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Profiles of tube r34c51 of Steam Generator 22

Tube r34c51 was profiled in the sludge region. This tube had two rather long cracks and two shorter cracks. All four were profiled, and are given in the figures below. All of the cracks were just above the tube sheet. The profiles were done using the 200 kHz and the 300 kHz test frequencies of the plus-point probe. Data were taken at 10 kHz, 100 kHz, 200 kHz and 300 kHz with both the plus point and the 0.115-inch diameter pancake coil. The 0.080-inch diameter high-frequency pancake coil was also used at 600 kHz and 300 kHz. The plus-point had the best signal-to-noise ratio for the tubes that I examined in the sludge pile region. The 0.080-inch diameter probe gave a sharp spike-like signal for the cracks. This coil may give better signal-to-noise at 800 kHz, where the noise should be rotated horizontal. Crack 1, as shown in Figure1

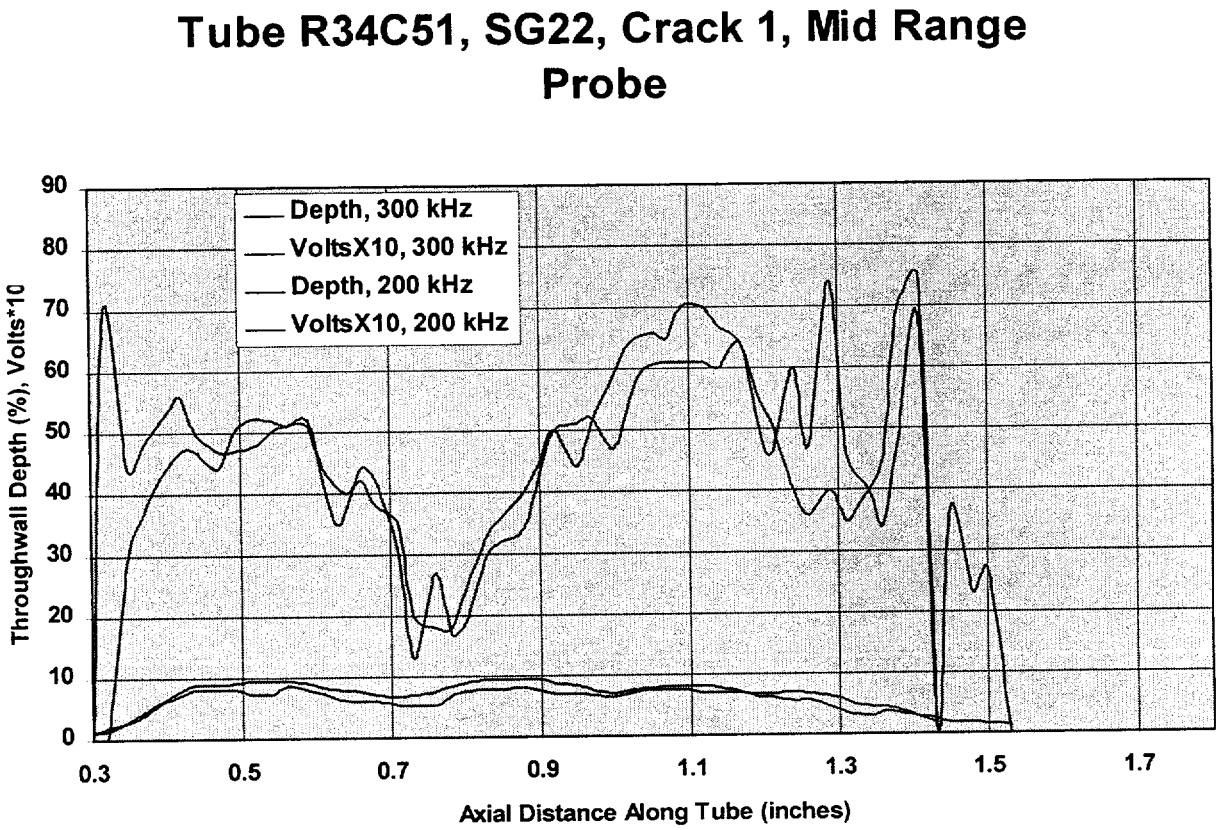

Figure 1 Profile of crack1 in tube R34C51 of steam generator 22.

was one of the larger ones, and had a voltage signal close to one volt. While this crack appeared to grow about 25% in voltage amplitude due to the pressurization, this is not the point were the tube burst.

