VLBA ACQUISITION MEMO #274

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Subject: Preliminary tests of various low friction surfaces

It is fairly certain[1] that we are damaging the edges of the thin tapes with extended running at high speeds. The current theory is that the "flash temperature" (see "Friction and Wear of Materials" by E. Rabinowicz, John Wiley and Sons, N.Y., 1965) produced by friction in the vacuum columns is exceeding the glass transition temperature (~150°C) or even the melting point (~250°C) of the mylar tape. Rabinowicz gives the flash temperature as

$$\frac{9400 f \gamma v}{J(K_1 + K_2)}$$

where

f = *coefficient of friction*

γ = *surface energy of softer material*

v = *velocity*

J = *mechanical equivalent of heat*

K_1, K_2 = *thermal conductivities of materials*

[1] The heating has now been observed by an IR camera as well as early methods using liquid crystal film and melting of plexiglass (see VLBA Acquisition Memo #266).

The Table 1 (from Rabinowicz) gives some examples of materials and their flash temperatures for 8m/sec (320 IPS).

FRICTION AND WEAR OF MATERIALS Computed temperature Rise Per Unit Sliding Velocity						
Material Combination	f	γ	k_1	k_2	θ/v (C/cm/sec)	At 8 m/sec
Steel on Steel	0.5	1500	0.11	0.11	0.75	600°C
Lead on steel	0.5	450	0.08	0.11	0.26	200°C
Bakelite on bakelite	0.3	100	0.0015	0.0015	2.2	1760°C
Brass on brass	0.4	900	0.26	0.26	0.15	120°C
Glass on steel	0.3	500	0.0007	0.11	0.3	240°C
Steel on nylon	0.3	120	0.11	0.0006	0.07	56°C
Brass on nylon	0.3	120	0.26	0.0006	0.03	24°C
Steel on bronze	0.25	900	0.11	0.18	0.17	136°C

Table 1. FRICTION AND WEAR OF MATERIALS by Professor E. Rabinowicz

We have tested several materials by mounting them in the edge contact region and the qualitative results are given below:

Glass - Streaks of deposit appear after a few hours of shuttling the tape at 270 IPS. Deposit is very hard to remove as if melted onto surface.

Alumina - Similar to glass but with somewhat lower incidence of deposit build-up.

Plexiglass - Fine at speeds <60 IPS. Severe damage to surface and deposits form rapidly at speeds >200 IPS.

Copper - Very little deposit after many days of shuttling at 270 IPS. Some wear is evident under microscope.

Stainless Steel - Better than alumina - but some deposits and streaks do eventually form after many days shuttling at 270 IPS.

Nedox - A special surface made by Magnaplate consisting of teflon impregnated into a nickel plate over aluminum. Very slippery to the touch. No appreciable deposits form and the small pieces that do stick are easily wiped away with light contact with a Q-tip.

Teflon tape - Much too soft. Wears through within hours. Wears through (in vacuum pull-down region - see VLBA Acquisition Memo #257) in about one day when used on faces of E-casting.

Another kind of test has been performed in which the material is held against the rotating edge of a tape pack (the front flange removed) as if it were a grinding wheel. The rather crude test shows that thermal conductivity is the most important parameter. Copper and aluminum will not gather deposits while glass, alumina, plexiglass, and stainless steel all become coated with melted tape. It is also impossible to coat the Nedox - but since it is a composite material it is hard to know much about its thermal conductivity on the micron scale.

Preliminary tests of edge wear, made by shuttling AMPEX tape at 270 IPS/10" vacuum on a transport temporarily outfitted with copper surface contact plate, shows no evidence of progressive edge damage. While copper has a high conductivity, it is too soft for a permanent fix to the edge heating problem. So far the Nedox is probably the best choice. Some of the other materials we are now trying to acquire for tests are:

Aluminum Nitride,
Silicon Carbide
Electroless Nickel Plate
Diamond/Graphite Composits