Only a few changes have occurred since this paper was written back in 1980. The important ones are:

1 The voice announcements now come from a hard-disk recorder.
2 Ampex and STL left the Calibration Tape business in the 1990s.
3 The prices are all higher -- for a 1/4 inch, 6 minute, tape, around 105 $; for a 2 inch, 15 minute tape, around 865 $.
4 The current edition of the IEC Standard Publication 94 (various parts) is now 1981 and later.
5 All of our "multifrequency" tapes now go up to 20 kHz.
6 The fluxivity level tolerance at 1 kHz is now +/- 0.3 dB.
7 Our stock Calibration Tapes now include tapes with the reference fluxivity of 355 nWb/m; 500 nWb/m is also available.
8 The German flux measurement is "DIN" (not "ein").
9 All of our tapes are now available with or without fringing correction.
10 The "difference method" azimuth adjustment tape is no longer available.
11 We no longer use the edge-loading guides.
12 The tape manufacturers today are reduced to just Quantegy.
13 The erasure field should read "5 kilamperes per meter (kA/m)"

J McKnight, 2006-04-26

RALPH HODGES

Magnetic Reference Laboratory and the State of Reproducer Calibration

If you are a total recluse or a permanent resident of the moon, you may never need a calibration tape. But if not...

IN THE SMALL FRAME STRUCTURE at 229 Polaris Avenue, Mountain View, California, some of the most technically-sophisticated recordings are made daily; but nobody ever listens to them if they can help it. In terms of entertainment value, they couldn't be drabber, being lengthy series of test tones and noise signals, relieved only by periodic voice announcements (dubbed from a broadcast-type tape-cartridge player, not sophisticated in any sense). Their intended audience is meters, scopes, and chart recorders, and their ultimate objective is to establish accurate and informative communications between tape machines. These recordings are the only truly practical means of accomplishing this.

Mountain View's Magnetic Reference Laboratory, founded in 1972 under the guidance of president Jay McKnight, is one of the few vendors of professional-quality reproducer calibration tapes extant, with significant competition in the U.S. coming only from Ampex and Standard Tape Laboratories. The current MRL catalog lists over 160 calibration tapes, some of them special-order items. The average ¼-inch tape plays for 6 minutes and sells for around $40. The average 2-inch tape is 15 minutes and costs somewhat over $400. In between are ½- and 1-inch formats, likewise available in all widely-employed tape speeds and equalization characteristics (most relevantly, NAB 1965, IEC 1968, and AES 1971). The wider tapes play longer because it takes more time to set up 24 tracks than 2. And yet, the MRL tapes do not have separate tracks; They are all recorded full width—the result of one of many conscious design decisions that must go into a product of this type.

As MRL creates it, the basic workhorse reproducer calibration tape is divided into three parts: a reference signal for adjusting operating level; coarse and fine azimuth adjustment tones; and finally, frequency response. This last part consists of ascending spot frequencies at octave intervals from 31.5 Hz to 8 kHz, and then at 1/3-octave spacings up to at least 16 kHz. Tapes other than the basic ones offer slow and fast frequency sweeps (for use with chart recorders and oscilloscopes, respectively), and broad-band noise signals for examination with spectrum analyzers.

The reference signal is a 1 kHz tone recorded at a precisely-defined fluxivity (±½ dB tolerance) to permit the setting of machine gain and the referencing of it to a known recorded fluxivity. Most useful for the U.S. user will be tapes with

Ralph Hodges is a freelance writer/editor based in the San Francisco bay area.

7 recorded fluxivities of 200 and 250 nanowebers per meter (nWb/m), corresponding to standard operating levels for general purpose (200) and high-output (250) tapes. Tapes with fluxivity levels suited to European standards are also available. In addition to the obvious benefits, a true calibration tape provides you with an "absolute": a recorded level that is precisely defined. This gets a little tricky. For example, how does a manufacturer of a calibration tape determine exactly what fluxivity he has recorded? One way might be to play the tape with a calibrated flux-measuring playback head. But how then does he calibrate this head? Well, maybe by playing a tape with a known fluxivity. But how does he determine the fluxivity recorded...? And so forth. This chicken-and-egg conundrum has exasperated experts on magnetism for decades, and it remains the case that there is a 10 percent difference between the 8 German (ein) flux measurement and the US measurement. Still, small differences in absolute fluxivity of calibration tapes—even from different manufacturers—are unlikely to be a serious handicap to normal studio operation. If they are, the obvious answer is to reference all machines involved in a production operation (no matter how far apart they are located) to tapes from the same manufacturer, which in MRL's view should provide agreement within a dB, at the very worst.

