2/3/82

To: C Cheng

cc C McCracken
W. Hazelton
S. Pawlicki
W. Johnston

From: R. Murphy

Subject: Location of Tube Rupture at RE Ginna

- Tube R42 C55 (3 rows in from periphery)
- Hot leg side
- non-sleeved tube
- apparently fishmouth failure 4 to 5" above tubesheet

Commentary: Ginna has a history of problems in this area, which may be fairly unique to Ginna. ~~Previous~~ Speculations by licensee in previous years regarding what is going on in periphery includes:

1) Degradation may involve ID cracking
2) 1st support plate may be skewed relative to tubesheet resulting in stressing of peripheral tubes

C/3

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Letter No. 0301-03-82

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

March 1, 1982

To: R. W. McClung

From: C. V. Dodd
C.V.D.

Subject: Travel to Rochester, New York, February 23-26, 1982

On Tuesday, February 23 I traveled to the Ginna Nuclear Power Plant near Rochester, New York to review the eddy-current inspection program of the steam generators that was being performed by Rochester Gas and Electric Company (RG&E). There was a tube rupture in steam generator B that resulted in a large leak (500-700 gpm). The tube that failed [row 42, column 55 (4255)] was near a wedge area on the periphery of the tube bundle. There was a substantial amount of debris found (using television optics) in the area, including a 1/2 × 4 × 6 1/2 in. plate and parts from at least two broken tubes (that were plugged previously). It is now believed that one of the broken tubes rubbed on the failed tube until it wore away most of the wall and allowed the tube to rupture.

I was asked by the NRC to address the following four questions: (1) verify that RG&E in-service inspections meet and exceed ASME Code Section XI requirements, (2) determine any immediate improvements that may be made in detecting this type of failure using present state-of-the-art techniques to detect fretting, (3) determine what long-range improvements can be made, and (4) conduct an investigation of old tapes and related tubes for similar failures and damage.

1. The RG&E specification meets and considerably exceeds the Section XI requirements. RG&E Procedure No. NDE-500-4 calls for four different types of standards. They are shown below.

Section	Standard	Description
8.1.2	Defect	100% × 0.067 in., 80% × 5/64 in., 60% × 7/64 in., 40% × 3/16 in., 4 in. × 20% × 3/16 in. diam on outside diameter, and 20% groove × 360° × 1/16 in. wide on inside diameter
8.1.3	Dent	0.023-, 0.020-, 0.014-, 0.011-, 0.007-, 0.0025-, and 0.005-in. radial ring-shaped dents
8.1.4	Support plate	Carbon steel doughnut on tube
8.1.5	Wall thickness	1-in.-long outside diameter bands 360°, 20 and 30% of wall

C/4

Carl Tycouski
c/4/20

The full range of standards is run at the start of the steam generator inspection. An in-line defect standard is run at the start and end of each tape, and this performance standard demonstrates that instrument calibration has been maintained.

The dent and wall thickness standards are in excess of the Section XI requirements and are not run at every calibration. The support plate standard (also in excess of the Section XI requirements) has been added to the in-line standard.

The RG&E inspection uses 200 and 400 kHz differential, 100 kHz absolute (which are the normal measurements made for multiple-frequency tests), and 210 kHz absolute. The mix of the 200 and 400 kHz differential signals allows the tubesheet and tube supports to be eliminated from the differential channel. In addition, a mix of the 100 and 210 kHz absolute channels (which is not done at any other plant) gives an absolute measurement of the wall thickness without the presence of the tube support and tubesheet signals. This additional absolute mix data channel is in excess of both the Section XI requirements and the normal commercial practice for multiple-frequency eddy-current testing being performed at any other nuclear power plant.

2. This type of failure can be detected at an early stage of degradation using present data collection techniques.

A fretting standard with 20, 40, and 60% of the wall removed was constructed. The gradual wall thinning along the length of a tube, as may be present in tube fretting, may not produce any signal on the differential channels. This is demonstrated on the scan of the 20% fretting standard. The 40 and 60% standards do produce indications on the differential channels, but these are dependent on the shape of the machined fretting standard and do not produce signals that could be correctly interpreted using the differential channels. A more gradual taper at the ends of the fretting standards would not produce any signal on the 40 or 60% standards.

