Standard Alignment Tapes – A History At and After Ampex[1]

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0 INTRODUCTION

Ampex announced the Model 200A tape recorder in 1947 October. This was the first USA-made professional audio tape recorder with the quality and durability needed for broadcasting and sound-recording studio operation. It was first used for recording, editing, and playing the Bing Crosby radio show, and also for time-zone delaying radio programs broadcast by the networks across the USA.

For such professional applications, Ampex design engineers (who were already familiar with disc-recording standards) understood that the recorders and reproducers, and the recordings made on different machines, needed to not only be of the highest quality but also interchangeable to ensure consistent equalization, azimuth, and recorded level. The Model 200A manual [1] notes (p 3) "*Using the best possible input and monitoring equipment, recordings cannot be distinguished from original program material when directly compared*."

By the late 1940s, the use of standards for recording and reproducing phonograph discs had been in use for twenty years. The earliest sound recorder that we would consider to be "high fidelity" was the electromechanical phonograph disc-recording system developed by the Bell Telephone Laboratories in the 1920s [2] . Those engineers realized that one requirement for a professional system was interchangeability of the recorders, the phonograph discs, and the reproducers. To that end, they defined a quantity for the recorded signal, called *the recorded groove velocity*, and developed means for measuring it, which later became an IRE (IEEE) Standard. Once these standards were defined, Bell engineers developed test recordings that contained the standard levels and the standard frequency responses. To standardize a recording and reproducing system, you would simply play the test record and adjust your reproducer for standard output voltage and flat frequency response. Only after you did that would you adjust your recording system to ensure that the standard reproducer again provided the standard output voltage and flat frequency response. Assuming no further changes were made, you could then record an audio program with assurance that it would conform to the standard.

The situation with a tape recorder is exactly the same – and on page 10 of the Ampex 200A manual we find: "*each machine is checked to match a standard tape to insure that recordings will be interchangeable among machines*."

1 THE FIRST ALIGNMENT TAPES AT AMPEX

To make the first alignment tape, Ampex engineers calibrated a specific recorder to record at optimum frequency response and level. Using this recorder, they then made a single "Standard Alignment Tape" with various tones at standard levels—this tape was then used to adjust playback level and equalization on all tape recorders ready for distribution. But having only one standard alignment tape is a bad idea since tapes are easily lost, erased, or otherwise damaged.

[1] Originally presented at the Association for Recorded Sound Collections (ARSC) Annual Conference at Stanford University, 2008 Mar 26...29

The Model 200A manual (page 19) mentions a "standard tape" with 18 tones across the audio band for setting up the azimuth, gain, and frequency response of the reproducer, with "taps" used to identify the frequencies. The exact history is unclear, but we do know that Ampex engineer Frank Lennert recorded a "master" standard tape and set up a pair of Model 200A recorders for copying. We also know that Alex Poniatoff hired "a bright high-schooler" (Ray Dolby, later famous for his noise-reduction system) to make duplicate tapes from this original master tape. Ray's memory was that this was in 1949 June. It is unclear whether these tapes were given or sold to Model 200A owners; however, the Model 200A manual (dated 1948 July 15) describes adjusting the reproducer "from a standard tape" and assumes its availability.

The recording level and the equalization standards used on the Model 200A were designed for use with 3M Type 112 magnetic tape. This tape had a randomly-oriented coating [3]. An improved tape, 3M Type 111 (yes, the numbering sequence is reversed) was used, beginning with the Ampex Model 300 recorder. 3M Type 111, like all subsequent magnetic tapes designed for audio recording (by both 3M and other manufacturers), had a longitudinally-oriented coating; this provided 3 dB higher output than 3M Type 112 [4] .

With the switch to the new improved 3M Type 111 tape, the Ampex model 200A level and equalization standards were obsolete once the model 300 was developed. That the original standard was abandoned isn't historically all that significant because few original tapes recorded on an Ampex 200A survive. To understand why this is so, one must remember that introduction of high-quality magnetic recording in 1948 generated much excitement—not only because of its wide bandwidth and low noise but also because it was so much more cost-effective than instantaneous cellulose-nitrate disc recording. As a result, most tapes recorded on Ampex 200A machines were reused after the recorded programing was broadcast.

The Model 200A equalization and level were rather arbitrarily optimized. This presented two disadvantages. First, there is no way to write a specification and standard for your recorded tapes or for the recorder. Second, if your "Standard Tape" becomes erased there is no way to go back and reconstruct it (to do that, you would need a fundamental physical specification).

By 1948 May, Ampex was developing the Model 300. The first Model 300 Manual has pages dated 1949 August 15, as does the Manual for the improved Model 200A (called the Model 201). The 300 Manual mentions the standards proposed by the *NAB Subcommittee on Magnetic Recording*, so that standards committee must have existed before mid-1949.

Frank Lennert developed a simplified equalization for Ampex that later became the NAB equalizations for 7.5 and 15 in/s (which are still used in the USA). In the Manual for the Ampex 201, Lennert published a comparison between the equalizations used on several professional recorders at 15 in/s—see page 11 of the Ampex201 manual [5] . It shows that by that time, all of the 15 in/s machines (except the Magnecord) used essentially the same equalization.

By 1950, magnetic tape recording was widely used around the world. The *International Radio Consultative Committee* (known by its French initials CCIR) was studying the means for standardizing the frequency response of the reproducers by fundamental methods, with participation by several European countries. They published a number of reports that were summarized in a 1952 AES convention paper by John D. Bick of RCA [6] .

