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 CONRAD MCCRACKEN ON DAARE/SAFE CONTENTION 9C AND LEAGUE CONTENTION 22

McCracken Summary

The following testimony addresses those aspects of DAARE/SAFE contention 9(c) and League contention 22 dealing with primary and secondary water chemistry control and corrosion as it relates to steam generator tube integrity. It makes the following principal points.

1. Numerous changes in steam generator and secondary cycle design and operational procedures, such as secondary water chemistry control, have been incorporated at Byron to minimize steam generator corrosion degradation.

2. These modifications, in conjunction with regulatory requirements for inservice inspection, make it highly unlikely that a steam generator tube rupture will occur due to corrosion.

3. These same elements, combined with tube plugging criteria, further minimize the probability of tube leakage.

4. Since the industry conversion to an all volatile secondary side chemistry treatment (AVT) in 1974, no plant which has begun operation on AVT has detected secondary side-initiated stress corrosion cracking.

5. Surveillance requirements and technical specifications will ensure that steam generator tube integrity will be monitored and maintained within allowable limits.

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(Byron Station,	)	
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TESTIMONY OF CONRAD E. McCRACKEN
ON DAARE/SAFE CONTENTION 9 (C) AND LEAGUE CONTENTION 22

Q.1 Please state your name and position with the NRC?

A.1 My name is Conrad E. McCracken. I am the Section Leader of the Chemical Technology Section, Chemical Engineering Branch, NRC Division of Engineering. A copy of my professional qualifications is attached.

Q.2 What is the purpose of this testimony?

A.2 The purpose of this testimony is to address those portions of DAARE/SAFE contention 9(c) and League Contention 22 dealing with primary and secondary water chemistry control and corrosion, particularly as it relates to steam generator tube integrity.

Q.3 What action has been taken at Byron to ensure that corrosion degradation of the steam generators is minimized?

A.3 Numerous design changes and operational procedures have been specifically incorporated at Byron to minimize steam generator corrosion. These include:

1. Steam Generator Design (Model D-4) Unit No. 1:
   - (a) Elimination of tubesheet crevices;
   - (b) Counterflow (axial flow) preheater which minimizes the propensity for steam blanketing; and
   - (c) Increased blowdown capability, plus a blowdown tee in the middle of the hot leg bundle to remove corrosion products on the tubesheet.
2. Steam Generator Design (Model D-5) Unit No. 2:
   - (a) Same as D-4, plus;
   - (b) 405 ferritic stainless steel tube supports; which are more corrosion resistent;
   - (c) Broached tube support holes, which further reduce/minimize concentrating crevices; and
   - (d) The Inconel 600 tubes are thermally tested to enhance corrosion resistance.

3. Balance of Secondary Cycle Design:

   (a) Improved condenser design, including stainless steel tubes and the ability to individually sample at eight condensate locations to minimize condenser leakage;

   (b) Feedwater recirculation line to facilitate system cleanup prior to initiating flow to the steam generators; and

   (c) Installation of a condensate polishing system for feedwater purification which processes one third of the total feedwater flow continuously during startup. Additionally, this system will be used to aid in rapid cleanup when condenser leakage occurs.

4. Operational Considerations:

   (a) A condition in the plant technical specification has been incorporated which requires a secondary cycle water chemistry program. Byron's secondary water chemistry control program was reviewed against the criteria of SRP 5.4.2.1 and was found acceptable. The secondary water chemistry program includes: (i) specific limits for impurities in the steam generators; (ii) power reduction to 50% if steam generator impurity limits are exceeded to minimize concentration of corrosive species; (iii) shutdown and flushing of steam generators if water chemistry becomes progressively worse; and (iv) administrative controls defining responsibility for interpretation of and corrective actions based on secondary water chemistry limits.

The combination of the above listed design changes and procedures will significantly reduce the potential for corrosion degradation of the Byron steam generators.

Q.4 Will the modifications which have been made prevent steam generator tube corrosion?

A.4 All metals which maintain contact with an aqueous environment will corrode at a given rate, depending on the corrosion potential of the aqueous environment. Therefore, corrosion of steam generator tubes will not be prevented but it will be reduced.

Q.5 Will steam generator tube corrosion be minimized to the extent that steam generator tube leaks or ruptures will not occur.

A.5 The modifications that have been incorporated at Byron in conjunction with regulatory requirements for ISI make it highly unlikely that a steam generator tube rupture will occur due to corrosion. To date there have only been two steam generator tube ruptures at operating PWR's as a consequence of corrosion. A 125 gpm rupture occurred at Point Beach in 1975 and a 50 to 80 gpm rupture occurred at Surry in 1976. It has been over six years since a steam generator tube rupture due to corrosion has occurred.

