Lucent Technologies

Grindo*Sonic*
Tests on Tubes
Applicability of the System to Detect Cracks

1. Defect Detection

The GrindoSonic measurement by itself does not provide an indication of cracks. However, calculating ratio's from two different vibration modes can provide an indication of a problem. Indeed, if we have a defect, it is very unlikely that two independent vibration patterns will shift to the same extent. In this case we will measure the longitudinal vibration mode and the flexural vibration mode. Both results are used to calculate the modulus of elasticity. Because the formulas are totally independent we expect some small variation between the two results that can be expressed in a ratio. This ratio has to be constant. Any significant deviation is an indication of defects.

In addition, the GrindoSonic instrument will not provide a repeatable measurement for seriously cracked tubes.

2. Measurement Technique

2.1 Flexural Vibrations

For the fundamental flexural mode, the tube is supported on two pieces of plastic tubing, positioned in the nodes at 0.224 of the total length of the tube, measured from each end. The tip of the probe is covered with a piece of rubber O-ring material to avoid contact with the steel needle which would damp out the vibrations, and also to maintain better contact with the slick round surface. Tapping is done with a 1" diameter rubber ball mounted on a thin wooden party stick. Alternatively, tapping can also be done with the knuckles.

To facilitate this measurement, it is possible to measure the second harmonic instead, or even the third harmonic. This can be easily accomplished by placing more supports in the appropriate locations.

2.2 Longitudinal Vibrations

For the longitudinal vibrations, the tube is supported on three pieces of plastic tubing, positioned at the center and at the ends of the tube. The probe is placed vertical at the end of the tube. The cross section is impacted with a small steel ball 4 mm to 12 mm in diameter.

3. Calculations

To calculate the modulus from the longitudinal vibration mode, we simply need the length of the tube and the density (mass divided by volume). Calculations are performed using the Spinner & Tefft Formulas.
To calculate the modulus from the flexural mode we need a formula specific for tubes, which requires input of OD, ID, Length, mass or density. The formula we use is not as scientifically justified, but has proven to be correct for tubes with a Length to OD ratio of better than 10.

Because the original tubes were broken, only the C tubes had sufficient length to make the two calculations:

C1 Edl = 1.989 Gpa and Etub = 1.975 Gpa - Ratio = 1.007
C2 Edl = 2.109 Gpa and Etub = 2.018 Gpa - Ratio = 1.045

Please note that C2 does not comply with the L/OD > 10 rule, which results in a significant deviation of the ratio from that of C1.

4. Conclusion

It may be difficult to implement the technique successfully on the 7 feet long tubes:

- The longitudinal frequency for a 92 cm section was 805 Hz. At full length, this frequency is expected to be below 400 Hz. Will such a frequency vibrate several times through the tube and back?
- The fundamental flexural frequency a 92 cm section was 113 Hz, and the second harmonic 302 Hz. At full length, these frequencies are expected to be below 55 Hz and 150 Hz. The measurement of the fundamental is likely to verv difficult if not impossible. The second harmonic is more realistic.
- Implementation and successful defect finding can only be guaranteed after extensive testing of large numbers of tubes right on the production line. This will require training and a dedicated operator.