Crack 2, as shown in Figure 2, is slightly longer and slightly deeper. This is the crack that burst. The voltage amplitude of this crack is about the same, and probably averages less than that of crack one. This demonstrates that voltage is not a good measure of crack size, depth or severity. Crack 2 appeared to go through wall, and the voltage amplitude increased by a large factor. This

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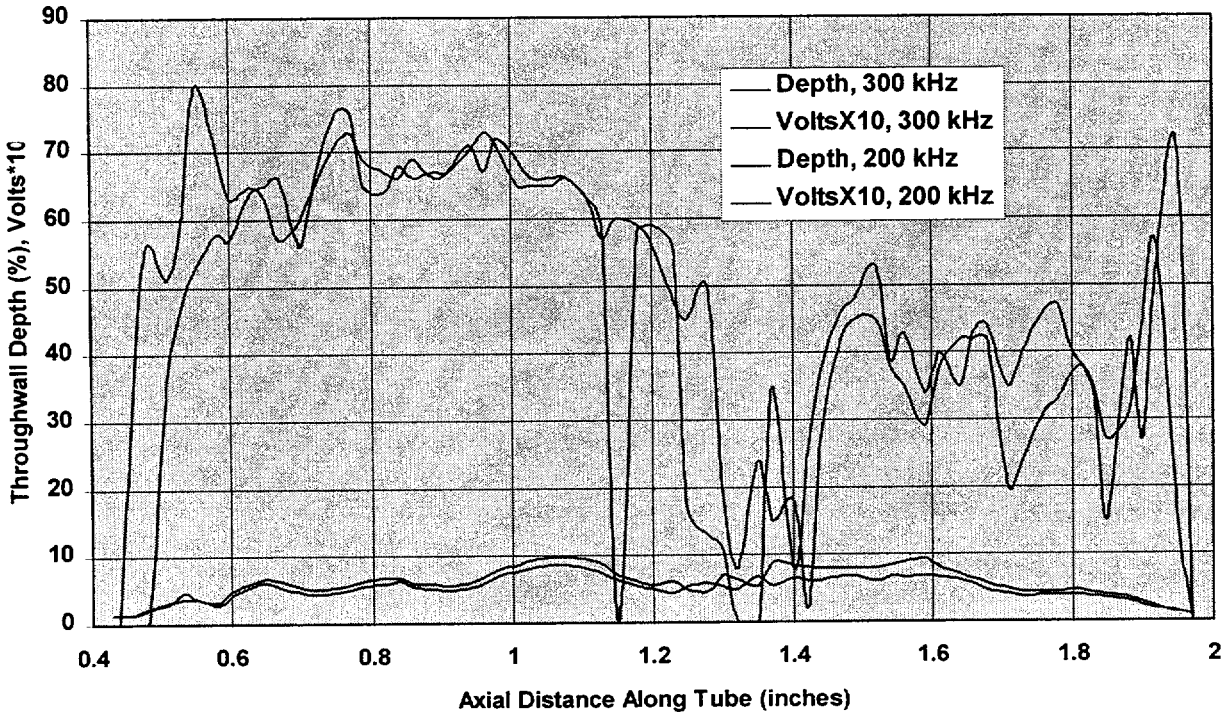

Figure 2 Profile of crack 2 of tube r34c51 in steam generator 22.

tube also had a large voltage increase of a crevice crack due to the pressurization.

In Figure 3 and Figure 4 we show smaller cracks. In the post pressure-test scan these cracks were still visible, but could not be profiled due to the large increase in signal from crack 2. Its signal distorted the phase of the smaller cracks, which were adjacent to it.

