

Commonwealth Edison Company
1400 Opus Place
Downers Grove, IL 60515-5701

January 30, 1997

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ComEd

Attn: Document Control Desk

Subject: Additional Information Pertaining to
Zion Unit 2 Steam Generator Inspection

Zion Nuclear Power Station Unit 2
NRC Docket Number: 50-304

Reference: Commonwealth Edison Company/Nuclear Regulatory Commission
Meeting dated November 15, 1996

At the November 15th meeting, the Commonwealth Edison Company (ComEd) and the Nuclear Regulatory Commission (NRC) discussed the Zion Unit 2 steam generators inspection results. During that meeting the preliminary results of the structural assessment of Tube R01C72, Steam Generator 3 were discussed. Subsequent to that meeting, the finalized calculation was completed which confirmed the preliminary results that the burst pressure would be in excess of the differential pressure load associated with a margin of three against burst during normal operating conditions. As you requested this finalized evaluation which has been reviewed and approved by ComEd is provided in Attachment A. Also, provided in Attachment B is the summary of the Zion 2 U-bend history along with ComEd's conclusion that the history reflects expected primary water stress corrosion cracking (PWSCC) with improved Plus Point Probe sensitivity.

If you have any questions concerning this correspondence, please contact Denise Saccomando, Senior PWR Licensing Administrator at (630) 663-7283.

Sincerely,

John B. Hosmer

John B. Hosmer
Engineering Vice President

Attachments

cc: C. Shiraki, Zion Project Manager-NRR
A. Vogel, Senior Resident Inspector-Zion
A. B. Beach, Regional Administrator-RIII
Office of Nuclear Safety- IDNS

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Attachment A

“Evaluation of Steam Generator 3, R01C72 U-Bend Indication”



NSD-RFK-96-040, Rev. 1

From: Steam Generator Design & Analysis
WIN: 224 - 5086
Date: January 27, 1997
Subject: Evaluation of Zion 2, SG 3, R1C72 U-Bend Indication

To: J. Pierce

cc: T. Pitterle
G. Whiteman
D. Malinowski
R. Smith

J. Houtman
W. Cullen
J. Bingaman

Note: Revision 1 corrects two typographical errors contained in the original release. In Section 2 "or rectangular" was corrected to "of rectangular," and "Alloy 600 steam" was changed to "Alloy 600 and 690 steam."

The attached evaluation was performed in response to a request from Mike Sears and Keith Moser, both of Commonwealth Edison, to estimate the structural integrity of the subject tube. The conclusion of the evaluation is that the burst pressure would be expected to be in excess of the differential pressure load associated with a margin to 3 against burst during normal operation conditions and 1.43 during postulated accident conditions, as indicated by the guidelines in draft Regulatory Guide 1.121. Please transmit the evaluation information to John Blomgren of Commonwealth Edison at Downer's Grove, and to Keith Moser at the Zion station.

If you have any questions regarding this letter, please address them to me at the above WIN number.

Sincerely,

Robert F. Keating, Advisory Engineer
SG Design & Analysis

Evaluation of a U-Bend Indication in Tube R01C72, SG 3, at Zion Unit 2

1.0 Introduction

During the most recent inspection of the steam generator (SG) tubes at the Zion 2 nuclear power plant, axially oriented indications were reported for which demonstration of tube integrity relative to the guidelines of draft Regulatory Guide (RG) 1.121 was deemed appropriate. One of the tubes, SG 3, R1C13, was in situ pressure tested to 5000 psi at ambient temperature, Reference 0. The normal operating (NOp) differential pressure, ΔP , during the last operating cycle was 1530 psi at temperature. Thus, the test pressure was 3.3 times the NOp ΔP . Accounting for the reduction in the flow stress of the tube material with temperature, 8.8% per Reference 0, the test pressure was at an equivalent margin of 3.0 relative to normal operation.

The indication in the second tube developed a leak and testing was terminated at a pressure corresponding to main steam line break (SLB) conditions. Since a pressure of 5000 psi could not be achieved by the test equipment, a structural analysis of the tube based on the eddy current inspection reported profile of the indication was requested by Commonwealth Edison.

2.0 Evaluation

The basis for the analysis of the burst pressure was the burst correlation information presented in Reference 0 for throughwall axial cracks in straight tubing. Since the indication is not everywhere throughwall, the correlation result is adjusted to account for the strength of the ligament material. In essence, the indication or crack is analyzed as being of rectangular profile with a linear interpolation being made between the nondegraded and throughwall burst pressures using the ratio of the indication depth to the thickness of the tube. For depths greater than about 75%, the interpolation is nonlinear to account for the fact that thin ligaments have a smaller critical crack tip opening displacement (CTOD) than thick ligaments. The analysis is programmed in a Excel[®] spreadsheet and actually calculates the burst pressure for every possible sub-crack of the main crack. The lowest burst pressure calculated is the value assumed for the tube being analyzed. The certified mill test report properties for the R1C72 tube, Reference 0, were used for the analysis.

