VLB ARRAY MEMO No. 517

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TO: Buck Peery

FROM: Hans F. Hinteregger, J. C. Webber

SUBJECT: Humidity and Temperature Control

In response to Ken Sowinski's note we want to assure you that we have no qualms about operating the VLBA recorders at low humidities. However, we are concerned more with tolerance than with the choice of operating point.

Mark III recorders have operated at relative humidities normally below 20% (at Mojave for example) without any indications of compromised performance or of high failure rate. The same low humidity conditions prevail at Honeywell TID in Denver where the recorders are produced and tested. "Gap smear" and "brown stain" have been observed at low humidities only with conventional instrumentation tape operating with conventionally contoured metal heads, none of which we use. The recommendation in NASA Pub. 1075 to avoid humidities below 30% applies to most existing instrumentation tape and recorder systems which use these (conventional) elements. But it should not be taken to apply to Mark III, IIIA and VLBA tape and recorders which share a rather different head/tape interface the intrinsic performance of which to the best of our knowledge is not significantly affected by changes in relative humidity from 0 to nearly 100%. (Condensed water can of course cause catastrophic failure in electronics.) Long-term shuttle tests with Fuji H621 and 3M5198 were conducted at Honeywell in 1981 with RH both above 75% and below 10% using Honeywell ferrite-and-glass surfaced headstacks with the then newly developed Mark III-type "stepped" contour. No performance changes were detectable and a headlife of at least 10,000 hours at over 70% RH was inferred from upper limit determinations of head wear. It has long been known that head wear (abrasivity of the tape) is a monotonically increasing function of relative humidity (due to the hygroscopic nature of conventional polyurethan binders). For conventional instrumentation tapes abrasivity increases slowly (by less than a factor of 2) from 0 to about 30% and then rapidly at higher humidities so that abrasivity at 90% RH is expected to be 10 times as high or more than at 30%. We do not know from measurements of our own or of the tape manufacturers what the abrasivity vs relative humidity curve looks like in detail for the modern high-coercivity video tapes currently in use. However, it seems safe to infer that the very low abrasivity (against a ferrite head) is more nearly constant over a wider range of RH than for conventional instrumentation tape. Nevertheless, it is still likely that the longest headlife will be attained at the lowest RH. Our recommendation of a 30% RH system operating point is based on this premise.

We consider this value only "moderately low" compared to standard computer room environments. Is it really true that other equipment is adversely affected by a 30% RH operating point consistently maintained? How low is the humidity in the VLA computer room where low humidity has "proven to be a problem"?

Note that our recommendation rests on extrapolation from the present operational system. The recommended (optimum) operating point may change somewhat when we know more about the wear and performance maintenance characteristics of the narrow track headstacks and the most advanced tapes. Somewhat different materials are in contact with the tape: single-crystal ferrite and calcium titanate instead of hot-pressed ferrite and glass. The relative proportions of these materials and of the epoxy "glue lines" between them are also different. The thinner tapes we want to qualify for VLBA also produce a somewhat different two-dimensional contour on the tape-bearing "step" of the headstack than the thicker tapes now in use. Nevertheless, when all things are considered, it is likely that "optimum" relative humidity will remain somewhere between 30 and 50%. It may therefore be sufficient to specify for now that the air conditioning system for the VLBA recorder environment should be able to maintain an operating point anywhere in this range.

Undoubtedly more important than the particular value of relative humidity operating point chosen for the VLBA system -- it must be the same at all stations and at the processor -- is the accuracy with which the relative humidity is controlled and monitored. For mylar (the tape substrate), a 15% change in RH produces the same change in tape width as a 6°C change in temperature. Each cause changes the distance between center and edge of a 1" tape by 2 micrometers. For the worst combination of these differences in humidity and temperature between write and read conditions, a track near the edge of the tape is displaced 4 micrometers from the corresponding head and results in a 20% signal loss for a 20 μm-wide track. This seems barely acceptable with a 5 micrometer guard band and a head edge placement accuracy of ±1 μm within each headstack. We have measurements that indicate the humidity expansion coefficient of the tapes in current use is considerably less than (only about 1/3) the published value for uncoated mylar given above. Thus, a 20% change in RH together with a 6°C change in temperature might result in only a 3 μm displacement of edge tracks or 15% signal loss. This is a little more comfortable worst case. But it may be optimistic since the mechanism of this reduced humidity coefficient is not understood and may disappear if a different tape type is ultimately used. (A possible explanation is that both the modern oxide coating and back coat are somehow formulated to provide a moisture barrier.) Thus, tape without a backcoat or a different oxide binder may have the unmodified humidity coefficient of mylar.

In conclusion, ±10% accuracy of humidity control and ±3°C of temperature control are barely adequate in the worst case with 20 μm tracks. Tighter control of both relative humidity and temperature is very desirable and may not involve much added expense. The main difficulty is probably to identify sufficiently accurate and stable electronically monitored humidity sensors. We favor the following specs:

	Control Range	Accuracy
Temperature:	17-27°C (MIN)	±1.5°C
Relative Humidity:	30-50% (MIN)	±5%

The accuracies recommended above are consistent with statements in early versions of the VLBA project book. Redundant humidity and temperature sensors should be located at least near (perhaps in) each recorder air intake.

Incidentally, what provisions are planned for keeping the air clean, that is, free of dust and especially of abrasive particulates? The long term reliability not just of the head/tape interface but of all electronics which use convection cooling (especially wire-wrap boards) is compromised by unclean air.