The positions of each of the cracks is labeled in the C-scan that is shown in Figure 5. Note the large voltage signal from the cracks in this tube, and the low noise. Other tubes do not have as good a signal-to-noise ratio and are more difficult to inspect in this region.

In Figure 6 we show the post pressurization scan of this tube. The signal form crack 2 is now much greater than the other cracks, indicating that this was the crack where the tube leaked. It appears that the crack opened to within about 0.3-inches of the tube sheet, and the voltage increased from near 1-volt to over 10-volts in places.

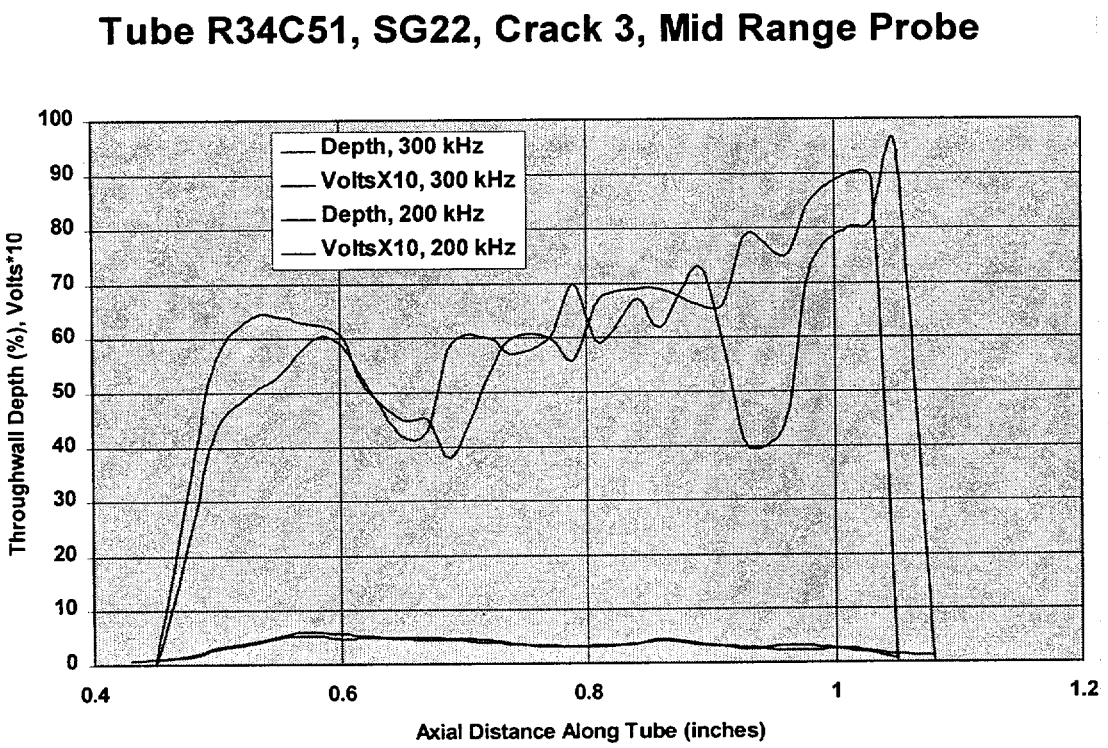

Figure 3 Profile of crack 3 in tube r34c51 of Steam Generator 22.