The analysis summary sheet is attached. The indication profile as a function of length was adjusted to account for the look-ahead and look-behind characteristics, i.e., end effects (EE), of the eddy current test (ECT) analysis signals. This is most apparent in the figure on the attachment where the depth given by the dashed line appears to increase at the right end of the indication. Using the actual material properties, the estimated burst pressure for the indication

is 4145 psi at normal operating conditions if the indication existed in the straight length of the tubing. References 0 and 0, present the results of burst tests conducted on fabricated straight-leg and U-bend indications in Alloy 600 and 690 steam generator tubes with nominal diameters of 7/8" and 3/4" and wall thicknesses of 0.050" and 0.043" respectively. The test results demonstrate that a 39%¹ increase in the burst resistance of a 1/2" long throughwall indication located on the extrados of a 7/8" diameter tube which has been bent into the U-bend shape for a row 1 tube. Hence, the expected burst pressure for the indication in service would be about 5720 psi. This is a factor of 3.74 times the NOp ΔP or about 125% of the margin of 3 specified in RG 1.121 for normal operating conditions. This would be expected to be quite sufficient to accommodate any potential ECT uncertainties. Moreover, an analysis of the profile with end effects led to a burst pressure prediction of almost 4800 psi or about 3.13 times the NOp ΔP .

It is noted that the guideline for margin during postulated accident conditions leads to a critical applied pressure of 3657 psi. Since this is less than 4590 psi, $3\Delta P$, the normal operation guideline governs. In addition, prior tests have demonstrated that the burst pressure of tubes with axial cracks is not significantly affected by bending loads such as could be developed during earthquake conditions or by flow during other conditions.

3.0 Conclusions

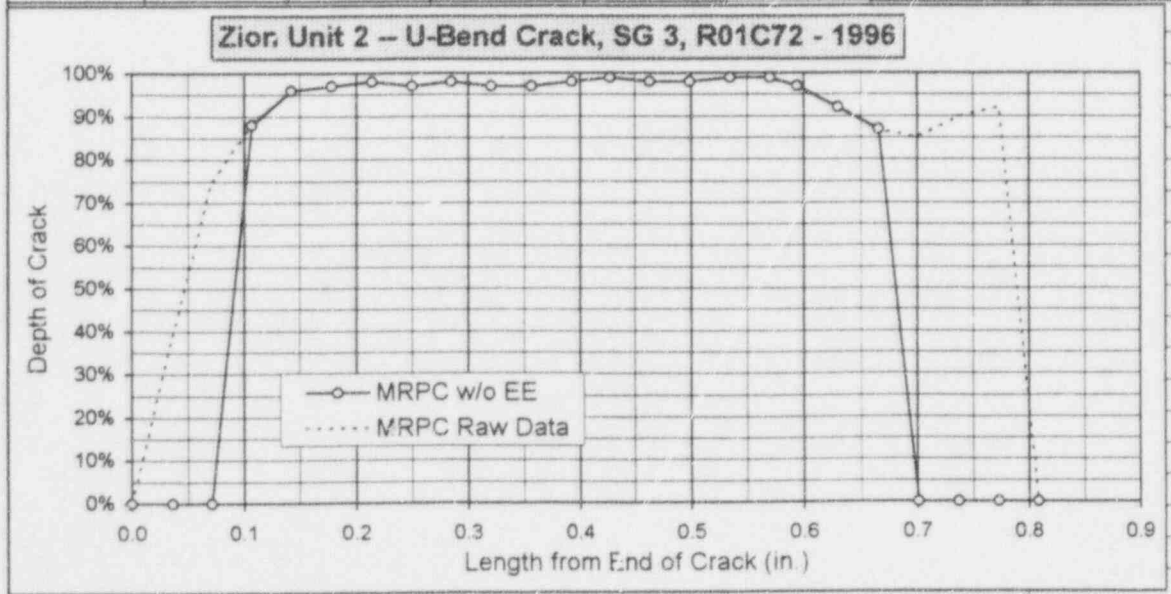
The burst pressure of the indication at normal operating conditions is estimated to be greater than 5700 psi, or 3.74 times the normal operating pressure differential. This is about 1100 psi greater than, or 125% of, the draft RG guideline regarding a margin of three relative to burst during normal operation. In summary, the guidelines of RG 1.121 were met at the end of the current cycle of operation with sufficient margin to accommodate significant ECT error.

