, and preparation of licensing documentation.

In June 1977, I transferred to the Mechanics and Materials Technology Department in the Water Reactor Division. I was the primary technical interface between the Mechanics and Material Technology Department and the Nuclear Safety Department. I made a number of presentations and provided technical assistance in support of licensing activities. I performed thermal seismic and LOCA analysis of Class 1 piping systems. I was also responsible for the preparation of the design specification for NSSS primary equipment supports, and for the formulation and interpretation of criteria involving safety class piping and supports. In addition, I was responsible for the turbine missile probability analysis for the Philippine Nuclear Plant. I was promoted to Senior Engineer in May 1980.

In August 1981, I transferred to my present position in Equipment Qualification Analysis. My responsibilities include qualification of various electrical equipment and devices by analysis and by shake table testing, and main control board qualification by analysis. I have performed seismic qualification of Class 1E medium power transformers using a combination of shake table testing and analysis. I have conducted seismic testing programs on electrical components of the Process and Protection System. I have assisted in the analysis of main control boards for several nuclear plants. In conjunction with other senior engineers in the Equipment Qualification Analysis group, I performed the structural analysis of the Byron main control board and other main control panels.

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

A.6. The scope of this testimony is to describe the analyses and inspections performed by Westinghouse to address the structural adequacy of main control panels which were designed and fabricated by Systems Control Corporation ("SCC") for the Byron Station. Analysis methodology and results are presented which demonstrate that these control panels will, with significant margin, maintain their structural integrity when subjected to a design basis seismic event, the safe shutdown earthquake, at the Byron site. This is the condition under which maximum loads would be applied to the main control panels.

Westinghouse has significant experience in seismic qualification of this type of equipment. Analyses using state-of-the-art computer modeling techniques have been completed for a number of main control boards at Byron and other nuclear plants. In addition, shake-table tests have been performed, the results of which validate the use of Westinghouse computer modeling techniques.

Q.7. Where are the main control panels located in the Byron plant?

A.7. They are located in the control room and contain the instruments, monitors and controls for all aspects of the operation of the Byron station. Some panels control safety-related functions while others control non-safety-related functions.

Q.8. Please describe the configurations of the main control panels and identify how many were supplied by SCC.

A.8. The main control panels are of two basic configurations. The first is characteristic of the main control board and consists of a vertical portion containing various meters, recorders, and indicators, and an angled bench portion which contains primarily switches and controllers. The main control board consists of seven separate sections which are arranged in a U-shaped assembly. The sections are bolted together and welded to the steel floor embedments. The main control board sections are a little over eight feet high and when assembled together are about 95 feet long. Four of the seven main control board sections contain equipment to monitor and control Nuclear Steam Supply System (NSSS) functions. These sections were designed by

Westinghouse and fabricated by the Reliance Electric Company. The remaining three sections, which contain equipment to monitor and control various balance of plant systems were designed and fabricated by SCC.

The second control panel configuration is characterized by stand-alone panels or panel line-ups in which the full height of the front face is vertical for location of the various instruments. The majority of these control panels were also designed and fabricated by SCC. The control panels which are mounted adjacent to each other are bolted together. All control panels are welded to the steel floor embedments. The control panels are approximately eight feet high and vary in length from about seven feet to over thirteen feet.

Q.9. What role did Westinghouse have with respect to an analysis of the structural adequacy of Byron main control panels supplied by SCC?

A.9. Westinghouse involvement with the structural adequacy of Byron main control panels initially began with a contractural obligation to seismically qualify the Westinghouse supplied portion of the main control board. In September 1981, Commonwealth Edison and Westinghouse agreed that, with some additional effort, the balance of plant sections could be evaluated as part of the main control board analysis. Thus all main control board sections would be coupled together in a single mathematical model which would be used to evaluate the response of the entire structure. In early 1982 Commonwealth Edison authorized Westinghouse to seismically qualify all control panels in the main control room.

Q.10. Had there been any earlier analyses or evaluations of the SCC main control panel?

A.10. At the time that Westinghouse began the main control panel qualification effort, it was recognized that Wyle Laboratories, under contract to SCC had performed seismic simulation shake-table tests on four of the control panels in the Byron main control room. The panels were tested individually to levels in excess of the main control room floor reponse spectra and demonstrated no degradation of structural integrity. I reviewed the reports of the tests conducted by Wyle Laboratories The tests were performed in accordance with standard practice and the results are reliable.

Q.11. Why were additional analyses necessary?

A.11. There were two areas in which the shake table tests did not provide complete information for panel qualification in view of the technology available in 1982 and 1983 to analyze these panels.

First, because the panels were tested as single units, the effect of any interaction due to other structures connected to the panels could not be obtained from the test results. Three of the four tested panels are bolted to adjacent control panels in the main control room. Second, for the qualification of Class 1E instrumentation mounted on these panels, it is necessary to define the seismic levels for these instruments at their mounting locations on the panel. The data recorded during the shake table tests was not sufficient to determine the necessary seismic levels for instrument qualification. For these two reasons, all main control panels were included in the Westinghouse analysis qualification program, regardless of their inclusion in the Wyle tests.