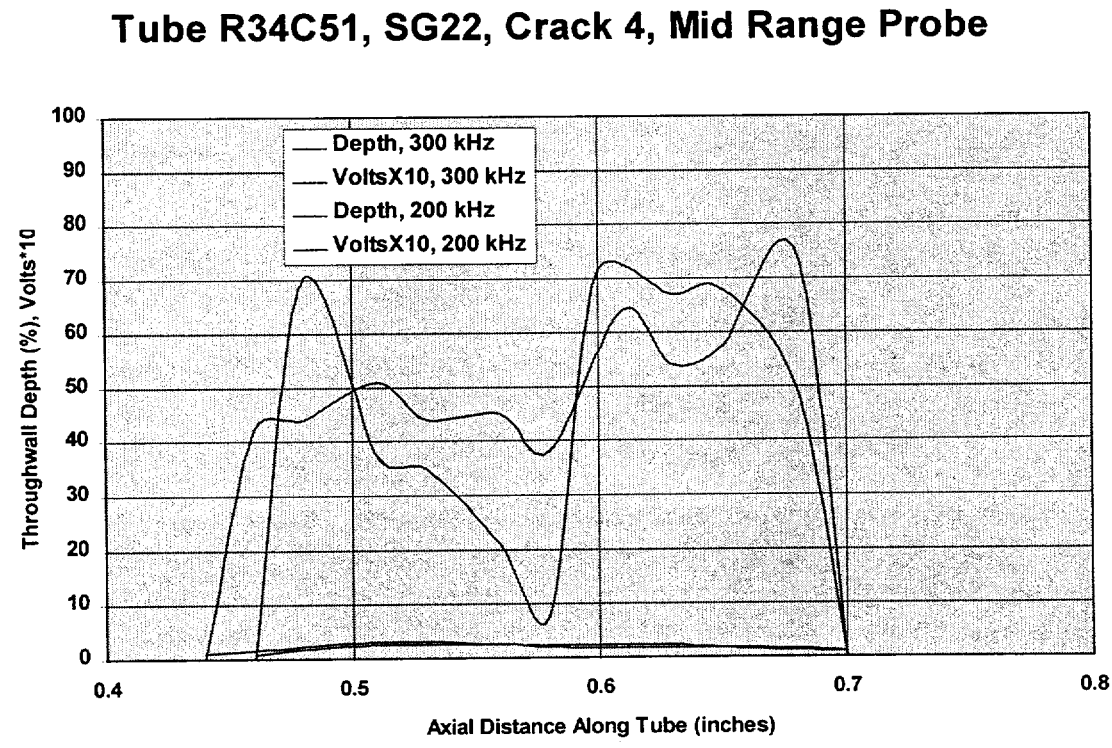

Figure 4 Profile of crack4 in tube r34c51 of Steam Generator 22.