¹ The average of three tests on extrados throughwall indications with the range of factors being 1.37 to 1.42.

4.0 References

1. Personal communication with M. Sears (Commonwealth Edison) on November 7, 1996.
2. WCAP-12522, "Inconel Alloy 600 Tubing - Material Burst and Strength Properties," Westinghouse Electric Corporation (January, 1990).
3. SG-95-03-010 (EPRI Licensable), "Burst Pressure Correlation for Steam Generator Tubes with Throughwall Axial Cracks," R. Keating, et al., Westinghouse Electric Corporation (February, 1995).
4. Personal communication with K. Moser (Commonwealth Edison) on November 12, 1996.
5. MT-SGMCE-144, "Burst Tests of Small Diameter U-Bends," A. Klein to C. Hirst, Westinghouse Electric Corporation (June 16, 1982).
6. STD-7.2.4-7180, "PWS 4.802 Final Report," B. Gowda to E. McDonough, Westinghouse Electric Corporation (December 21, 1987).

Zion Unit 2 -- U-Bend Crack, SG 3, R01C72 - 1996							
01/27/97							
OD	t	Rm	Sf.LTL	Sf.Nom	Sf.RT2OP	Sf.cert-RT	Sf.cert-OT
0.875	0.050	0.4125	63.12	68.78	91.1%	78.50	71.54
Pbar2Pb	P0	P.pri	P.sec	dP.nop	dP.slb	3.dP.nop	1.4.dP.slb
15.301	9.147	2.250	0.720	1.530	2.560	4.590	3.657
	MRPC, Final		Adjusted, Final				
Axial Location	Crack Depths	Extrados Lengths	Crack Depths	Extrados Lengths		Weak Link Function Using BKH2 Model	
9.41	0%	0.000	0%			X.min	0.000
9.44	39%	0.036	0%			X.max	0.594
9.47	75%	0.071	0%			Length	0.594
9.50	88%	0.107	88%	0.000		Depth	93.6%
9.53	96%	0.143	96%	0.036		Pb / Sf	0.058
9.56	97%	0.178	97%	0.071		Pb.Nom	3.985
9.59	98%	0.214	98%	0.107		Pb.LTL	3.657
9.62	97%	0.250	97%	0.143		Pb.Cert	4.145
9.65	98%	0.285	98%	0.178		Pb.Thru	4.013
9.68	97%	0.321	97%	0.214	U-Bend location:	Extrados	
9.71	97%	0.357	97%	0.250	U-Bend strength factor:	1.38	
9.74	98%	0.392	98%	0.285		Pb.nom	5.500
9.77	99%	0.428	99%	0.321		Pb.LTL	5.047
9.80	98%	0.464	98%	0.357		Pb.cert	5.721
9.83	98%	0.499	98%	0.392	Pb.cert / dP.nop	3.74	
9.86	99%	0.535	99%	0.428		Estimated burst pressure	
9.89	99%	0.571	99%	0.464		for U-bend axial	
9.91	97%	0.594	97%	0.487		indication.	
9.94	92%	0.630	92%	0.523		Extrados Length Adj	
9.97	87%	0.666	87%	0.559		OD	0.8750
10.00	85%	0.701	0%	0.594		t	0.0500
10.03	90%	0.737	0%			Rm	0.4125
10.06	92%	0.773	0%			R.min	2.1875
10.09	0%	0.808	0%			Ex.Factor	118.9%
	D.avg	87.5%	D.avg	93.6%		Heat	1733
	L	0.808	L	0.594		Sy	55
	Pb.600	3.299	Pb.600	4.145		Su	102
	Ratio Pslb	1.3	Ratio Pslb	1.6		Sf	78.5



Attachment B

Zion 2 U-Bend Information

Zion 2 U-Bend Indications

- Row 1 U-Bend Indications

- 3/84	2	- 9/85	1	Bobbin Coil Inspections
- 6/87	3	- 11/88	2	Bobbin Coil Inspections
- 1/89	6	- 4/90	28	U-Bend MRPC Inspections
- 12/92	36	- 2/95	35	U-Bend MRPC Inspections
- 9/96	64			+Point RPC Inspections

- Prior to To Fall 1996

- MRPC:

- 100% Row 1 Each SG
 - 25 Tubes Row 2 Each SG

- Fall 1996 Inspection (Z2R14)

- Plus Point

- 100% Row 1 & 2 Each SG

- 64 Tubes Plugged Due to U-Bend Indications

- 3 Indications Identifiable In Spring 1995 Data Review

- All Remaining Row 1 Tubes Preventatively Plugged

- All Zion Unit 1 Row 1 Tubes Were Preventatively Plugged in 1982

- Conclusion: Expected PWSCC Degradation With Improved Plus Point Sensitivity