VLBA ACQUISITION MEMO #133

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30 March 1989

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To: VLBA Data Recording Group

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Subject: Measurement of the thermal and elastic constants of magnetic tape

1] Longitudinal elastic constant

Young's modulus can be easily measured using the following relation for a uniform beam bent under its own weight

$$Y = (3/2)\ \rho\ L^4/T^2 d$$

where
ρ = material density (≈0.07 lbs/cu")

L = beam length (from clamp to free end)

T = tape thickness

d = beam droop at end

for example 3M5198 drops by 0.5" for a 1.5" length from which the modulus can be calculated to be 1×10^6 lbs/sq".

2] Transverse elastic constant

The transverse (thickness direction) modulus can be measured by winding a tape with different tensions and counting the number of turns in a fixed length.

The increased number of turns is related to the transverse Young's modulus as follows (see memo on tape pack):

$$\Delta N \approx \frac{TN}{Y}(1 + R/12) \qquad \text{(valid for } N \geq 2000\text{)}$$

where
Y = Young's modulus along the tape

R = ratio of Y to Young's modulus in thickness

N = number of turns

T = tension (10" ≈500 lbs/sq")

A value for R of about 10 was measured for 3M5198 - but measurement error is large. A better method is to measure the complete pack spiral (see memo on Tape Pack).

3] Longitudinal thermal expansion coefficient

Stretch a tape along a steel ruler and then cool in refrigerator - measure the change in length and correct for the thermal expansion of steel. For 3M5198 I measure about 2 x $10^{-5}/^{o}C$.

4] Transverse thermal expansion coefficient

As with the measurement of transverse elastic constant, observe the number of turns for a given length of tape - but this time vary the ambient temperature. The transverse thermal expansion coefficient is given by

$$-2(n/N)/\Delta t + e_c$$

where (n/N) is the fractional change in the number of turns

e_c is the longitudinal expansion coefficient

Δt is the temperature change

For example a roll of 3M5198 increased by one turn out of 500 when cooled from $65^{o}F$ to $40^{o}F$. This measurement gives a transverse expansion coefficient of about 3x $10^{-4}/^{o}C$.

5] Longitudinal anisotropy in elastic modulus

The difference between the elastic modulus along the tape and across the tape is clearly observable in some tapes (Ampex 721 for example) which are about a factor of 2 less rigid when bent across the tape. The method of Section 1 can be used to make a quantitative measurement.

6] Elastic relaxation time constant

Bend a piece of tape at right-angles over the edge of a table (as if doing test in Section 1), hold for a minute and then release to observe relaxation. All tapes tested show a relaxation of a few seconds which is long enough that a tape coming off a reel for the first time after storage will not be relaxed when the tape reaches the headstack - at least for speeds greater than 30 inches/sec.

7] Alignment of anisotropy axis

The axis of maximum elastic modulus will not be perfectly aligned with the tape direction. Cut about one foot of tape and heat the end with a lamp until it curls. Repeat for the other end of the tape. In each case the curl, I think, occurs along the modulus axis. Typical alignment for 3M5198 is about 10 degrees.