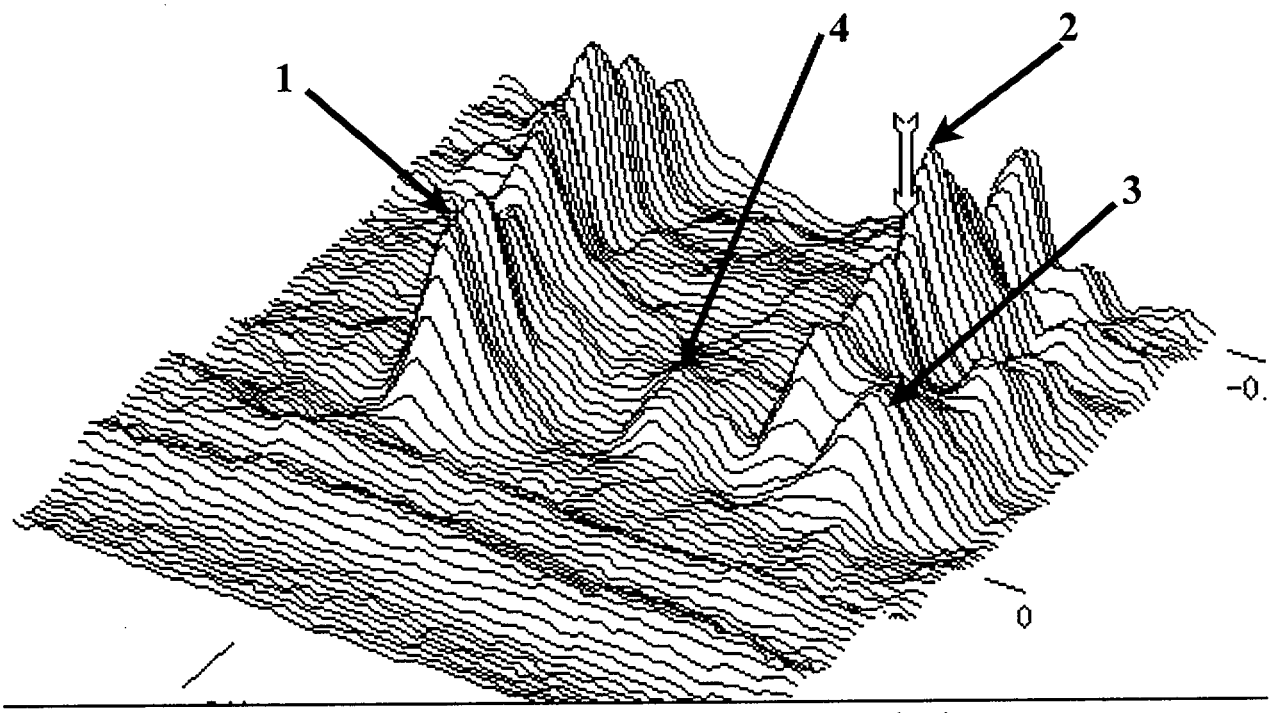

Figure 5 C-scan to tube r34c51 of steam generator 22 before pressurization.

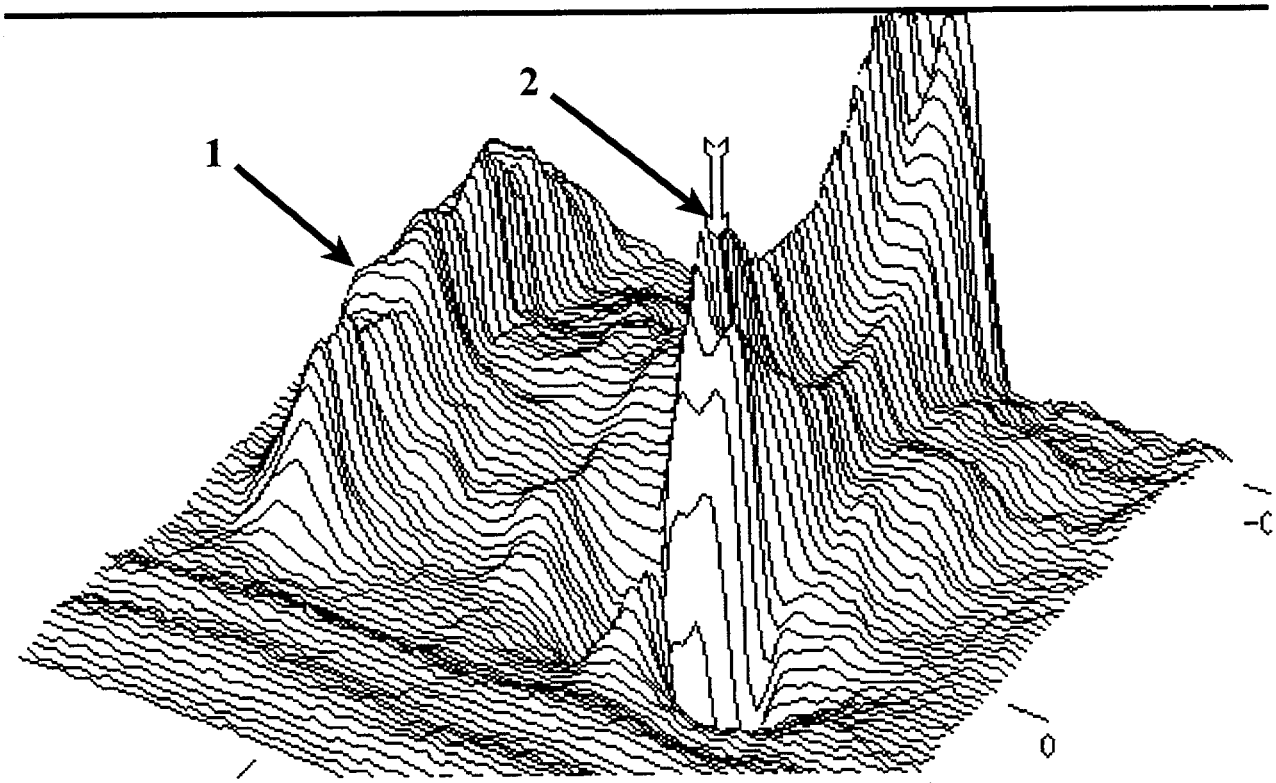

Figure 6 C-scan of tube r34c51 of steam generator 22 after pressurization.

