Is My Calibration Tape Still Accurate?

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Recording engineers use a calibration tape to set up analog audio magnetic tape reproducers to standard azimuth, frequency response (equalization), and reference fluxivity ("recording level"), as recommended in IEC Standard 60094 [1]. They ask us "How long is a calibration tape good for? Is my calibration still accurate? " Our answer is "It is good for ever, unless something damages it."

The common causes of errors in calibration tapes are:

- Mechanical damage to the tape (stretching or scuffing),
- Chemical damage to the tape (shed), and
- Magnetic damage to the tape (demagnetization).

So how do you verify the accuracy of a calibration tape? One way is this: When you buy a new calibration tape, buy *two*, not just one. Test them for consistency with each other, and with your previous calibration tapes. Then put one into daily use as the secondary standard, and put the other away as a primary standard, to be used only to verify the secondary standard tape.

While this works in principle, many will find it too expensive. And few engineers think of it until it is too late, and a problem already exists. What can you do without a primary standard for comparison? Here are some techniques.

Mechanical Damage to the Tape:

Stretching

Many things can mechanically distort the tape: For example, storing the tape with an uneven wind (that is, with individual turns of the tape sticking out of the pack, not supported by the rest of the pack); winding the tape at very high tension, especially on a plastic reel; winding the tape against a reel flange. These will usually result in edge damage or a stretched edge.

Symptoms: A stretched tape edge will cause level variations on one of the edge tracks (that is, either the top track or the bottom track) of a multi-track reproducer; a vu meter needle or oscilloscope pattern will shake rather than showing steady readings on the tones. The shake is due to the intermittent loss of intimate contact between the tape and the head, and will be least at low frequencies, and more and more at higher and higher frequencies.

Further confirmations:

1 Look at the tape as it comes off of the feed reel, and as it goes over the heads. The tape should not "flap" either place. If it does, suspect mechanical damage to the tape.

2 Use a finger as a temporary pressure pad to press the tape into good contact with the reproducing head. Use care to avoid throwing the azimuth off — push this way and that for maximum level reading and steadiness.

> Note first that the holdback tension is what holds the tape in contact with the heads. Therefore higher holdback tension and more compliant tape will reduce the shake for a given amount of edge stretch.
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> Note secondly that if the transport mechanical adjustment (especially the head zenith) is incorrect, you may see the tape flap even with an undamaged tape. Try some new high-quality blank tape, and see (both mechanically and for steadiness of recorded tones) how it runs on your transport. If it looks good, suspect mechanical damage to your calibration tape.

3 Lay a meter or two length of the tape on a flat table top. See how the tape lies — it should look like a mirror. If it looks likes waves on a lake on a windy day, it is stretched.

Scuffing

Most tape transports have a capstan that runs all of the time. When you start the tape in play mode, a capstan idler roller presses the stationary tape against the moving capstan. Each time you start playing a tape, the stationary tape is yanked almost instantly up to full playing speed, and this causes a scuffing of the tape surface by the capstan. This scuffing causes a very small dropout of the signal at the point that is at the capstan at startup. A tape that has been used many times, with starting in the middle of the tones, will usually have unsteady output, especially at high frequencies. For this reason we recommend that you not start the tape in the middle of a tone, especially not a high-frequency tone.

Tape Shed

A few batches of tape made before 1995 from ALL manufacturers have shed, which is due to hydrolysis (chemical decomposition) of the tape binder [2]. It commonly results in goo that transfers to the heads. You can see this by eye after you run the tape. If you clean it off of the heads, it will come right back the next time you play the tape. It may cause the tape to stick to the heads or guides so tightly that the transport can't move the tape even in "play" mode! More subtly, it will lift the tape away from the heads, causing poor high-frequency response, and the more tape you run, the worse the response gets. So if you see erratic levels, usually getting worse and worse as you play the tape, suspect shedding.

You can bake the calibration tape at 120 °F for several hours, and get a temporary repair [2], but the tape is basically a complete loss.

Magnetic Damage

WARNING: If you are comparing a secondary standard calibration tape to a primary standard, and you have magnetized heads or guides, you will ruin the primary standard tape in the process!

Magnetic damage — tape erasure — can come from the tape recorder itself (magnetized heads or guides), or from other fields.