Q.12. What technique was used by Westinghouse to analyze the main control boards?

A.12. The structural adequacy of the main control panels was established through the use of detailed computer analysis using finite element modeling techniques. Analysis with finite elements involves building a computer model of the structure using mathematical representations of the structural members. The panels were analyzed as a unit to take account of the interactive effects described in answer to Question 11. For the modeling of the control panels, three basic types of member representations, or elements, were employed: beam elements, plate elements, and lumped mass elements. The welds in the main control panels were assumed to be adequate for this portion of the analysis. The mathematical models were constructed using the Westinghouse Electric Computer Analysis (WECAN) computer program, developed and maintained by Westinghouse. The finite element analysis generates loads and stresses in each structural member in the model based on the seismic input at the main control room floor elevation, which was developed by Sargent and Lundy.

Q.13. Did you make any further analysis of the welds in the main control panels?

A.13. Yes. In order to assure that the analysis addressed the as-built condition of the control panel welds I inspected the control panel structural welds in March 1983. I was accompanied by a certified Level II welding engineer employed by Westinghouse. The inspection was visual and was undertaken to determine the overall quality of the welds. Paint was not removed from the welds. The inspection included each control panel in the main control room. All accessible welds were inspected, concentrating on the welds connecting primary structural members, such as K-frames. These welds are the primary welds of significance to a determination of structural adequacy. Approximately 90% of the primary structural welds, and approximately 70% of the welds in members of secondary importance, were accessible for inspection.

Q.14. What were the results of this inspection?

A.14. The results of this inspection were:

1. Overall, the welds are evenly spaced and consistent in length and size.
2. Fillet contour was generally consistent; however, some welds exhibited excess convexity. This is only a cosmetic variation and does not affect the integrity of the weld.
3. Several instances of excessive weld spatter were noted. Again, the effect is only cosmetic; no rework was necessary.
4. No significant cratering, porosity, or undercut was observed.
5. No cracks were observed during this inspection, which concentrated on the primary structural member welds.

The results of our inspection demonstrated that the condition of the welds was acceptable. In addition, several welds were added to the Unit 2 main control board to assure that sufficient weld length existed for all members. The main control board for Unit 1 contained sufficient weld length for all structural members that were inspected.

Q.15. What use, if any, was made of the results of this inspection?

A.15. Using minimum values for weld length and size which were indicated as a result of our visual inspection, and the maximum loads generated by a seismic event acting on each type of structural member as determined by the finite element analysis described above, I then calculated whether specific welded connections would have sufficient strength to withstand these applied loads. The weld analysis and acceptance criteria followed the recommendations specified in Blodgett's "Design of Welded Steel Structures ", a recognized authoritative source for this type of analysis.

Q.16. What conclusions did you reach regarding the structural adequacy of the SCC main control panels and the welds you analyzed?

A.16. My conclusions are set forth in Westinghouse proprietary reports which were submitted to Commonwealth Edison Company in the fall of 1983. The results of the finite element analysis indicate that the main control board and most of the control panels do not have natural frequencies below approximately 25 hertz, and thus will not experience dynamic amplification of the floor seismic input. For those panels which do exhibit frequencies in this range, dynamic analysis was utilized to determine loads and stresses, and to develop amplified seismic levels for Class 1E instrument qualification.

The allowable stress criteria applied in the determination of acceptability of the structural members in the control panels were taken from the AISC Manual of Steel Construction; specifically, the allowable maximum stress is 60 percent of the material yield stress. The structural welds were evaluated using Blodgett's design criteria which limits the maximum stress to approximately 60 percent of the shear yield stress.

The maximum stress calculated for the internal structural welds in the SCC main control panels is 80% of that allowed by the Blodgett design criteria. Similarly, the maximum stresses calculated for the floor attachment welds are 51% of the allowable value for the main control board sections and 65% of the allowable value for the other main control panels, again based on Blodgett's design criteria. For structural members of the control panels, the maximum calculated stress is 60% of the allowable design value specified by AISC.

A more meaningful measure of the margin of safety inherent in the construction of the main control panels is a comparison of the maximum calculated stress levels to the shear yield stress for welded connections and material yield stress for structural steel components. The yield stress in a material is reached when the applied load is large enough to produce plastic behavior in the material. It is important to realize that even if a welded connection or a structural member were to experience loads sufficient to cause yielding, this does not imply structural failure, as the yield stress is still lower than the ultimate stress at which failure would occur.

For the internal structural welds in the main control panels, the calculated stress indicates a minimum margin of safety of 1.9, based on the shear yield stress of the weld metal. This means that the loads applied to the control panels would have to be 190% higher than the Byron seismic loads in order to reach the yield stress. Likewise, the maximum stresses in the floor attachment welds indicate a margin of safety of 3.1 for the main control board sections, and 2.4 for the other main control panels, again based on the shear yield stress of the weld metal. The maximum calculated stress in the structural members of the control panels indicates a margin of safety of 2.8, based on the material yield strength. Based on these considerable margins of safety, it is concluded that the structural integrity of the Byron main control panels, including those supplied by SCC, will be maintained in the event of a design basis earthquake for the Byron site.