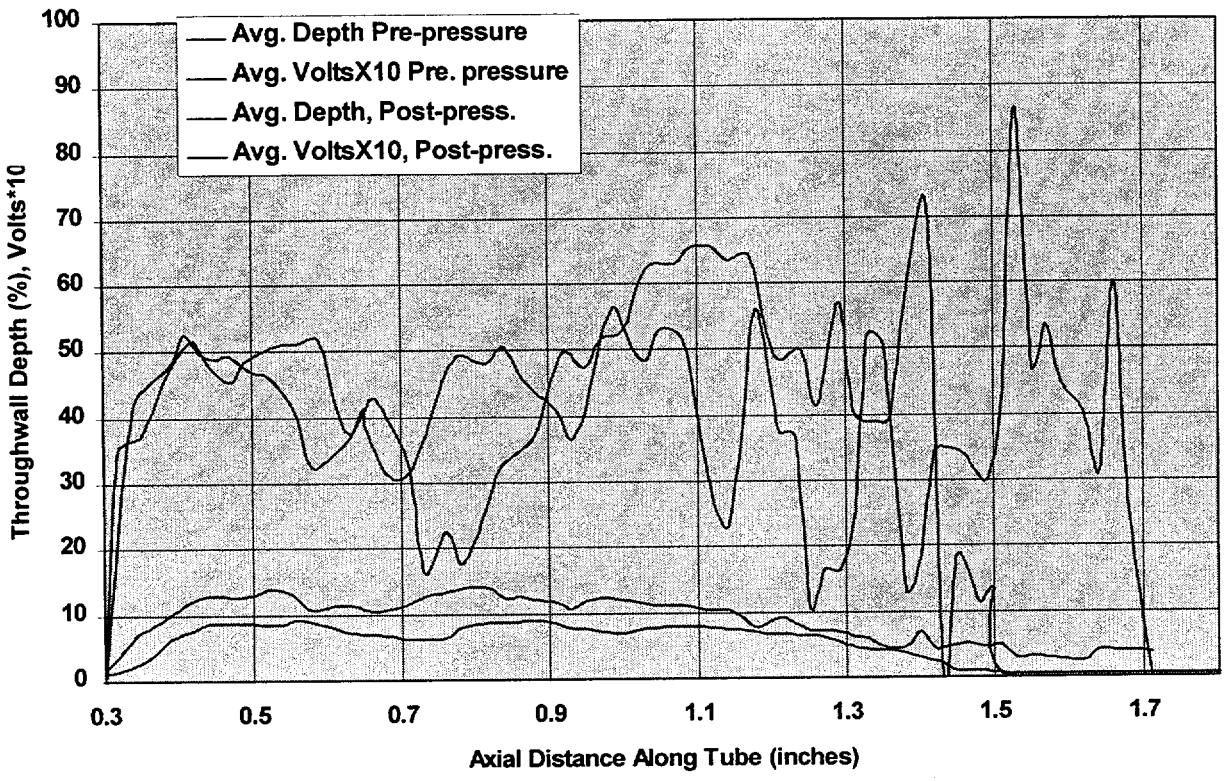

Figure 7 Effect of pressurization on Crack 1 for tube R34C51 of steam generator 22.

In Figure 7 we show the profiles averaged for the plus-point probe for the 300 kHz and the 200 kHz frequencies. The first part of the crack nearer the tube sheet seems to be about the same. For the second part of the crack, the readings seem to have become unreliable. The signals form all the coils were reviewed. The pancake coils showed a deeper crack, but there also was evidence of increased lift-off. The crack may have spread apart somewhat, due to the pressure test, and is no longer strictly crack shaped. The amplitude of the signal increased for all of the coils. This increase was about 25% for most of the crack for the plus-point coils. There probably would have been more increase if Crack 2 had not opened up, relieving the stress.

