2/22/83

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
	)	50-455
(Byron Station, Units 1 and 2)	)	

TESTIMONY OF JAI RAJAN ON DAARE/SAFE
CONTENTION 9C AND LEAGUE CONTENTION 22

RAJAN SUMMARY

The following testimony addresses that aspect of DAARE/SAFE Contention 9(c) and League Contention 22 concerning flow-induced tube vibrations in Model D steam generators. It makes the following principal points:

1. A relatively recent problem with flow induced vibration and subsequent wear of tubes in the preheater section of Model D steam generators has been identified at lead operating facilities with Model D steam generators.

2. Early studies by Westinghouse have indicated that for the counter-flow type preheater (Model D-4/5), vibration response in the preheater section is negligible for main feedwater flow rates up to about 70%.

3. Westinghouse has installed modifications entailing feedwater flow configuration to the auxiliary feedwater system at the foreign operating facility with Model D-4 steam generators.

4. Westinghouse has also initiated a generic Model D-4/D-5 program which includes an evaluation of alternative modifications to correct the preheater vibration problem.

5. It is not clear whether the Westinghouse program to develop corrective modifications can be completed in time to permit Staff review and approval and to permit installation of these modifications before Unit 1 is scheduled to receive an operating license. If these modifications do not become available in time, the Staff believes it is likely that the Applicant could justify an acceptable program for interim operation pending implementation of an acceptable program.

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TESTIMONY OF JAI RAJ N. RAJAN
REGARDING DAARE/SAFE CONTENTION 9(c) AND LEAGUE CONTENTION 22

Q1. Please state your name and affiliation.

A1. My name is Jai Raj N. Rajan. I am a Mechanical Engineer in the Mechanical Engineering Branch, Division of Engineering, NRC Office of Nuclear Reactor Regulation. A statement of my professional qualifications is attached.

Q2. What is the purpose of this testimony?

A2. The purpose of this testimony is to address the Staff position with regard to that aspect of DAARE/SAFE Contention 9(c) and League Contention 22 concerning flow-induced tube vibrations in Model D steam generators.

Q3. Has there been any adverse operating experience regarding tube degradation at plants which employ Westinghouse Model D steam generators?

A3. Yes. A relatively recent problem with flow induced vibration and subsequent wear of tubes in the preheater section of Model D steam generators has been identified at lead operating facilities with Model D steam generators. These include McGuire Nuclear Station

Unit 1 (Model D-2) and three foreign faciliites (Models D-3 and D-4). Based upon data available at this time, the tube excitation mechanism appears to be a combination of a threshold type of fluid elastic instability and turbulent buffeting.

Q4. Has Westinghouse undertaken any studies to assess the significance of the problem for the Model D-4/D-5 steam generators utilized at Byron?

A4. Yes. Model D-4 and D-5 steam generators employ a counter-flow type preheater design as opposed to the split-flow design employed for Model D-2 and D-3 steam generators. Early studies by Westinghouse have indicated that for the counter-flow type preheater, vibration response in the preheater section is negligible for main feedwater flow rates up to about 70% (i.e., threshold value). Internal accelerometer instrumentation at the foreign facility, which is the first operating Model D facility employing the counter-flow (Model D-4) type preheater, has recently indicated evidence of vibration activity at a power level above 70%.

Q5. Are any modifications under current assessment for the operating facility utilizing a Model D-4 steam generator?

A5. Yes. Westinghouse has installed modifications to the auxiliary feedwater system at the foreign operating facility with Model D-4 steam generators. These modifications permit 30% of the total feedwater flow at 100% of full power to enter the steam generators through the auxiliary feedwater nozzel which is located above the tube bundle. This would permit the feedwater flow through the main feedwater nozzel and the preheater section to be limited to 70% of total feedwater flow which Westinghouse had believed would not lead to significant tube vibration in the preheater region on the basis of its early analysis and test data. However, there is some preliminary information (accelerometer data from the foregin facility) which suggests the tube vibrations corresponding to the 70%-30% split feedwater flow configuration is higher for some tubes than that for a 70%-0% (i.e., no auxiliary feedwater flow) configuration. Thus, it is unclear at this time whether this modification will be sufficient to correct the tube vibration problem sufficiently to preclude significant wear degradation at 100% power.

Q6. How will the success of these potential modifications be verified?

A6. Implementation of these modifications at the foreign facility will be followed by an analysis of accelerometer data during subsequent operation and eventually by eddy current testing to verify that the vibration and tube wear problem has been corrected.