The in-line hole standard does not look like the fretting standard on any of the four channels. The phase angle will give the opposite interpretation, with the fretting standard decreasing in phase shift as the fretting defect increases in depth. The magnitude of the signal increases as the fretting wear increases. This magnitude does not increase as much with wall removal as it does with a uniform 360° removal of wall around the entire outside diameter of the tube (as a uniform wastage would produce). If the uniform wastage is gradual along the length of the tube, it would not produce any differential signal (but this is not the case with all the observations to date).

By looking at the magnitude of the absolute signal (either 100 or 210 kHz), this type of signal can be detected, even if there is no signal on the differential channels. However, there is no way to separate the fretting signal from the 360° uniform thinning signal

100% of the time with the circumferential probe and if the fretting standard is used as the plugging criteria; some tubes with small wastage defects will be plugged. However, the fretting standard should be used: (1) where fretting is likely to occur, such as the wedge areas or high flow areas; (2) in regions where no wastage has occurred; and (3) where the signal extends a relatively long distance along the tube.

The extent and location of the defect along the tube can be measured using the absolute readings plotted on the strip-chart recorder. The recorder can be run at a high enough speed to measure the defect length fairly accurately. The defect on tube 4255 measured about 5 in. long on the data taken from the April 1981 inspection. The maximum depth of the fretting defect was slightly greater than 40%, using the fretting standards.

By adding additional requirements to the data interpretation, this type of fretting defect can be detected using existing inspection procedures.

3. Long range requirements can be made that will improve the detectability of this type of defect.

An array of absolute pancake coils that cover the entire circumference of the tube could perform a more accurate inspection of the steam generator tube in general, and this type of defect in particular. The array would have the capability of distinguishing the difference between fretting and uniform circumferential wastage. Each pancake coil would be inspecting a smaller volume of material and would have a higher signal-to-noise ratio than the circumferential probe. The pancake probe would be sensitive to both circumferential and axial defects. The pancake coil is oriented so it would be sensitive to a conducting or ferromagnetic object touching or near a tube, while the circumferential coil requires that the conducting object encircle the tube. The electronics and probe for this system would be more expensive, but well worth the additional expense. This array should be a high priority development item for steam generator inspections.

4. Investigations were made on adjacent tubes and tubes in similar positions from the recordings of the scans on magnetic tape from inspections made between April 1976 and February 1982. Several tubes in this region (4455, 4456, and 4554) showed traces that were called bulges plus inside diameter defects, based on the shape and direction of the response of the 400 kHz differential signals. Additional evidence from the results of pulled tubes and leaks probably influenced this determination. After reviewing the tapes it appears that this interpretation is reasonable but not certain, based on the available data. A multiple-frequency inspection with an array of pancake coils would improve our knowledge of what properties were changing, but still may not resolve a signal this complex. The tubes showed an apparent slow increase in inside diameter with some waviness and a rapid decrease in diameter, where the tubesheet was keeping the tube from expanding.

Tube 4353 was reviewed using data from the April 1981 inspection. This test was performed using the 100 and 210 kHz absolute and the 200 and 400 kHz differential. The absolute signals from this tube are not exactly the same as either tube 4255 or the fretting standard, but were somewhat similar. Using an extrapolation of the fretting standard results would give a depth of 35% for the depth of this defect. The length along the wall was about 2 in. long. This shorter length and greater depth resulted in sharper variations in the wall thickness, which produced a 400 kHz differential signal. This resulted in the tube being recognized as defective and plugged.

Investigations of the April 1981 and February 1982 scans of the three nearest neighboring tubes (4256, 4155, and 4254) have not shown any indications in the region between the tubesheet and the first tube support.

CVD:jlb

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