Azimuth alignment involves adjusting the geometry of the tape-to-head interface so that the head gaps are perfectly perpendicular to the edge of the tape, and therefore perfectly lined up with the flux pattern recorded on a properly-made tape. Needless to say, a calibration tape must therefore be very carefully made. As the calibration tape is recorded, any weaving as it passes over the recording head makes it useless (and any serious weaving of the tape as it passes over your playback head makes it unsuitable on your machine). Weaving can result from poor slitting of the tape edges; from worn or tilted head faces; and from imprecise tape guidance, referring generally to the accuracy with which guides, capstans, and pinch rollers route the tape across the head contours. What the manufacturer of a calibration tape does—or should—guarantee is that the tape is slit in a straight line, the tape stock is uniform, and the recording machine he uses always provides near-perfect tape guidance and alignment. If he fails to ensure any of these conditions, wide fluctuations of the meters as you attempt to use the azimuth-adjustment tones—or any of the other higher frequency tones on the tape, for that matter—will be the giveaway. Of course, the same sort of fluctuations will occur if it is *your* machine that is introducing the weave.

The spot frequencies for playback response adjustment comprise the lengthiest section of the calibration tape. As a rule, a regularly maintained machine will not have to be subjected to a check-out on the whole sequence of tones very often; a quick run-through of the azimuth-adjustment tones is usually enough to verify that a machine is maintaining its high-frequency response. But if it is not, and the reason is not readily apparent (worn heads, for example), then the spot frequencies will help in the hunt for serious anomalies.

As noted earlier, calibration tapes are usually recorded full width in all formats. There are several reasons for this, the most obvious being that different tapes need not be offered for every conceivable track format. (Reflect that ¼-inch tape can be full-track, ½-track, 1/3-track, ¼-track, or ⅛-track, with variations in track widths and positionings to boot.) Furthermore, with a full-width format, one needn't struggle to ensure identical performance from as many as 24 tracks of a master recorder, including identical azimuths for 24 gaps in a head stack—an as-yet-unrealizable goal in tape-head manufacture. But there is one serious drawback to the full-width calibration tape: on playback, it creates a rise in low frequencies, due to fringing effects.

Actually, for ¼-inch 2-track tape especially, fringing effects could not be completely avoided even with an ideal calibration tape, because there are too many non-standard details of head construction that can influence the situation. According to McKnight, the best way to adjust the *low*-frequency performance of a recorder is to work on its record-play response with tapes you make yourself from an audio-generator source. An alternative way is to pre-compensate the calibration tapes as they are recorded to anticipate the low-frequency rise. Still another alternative is to provide a table that lists the response errors to be expected when a full-track calibration tape is used with various multi-track formats. MRL has embraced both alternatives to a certain extent. Its wider calibration tapes are recorded with pre-compensation (which is also being 9 considered for ¼-inch tapes, pending a bit more research into non-standard track winding and spacings). It provides tables that can be used when pre-compensation is not present, and also works hard at thinking about ways to eliminate the problem entirely. The problem is, of course, immensely complicated by the so-called head-contour or head-bump effects that introduce regular undulations in the low-frequency response of a tape machine. Because of these, spot frequencies, unless very closely spaced, cannot be relied upon to document the long-wavelength performance of a recorder. The best solution remains a record-play check.