The rupture at Point Beach was caused by secondary side intergranular stress corrosion cracking which occurred as a consequence of reactions between condenser inleakage impurities and residual phosphates. Byron will use all volatile chemistry treatment (AVT); consequently, the chemical reactions which caused the Point Beach rupture cannot occur at Byron. Since the industry conversion to AVT in 1974, no plant which has started up on AVT has detected secondary side initiated stress corrosion cracking.

The rupture at Surry was initiated from the primary side of the tube and caused by excessive tube stress. The excessive tube stress resulted from extensive tube denting which first froze the tube in place and then physically moved the tube support plates, resulting in a significant deformation of the tube and resultant high stress. The water chemistry control requirements at Byron in conjunction with ISI requirements will combine to make it highly unlikely that extensive denting will occur.

The design modifications and procedures incorporated will also act to reduce the probability of tube leakage. However, it can be anticipated that some instances of steam generator tube leakage will occur during the plant lifetime. The inservice inspection program, combined with tube plugging criteria, will minimize these occurences.

Q.6 What is denting and can we anticipate denting in the Byron steam generators?

A.6 Denting is a process whereby corrosive impurities are concentrated between a heat transfer tube and the tube support. The resultant corrosion converts the base support metal to metal oxide. In the case of carbon steel supports, the metal oxide occupies approximately twice the space of the original metal. Thus, it closes the gap between the support and the tube. Once the tube to tube support gap is closed, the occurrence of additional corrosion will exert pressure on the tube until sufficient pressure is applied to plastically deform (dent) the tube.

It is probable that denting, to some extent, will occur in the Byron steam generators. Based on PWR experience to date, I would anticipate that Unit No. 1 could have minor denting within 3 to 10 years, based on how well feedwater chemistry is controlled. Unit No. 2 which has ferritic stainless steel tube supports will take significantly longer to dent, if denting occurs at all.

Q.7 What is the effect of denting on steam generator tube leakage?

A.7 Denting does not directly result in steam generator tube corrosion. It simply deforms a tube which increases the tubing stress. As tubes become more highly stressed, they are more susceptible to stress corrosion cracking. In instances where denting is controlled to prevent significant movement of the support plate, it is unlikely that sufficient tube stress will be induced to significantly increase the stress corrosion cracking potential. Therefore, the occurrence of denting at the Byron units does not indicate that the propensity for steam generator tube leakage has been increased.

Q.8 In summary, what is your opinion of the secondary chemistry and corrosion control program and features at Byron Station?

A.8 The improved chemistry and corrosion control measures at Byron will significantly reduce the rate of corrosion of steam generator tubes. Surveillance requirements and technical specifications will ensure that steam generator tube integrity will be monitored and maintained within allowable limits. The combination of improved chemistry corrosion control and surveillance requirements provide reasonable assurance that the public health and safety are protected.

[illegible]

Professional Qualifications

I am Section Leader of the Chemical Technology Section in the Chemical Engineering Branch of the Division of Engineering, Office of Nuclear Reactor Regulation. My responsibilities in this position include supervision of the evaluation of all PWR's for compliance with chemistry and corrosion requirements of the commission. Specifically, this includes evaluating the chemistry and corrosion control measures that are instituted to minimize corrosion of steam generator materials. I have served in this capacity since April 1982. Between February 1981 and April 1982 I served as a senior chemical engineer with the same branch, where my duties included the evaluation of steam generator chemistry and corrosion program at both operating plants and plants in the licensing process.

From 1966 to 1981 I was employed by Combustion Engineering Corporation in a variety of management and engineering positions, the last of which was Manager of Chemistry Development from 1977 to 1981. During this 15-year period, my prime technical responsibility was support to operating nuclear power plants and nuclear plants in construction in the area of chemical and radiochemical sampling, analysis, data interpretation, establishing chemistry specifications and conducting laboratory experiments to verify or support nuclear plant requirements. In this capacity I made frequent visits to nuclear power plants where I physically conducted sample and analysis programs or audited the utilities' capabilities in the chemistry and radiochemistry area. During the last twelve years at Combustion Engineering, approximately fifty percent of my time was expended in areas associated with understanding and resolving steam generator corrosion problems.

From 1958 to 1966 I served in the United States Navy where I was Qualified in submarines for all nuclear duties. For three years of this period I was an instructor, responsible for teaching office and enlisted personnel in the area of chemistry, corrosion and mechanical systems operation and control. My final duty station in the Navy was on the USS Nautilus where I was responsible for all chemistry and corrosion control and personnel radiation exposure.

Education

I attended the University of Hartford School of Engineering and completed course work in 1970. I am a Registered Professional Corrosion Engineer.