The easiest test for magnetization of heads or guides is this: On a blank tape, record a 16- or 20-kHz signal for about 30 seconds. Note the reproducer level meter reading as you make the recording. Then rewind this recording, reproduce it again, and note the level. Rewind and replay several times (do *NOT* re-record). If there is magnetization of the transport, the level will drop with each succeeding play. [At the shortest wavelengths (the highest frequencies at the slowest speeds) a small loss (<0.5 dB) is common, and does not necessarily mean that there is any magnetization of the heads or guides.] The effect from multiple replayings is logarithmic: If the level is 0 dB in recording, and drops to -1 dB the first play, it will drop to -2 dB on the 3rd play, -3 dB on the 6th play, etc. If the level of this high-frequency that you just recorded drops with each playing, do not play your primary standard until you have both demagnetized the heads and any magnetic guides, and re-run the magnetization test to prove that there is no more magnetization. See the author's paper "Demagnetizing a Tape Recorder" [3].

> The erasure is always more at the higher frequencies than at the lower frequencies, so a drooping high-frequency response could be erasure. Unfortunately, however, almost everything that can go wrong with a tape recorder results in a drooping high-frequency response, so a drooping high-frequency points to a list of possible problems, not to a unique problem.

Because the magnetic field decreases very rapidly with distance from its source, most commonly cited other fields (magnets in loudspeakers, meters, and X-ray machines; and currents in electrical power wiring) are unlikely to erase tapes. But be careful of head demagnetizers and bulk tape demagnetizers. Because these produce localized fields, they typically can erase one small area of the tape on the reel. In this case, when you play the tape the level fades in and out in synchronism with the rotation of the reel. (Unless of course the signal was erased when the tape was wound on a different reel diameter, or "tails out").

When tape on a reel is partially erased by an external field, the process is very much like contact duplication; therefore you will hear greatly increased print-thru, especially on the voice announcements. This is probably the best clue that the tape has been exposed to an external field. The effect may be much greater on one edge of the tape than the other — that is, on a 2-track tape, track 1 may be much worse than track 2, or vice versa.

When the erasure is due magnetized heads or guides, the effect is usually much more on some tracks — the ones having magnetized heads — than on others.

If you have a multi-track machine, some tracks may look noticeably different from the others, either in 1 kHz level or in response *vs* frequency. How do you tell whether the calibration tape or the tape reproducer is wrong? Easy: play the calibration tape *from the other end*. MRL tapes are supplied "tails out", to be placed label-side-up on the takeup reel and rewound before using. So, instead, place the reel label-side-down on the feed reel, and play it from end to beginning. Now track 1 of a two-track tape is over channel 2 of the reproducer, and vice versa. If the fault stays with the same *reproducer* channel, the problem is with the reproducer. If the fault stays with the *tape track* (that is, it moves to the other reproducer channel), the problem is with the calibration tape.

If You Don't Have a Primary Standard

If you don't have a Primary Standard, there is an alternate for you if you have *any* other calibration tapes of the same width that is undamaged. You can make an intercomparison by using a conversion table [4], [5] between different reference fluxivities, equalization standards, and speeds.

So if you have a tape at 15 in/s, with IEC equalization at 355 nWb/m, you can compare it (using the conversions) with a 7.5 in/s tape with NAB equalization at 250 nWb/m. If the two calibration tapes give essentially the same response (after the corrections are made from the conversion table), then the calibration tapes are probably correct; otherwise one of them is incorrect.

REFERENCES

[1] IEC Standard 60094-1, "Magnetic Tape Sound Recording and Reproducing Systems, Part 1: General Conditions and Requirements", Sec. 15. International Electrotechnical Commission, Geneva, Switzerland 1981. Available for purchase from the IEC at http://webstore.iec.ch/ .

[2] "Tape Binder Shedding", MRL Publication SHED3, 2009.

[3] J. G. McKnight, "Demagnetizing a Tape Recorder", *db Magazine*, vol. 21, pp 41...43 (1987-07/08).

[4] "Choosing and Using MRL Calibration tapes...", MRL Publication Choo&U, Magnetic Reference Laboratory, Mountain View, CA, 1997.

[5] " MAGTAPEQ , A Computer Program for Calculating Magnetic Tape Equalization Conversions" In F- PC Forth, for DOS, available online with the two files http://home.comcast.net/~mrltapes/magtapeq.exe (A Forth program to Make tables of Audio Magnetic Tape Recording Eq & Conversions) and http://home.comcast.net/~mrltapes/magtapeq.seq (above program explained -- change suffix to ".txt" to read), and http://home.comcast.net/~mrltapes/EQTABLES.pdf (The tables from above)