OTHER CALIBRATION TAPES

The basic calibration tape discussed so far is certainly adequate for the studio with basic test instruments and a typical maintenance schedule. But, for more demanding applications, or when a cornucopia of test gear is at hand, there are calibration tapes that can make adjustments more accurately, more rapidly, or both. Both pink and white broadband-noise tapes are available, and can be used with a spectrum analyzer to make any response anomalies instantly apparent. If the outputs of multiple tracks are summed, these tapes will also point up serious gap-scatter problems in the playback head with a characteristic comb-filter display on the CRT. Swept-frequency tapes with low- and high-speed sweeps can be used with chart recorders (low-speed 50-second sweep) or oscilloscopes (high-speed repetitive 1/10-second sweeps with scope-triggering pulses). The high-speed sweeps will display the upper audio spectrum (500 to 20 kHz) on a scope screen, enabling you to verify the response of each track of a multitrack tape machine in a fraction of a second. Graticules that calibrate the 'scope face for frequency and levels when they are applied to the face of the CRT are also available.

10 For mono tape reproducers, a "difference-method" azimuth-adjustment tape can be used. This is recorded with alternating equal azimuth errors in opposite directions, so that equal output from both signals is a positive assurance of correct azimuth. Because long recorded wavelengths can be used for this test, it is possible to turn the tape over and play it through its backing for a confirmation of the azimuth adjustment tape. Finally, there are tapes recorded with a single frequency, at defined fluxivity, that play for up to 30 minutes.

For any professional tape recordist, the ultimate question is not whether he needs a reproducer calibration tape, but "who do you trust"? As a way of getting in touch with the rest of the recording world, a good test tape is indispensable. But if the rest of the world is playing to a different calibration tape than the one you're using, there may be problems in communication. Elsewhere in this article, Jay McKnight makes the case for accuracy; but it is still a fact that accuracy is one thing and standardization another. A calibration tape that is both standard *and* accurate is the obvious goal, and the way to approach it is to keep aware of the state of calibration tapes and the ways in which they might be improved.

As a way of getting in touch with the rest of the recording world, reproducer-calibration tapes are indispensible to the professional recordist. The characteristics of an ideal calibration tape are absolute accuracy and sample-to-sample consistency. If, in a less than ideal world, it proves to be impossible to get both, a typical recordist should probably place the greater emphasis on consistency—provided the other studios with which he (she) does business adhere to that same consistent standard. But, given the state of calibration tapes today, there is no compelling reason why one shouldn't be able to get both, executed to a high degree of precision. ■

Jay McKnight and MRL

WITH MORE THAN fifty publishing credits to his name in the *Journal of the Audio Engineering Society*, and a reputation that extends far beyond that, MRL president Jay McKnight can justifiably claim to be a reasonably knowledgeable man in the field of tape recording. What follows is the distillation of a long interview with him, freely excerpted and paraphrased.

ON MANUFACTURING CALIBRATION TAPES:

Recording calibration tapes is pretty straight-forward. You just have to be careful, adjust bias, record level, and equalization for each roll of blank tape. A fixed-calibrated reproducing system is frequently cross-checked with an in-house reference-standard tape used to permit cross checks, and we feel confident that this "cross-check standard" lets us know where we are at all times. For care, we go over the reproducing system at the beginning and end of each production day, or whenever the calibration tape type is changed. We check azimuth, sensitivity at 1 kHz and high frequency response and wear on tape guides and heads, relapping parts as necessary. Although the tapes are recorded full track, we monitor on a multi-track playback head. One track drives a chart recorder to provide a plot of the response, but any significant deviation from correct response on other tracks is automatically sensed, resulting in a shutdown of the system until the problem is located and corrected. We estimate that we are well within our specified tolerances on all tapes that leave the house, and even further within the tolerances that can be expected from recorders/reproducers in the field.

ON HAZARDS:

The keys to a good calibration tape are (besides suitable tape stock) a mechanically-stable transport and tape heads with a known and stable gap length, plus amplifiers that are similarly reliable. Without these, everything becomes a hazard. Beyond that, there is the constant possibility of oxide shed building up on the tape heads. You could ride gain as you produce a tape, turning the level up when you see the output dropping. If the output drop is caused by contamination of the playback head, you wind up with too much flux on the tape. If the contamination is on the record head, you might be all right for a mono reproducer. And what if the tape is intended for a multi-track reproducer, and one or two tracks are troubled while the rest are fine? We prefer to shut down and look around when any anomalies turn up.

11 Tape guidance is a horrendous problem; we just do the best we can. For our ¼-inch tapes we use edge-loading tape guides—a carefully chosen weight pressing on the upper edge of the tape to position it accurately. For wider tapes, we modify the guides to very close tolerances. If the tape jams, we throw it out. The loss is not significant; audio oscillators are cheap talent.