Q7. Are any alternative corrective modifications under active consideration by Westinghouse?

A7. Yes. In parallel with the effort underway to develop and implement auxiliary feedwater system modifications at the foreign operating D-4 facility, Westinghouse has also initiated a generic Model D-4/D-5 program which includes an evaluation of alternative modifications such as tube expansion to correct the preheater vibration problem. This generic program will include extensive analyses and tests, including large scale model tests, to evaluate the causes of present difficulties and to evaluate the effectiveness of various corrective modifications.

Q8. Will implementation of steam generator modifications to correct the potential vibration problem be required as a condition for issuing an operating license?

A8. Based on the latest information available, it is not clear whether the Westinghouse program to develop corrective modifications can be completed in time to permit Staff review and approval and to permit installation of these modifications before Unit 1 is scheduled to receive an operating license. If these modifications do not become available in time, the applicant may propose a program for interim operation of the unit pending implementation of appropriate program. The Staff believes it is likely that the Applicant could justify an acceptable program for interim operation which provides reasonable assurance of tube integrity and safe operation of the facility. The elements of such a program could be similar to that which has previously been approved for McGuire Unit 1 (Model D-2) and involve (1) operation at power level less than 100% where feedwater inlet velocities are less than that necessary to result in excessive tube vibrations, (2) frequent shutdowns in excess of Technical Specification requirements to ensure that wear is not developing at higher than anticipated rates, and perhaps (3) the use of accelerometers to provide additional assurance that excessive tube vibrations are not occuring. The specifics of such a program, and the justification (analytical and test data, and operating experience from operating plants with similar steam generators) would be reviewed by the Staff prior to issuing an operating license. Based on review of tube vibration data obtained at a foreign plant, it is the Staff's assessment that operation at 70% power level may be acceptable on a long-term basis.

PROFESSIONAL QUALIFICATIONS

JAI RAJ N. RAJAN

U. S. NUCLEAR REGULATORY COMMISSION

MECHANICAL ENGINEERING BRANCH

DIVISION OF ENGINEERING

I am a mechanical engineer responsible for reviewing and evaluating safety analysis reports with regard to mechanical engineering aspects of components, the dynamic analyses and testing of safety related systems and components and the criteria for protection against the dynamic effects associated with postulated failures of fluid systems for nuclear facilities. I am the Mechanical Engineering Branch's principal reviewer on the issue of the structural integrity and plugging criteria of degraded steam generator tubes. I am also responsible for the review and evaluation of vibration problems of a generic nature in the piping systems and components of nuclear facilities.

I received a B.S. degree in 1953 from Lucknow University India majoring in Physics, Mathematics and Chemistry. In 1956 I received a B.S. in Civil Engineering from Roorkee University, India majoring in Structural and Hydraulic Engineering. In 1962 I received a M.S. degree from Duke University majoring in Applied Mechanics and Ph.D. degree in 1966 from the same university with majors in Fluid Mechanics. From 1960 to 1962 I was an instructor in structural engineering at Duke University. From 1962 to 1966 I was employed by the U.S. Army Research Office in Durham, N.C. as a research engineer conducting theoretical and experimental research in high pressure pneumatic and hydraulic shock tubes and investigating wave propagation phenomenon in pipes. From 1966 to 1973 I worked as a project mechanical engineer and subsequently as a senior project mechanical engineer at the Naval Research and Development Center at Annapolis, Md. Major projects involved design analysis, test and evaluations of fluid piping systems and power fluid systems of advanced nuclear submarines. Investigations were multidisciplinary in scope utilizing advanced techniques. Mathematical models of power plant machinery and piping systems of nuclear submarines were developed and analyzed to determine system response to flow induced vibrations and hydraulic shock. Thermodynamic and hydrodynamic analyses of naval boilers and steam plants were conducted including full scale tests.

In April of 1974 I joined the U. S. Atomic Energy Commission prior to the formation of the U. S. Nuclear Regulatory Commission and have remained with the Mechanical Engineering Branch of the Division of Engineering as a mechanical engineer performing the type of work as previously described.

I have taught at the University of Maryland on a part-time basis since 1967 both at the graduate and undergraduate levels in courses of mechanics of materials, fluid mechanics and applied mechanics.

Publications include Journals of AIAA and ASME and I am an associate member of Sigma Xi honor society.