

NASA TECH BRIEF

Langley Research Center



NASA Tech Briefs announce new technology derived from the U.S. space program. They are issued to encourage commercial application. Tech Briefs are available on a subscription basis from the National Technical Information Service, Springfield, Virginia 22151. Requests for individual copies or questions relating to the Tech Brief program may be directed to the Technology Utilization Office, NASA, Code KT, Washington, D.C. 20546.

Nondestructive Measurement of Capillary Tube Internal Diameter

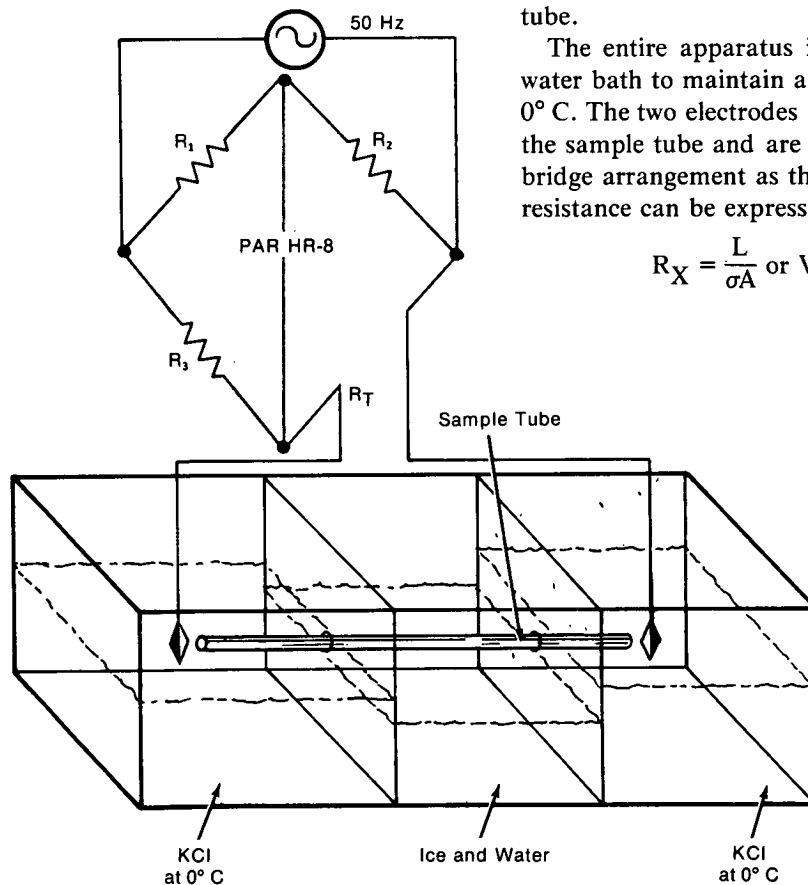
A new technique for measuring the internal diameter (ID) of a capillary tube has been developed. The technique provides a nondestructive method of making a quick, accurate determination by measuring the electrical resistance of a capillary tube when it is filled with an electrolyte of known conductivity. The measurement apparatus is shown in the illustration and consists of a conductivity cell and

equipment for measuring resistance and for monitoring and controlling temperature.

The conductivity cell has three separate chambers, in series, with electrodes in each of the end chambers. The two end chambers and the sample tube connecting these chambers are filled with a known solution (1 N KCl). The middle chamber, electrically isolated from the other two, is filled with an ice-and-water mixture which surrounds the capillary tube.

The entire apparatus is immersed in an ice-and-water bath to maintain an electrolyte temperature of 0° C. The two electrodes are placed near each end of the sample tube and are connected to a Wheatstone bridge arrangement as the unknown resistance. This resistance can be expressed as

$$R_X = \frac{L}{\sigma A} \text{ or } V = \frac{L^2}{\sigma R_X}$$



$$\begin{aligned} R_1 &= R_2 = 100,000 \text{ ohms} \\ R_3 &= \text{Known Resistance} \\ R_T &= R_2 R_3 / R_1 \end{aligned}$$

Apparatus for Nondestructive ID Measurement of Capillary Tube

(continued overleaf)

where: L = length of the sample tube,
 A = cross-sectional area of the tube,
 σ = conductivity of the KCl electrolyte
(0.06541 mhos per cm at 0° C for 1 N
solution), and
 V = volume of the sample in the tube.

For tests with the apparatus prototype, the bridge was excited with ac at approximately 50 Hz to avoid polarization due to electrolysis at the electrodes. A lock-in amplifier was used as a detector, along with two precision resistance boxes (100,000 ohms) and a precision variable-decade resistance box in the other bridge arms.

The resistance of the empty tube, measured by trapping a section of air in the tube, was on the order of 1,000 megohms. Stray effects occurring between the ends of the tube and the platinum electrodes were found to be negligible (less than 10 ohms). The length of the tube was measured with a traveling microscope to better than 0.05 percent. The resistance measurements were measured to better than 1 part in 10^4 and, typically, would be in the 100,000-ohm range for capillary tubes of 10 cm in length and 0.04 cm ID. The overall accuracy achieved for V or A was better than 0.1 percent.

Measuring extremely nonuniform tubes with this method gives a smaller volume measure than the true value because the smaller cross sections are more heavily weighed. A tube with a 5-percent taper has a volume error of only 0.02 percent, whereas for a 10-percent taper, the error is of the order of 0.08 percent.

A sample tube was measured by the conductivity method. Then the tube was cut into approximately 10 sections, and the diameter was measured. The averaged cross-sectional area was within 0.15 percent of the conductivity measure. This error is approximately the uncertainty expected in the destructive measuring method. The conductivity technique is useful for measuring cross-sectional area or volume of small capillary tubes, and it has been found to have advantages over all other ways of obtaining these measurements.

Note:

No further documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
Langley Research Center
Mail Stop 139-A
Hampton, Virginia 23665
Reference: B75-10156

Patent status:

NASA has decided not to apply for a patent.

Source: William W. Ho, Allan W. Love, and
Marinus J. Van Melle of
Rockwell International Corp.
under contract to
Langley Research Center
(LAR-11647)

Categories: 02 (Electronics Systems)
04 (Materials)
06 (Mechanics)
05 (Life Sciences)