ON CHOOSING TAPE STOCK:

From the user's point of view, the tape stock used for a calibration tape should make no difference, provided there are no mechanical hang-ups ("sticktion," etc.) when he runs it through his machine. In practice, we use stock from three 12 suppliers: Agfa (PEM 468), Ampex (456), and 3M (250). These are widely-used tapes, and most of our customers prefer to use a tape stock they're familiar with. We don't specify the tape type on the packaging in any obvious way, but we don't deliberately make a secret of it either. Agfa is marked by a white dot on the box, Ampex with a blue, and 3M with a red. Tape varies from batch to batch, and there are times when one supplier is doing well and another poorly. We maintain supplies from all three vendors so that our production can keep going despite the occasional difficulties that one or another vendor might get into.

The final criterion we apply to raw tape stock is uniformity. It must be properly slit, regular throughout its length in magnetic performance, and free of drop-outs and other effects of asperities. A tape used in a music studio can exhibit variations in output up to 0.4 dB and still be fine. but that is not good enough for our purposes.

ON PACKAGING AND SHIPPING:

No evident problems. We use four-in. hub plastic reels for ¼-inch tape and precision aluminum reels for the wider tapes. We have seen no evidence of erasure as a result of airport security devices, or even proximity to powerful permanent magnets like loudspeaker assemblies. Erasure fields have to be about 20 percent of the tape coercivity in order to have a perceptible 13 effect, and that involves something like 5k per meter passing through any erasing device. It's not likely this would occur by accident. In any case, our warranty provides for verification of a tape's accuracy if any damage is suspected to have occurred before it reaches the customer.

Sometimes we are asked about heat, but in general, any temperature you can comfortably live in will be comfortable for the tape as well. Although higher temperatures will encourage print-through, this will not necessarily affect accuracy of the recorded signal. It will simply implant ghostly additional recordings on adjacent layers of tape.

ON USE:

Properly used, a calibration tape will last until it becomes so limp that you're sorry for it. But, even one pass through a machine that is magnetically or physically hostile can end its usefulness in a moment. The magnetic threat is residual field from the guides or other tape-contacting surfaces. The physical threat is anything that might rub against the tape (reel flanges, guides) to cause ripples at the edges, making it worthless for the evaluation of outside tracks, and chancy for the inner ones as well. You can recognize physical troubles by variations in the output of the outermost tracks, but you can't do anything about it once it has occurred. If you suspect magnetic damage, you can check your tape against a known calibration tape. But with reasonable care, none of these steps should be necessary.

One other thing: some tape transports start and stop with violent jerks that may cause damage to the calibration tapes. Others have chronic circuit-switching problems that will mysteriously leave record and erase heads active when you want them to be dead. For caution's sake, a calibration tape should be played with all recording circuits thoroughly out of the way, and it should be played all the way through without stops or rewinds. It should also be stored tails out.

ON FOLLIES:

Calibration tapes are costly, so some users decide to dub them onto another tape and use that, keeping the calibration tape in storage. All this does is perpetuate the errors that the tape recorder is making in the first place. The purpose of a calibration tape is to define the relationship between it and the gaps of the playback head. This relationship is crucial, and only the touch of a precision-made calibration tape on the actual surface of the playback head can evaluate it. Substitutes may be convenient for rough checks, but they are no substitute for an absolute standard.

In time, any calibration tape will begin to show poor results because of the aging (through use) of the tape, your machine, or both. At that time you'll begin worrying about the accuracy of your calibration tape, and you might be inclined to buy a new one, only to find that its results do not agree with former ones. Which is right? The new tape? The old tape? The machine, despite what any of the tapes say? You can't know immediately, and pressures of session schedules may keep you from poking into the situation later. But if you had bought *two* calibration tapes—one for general use and the other for storage—you'd have a reference dating back to your first alignment. If discrepancies are still present, chuck the tape you've been using for routine set-up (or at least have it checked for accuracy), bring in the calibration tape that's been in storage, and buy a new calibration tape for back-up. The process seems expensive at first glance, but it pays off down the road. ■