Measurements made on this crack with the 0.080-inch high frequency probe showed a very sharp spike-like response before pressurization, and a more broad response afterwards, also indicating some spreading of the crack. A comparison of Crack1 in figures 5 and 6 show that the base of the crack is much fatter as the distance from the tube sheet has increased. Another crack parallel to Crack1 may have opened in this region, causing errors in the depth readings.

In Figure 8 we show the profiles for Crack 2, for the plus-point probe, averaged over the 300 kHz and the 200 kHz frequencies. These readings appear to be more regular, but they were also considerably distorted. This crack reading switched from od to id a number of places along the

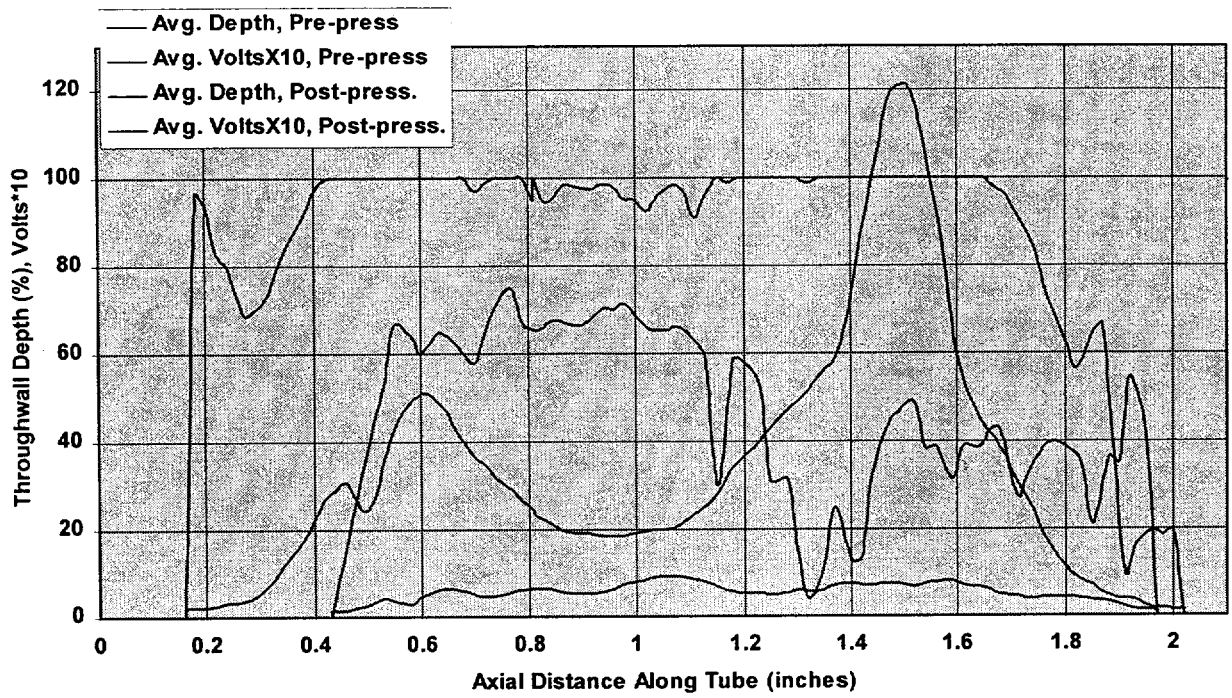

Figure 8 Effects of pressurization on Crack 2 in tube R34C51 of Steam Generator 22.

length, and the crack signal was not the classic shape that occurs on the calibration standards. When the signal went to id, the crack was assigned a value of 100%.

The amplitude of this crack signal increased to 12 volts. The amplitude calibration was set for a 100% EDM notch to have a voltage of 20-volts. Even a through wall crack must have some current bridging across the crack face to cause the signal to decrease to this value.