Over the years, there has been confusion about the name of the physical quantity that describes the signal recorded on magnetic tape. In the original CCIR reports, *surface induction* was used ("induction" is an alternate name for "magnetic flux density") because this quantity (like the output from a magnetic reproducing head) has an output voltage *versus* frequency that rises 6 dB per octave from a constant flux input.

John D. Bick titled his 1953 paper *Methods of Measuring Surface Induction of Magnetic Tape* but he soon found out that the recorded quantity in his paper was actually *flux* rather than *flux density*, and in fact published a little-known Errata [7] in the AES Journal in 1954 April, acknowledging that this error—that is, the use of the term "surface induction" instead of "flux"—had been incorporated into CCIR and NAB

standards and "will be corrected in the near future." Unfortunately it was not corrected for many years; we still get occasional inquires "why does MRL say *flux*? Isn't it *flux density*?" And the answer is, no, it really is just plain "flux."

Lennert at Ampex gave a technical paper at an IRE Convention in 1952 and published it in an IRE Transactions in 1952 [8] . It explained the equalizations and the basis for them, and the notion of measuring the tape flux using an "ideal" reproducing head. This measurement method was used by Ampex to calibrate the reproducers that were used to make the "Ampex Standard Alignment Tapes," and, in essence, is still used to this day.

The first Ampex specification of the "operating level" (which we now call "reference fluxivity") was the flux level that would produce one percent harmonic distortion on playback, which is approximately 6 dB below the level for three percent harmonic distortion. This is not a very repeatable flux because it depends on the particular tape used for the measurement and on the way that the biasing current is set. Furthermore, the "fundamental cancelling" distortion meters used at the time measured the tape noise and bias leakage along with the distortion products; this could cause an error in the measured distortion. Thus to avoid additional measurement error, the thinking at the time was that it was better to copy a standard flux from a reference recording rather than being re-measured "from scratch" and a new standard tape recorded each time it was needed. The Rundfunktechniche Institut of the German Broadcasting System developed a flux-measuring standard in 1956 [9] . We revisited this standard and improved it in AES papers in 1970 [10] and in 1998 [11]; later, we wrote an AES Flux Measurement Standard in 1982 and updated it in 2000 [12]

The first Ampex standard alignment tapes, as I said before, were just copies of a master tape. This has several serious drawbacks. First, whatever level dropouts are on the master are copied, making the levels on the copy less stable. Second, any frequency-response errors on the master are copied. And third, a master tape that is repeatedly handled and played may suffer partial erasure, introducing an error in the master that also gets copied. It is therefore much better to record the tones on the Standard Alignment Tape directly from an oscillator and re-record only the voice announcements from another tape.

2 THE AMPEX "STANDARD TAPE LAB"

Around 1949, Ampex developed an improved system for making a Standard Tape. It used a master voice-announcement tape (played from another recorder) and combined these announcements with tones from a multi-frequency oscillator. An operator switched the record input to the machine recording the newly-created master tape between voice announcements and tones. The record level was trimmed manually, as needed.

This system is shown in a 1958 paper by Frank Richards in the AES Journal [13]. It includes photos of the modified Model 300 used at Ampex to record the Standard Tapes. Also shown is the playback head azimuth indicator on this transport, the specially-built oscillator (with manually switchable frequencies), a switch to change between voice and tone, and a level trim-pot for each frequency. This system was used at Ampex from 1950 until the 1980s. A copy of this system was later used at both STL (Standard Tape Laboratory) and MRL (Magnetic Reference Laboratory).

Richardson also describes the manufacturing process:

> The voice instructions of the Standard Tape are reproduced from another machine, and since all Standard Tapes are recorded in reverse to eliminate the necessity for rewinding, the voice is reproduced backwards from one track of a two-channel machine. The other track carries cue tones to guide the operator who, incidentally, is a laboratory engineer devoting full time to the production of these tapes. Surveillance of each tape is maintained as it is being recorded, and any tape showing deviation from accepted standards is immediately discarded. Tolerances of ± 2/3 minutes for azimuth setting, and ± 1/4 dB in level are maintained.

Let me add a comment here: We at MRL think that recording the Standard Tapes backwards, as Ampex did, was actually *not* such a good idea. Here's why:

- Any level corrections from one tone to the next occur at the ***end*** of the tone. But when you're adjusting the response of a reproducer, you are probably making the last fine adjustment at the end, when the recorded level is moving around. Better to record in the "normal play" direction, so the corrections are made at the *beginning* of the tone so that the end of the tone is steady.

- When the recording is "heads out" you have to rewind it after use for storage. Rewinding (typically a very fast, high-tension rewind) is not as good for storage as a slower playback wind. It's better to store the tape played then only rewound just before use; this way, the master tape will be loosened up with a rewind but only just before use.

- Even though engineers who are used to "heads out" tapes may be confused by a calibration tape that is stored "tails out," the benefits of storing an expensive calibration tape this way far outweigh any perceived inconvenience.

Continuing research at Ampex and other companies improved the understanding and practices for the standardization of the tape flux ("recorded level"), the flux vs frequency ("equalization"), and the azimuth [14] . These also resulted in papers in the AES Journal about using Standard Alignment Tapes by Morrison [15] and by McKnight [16] .

3 COMPETITION

Morrison [17] left Ampex to found the competing "Standard Tape Laboratory" in 1968; STL closed in1990. McKnight and Bardakos left Ampex to found "Magnetic Reference Laboratory" in 1972; we are still making Calibration Tapes in 2019. The MRL system that we developed in the 1980s is computer automated and now has the voice on a hard-disk recording, with computer-controlled switching of voice and tone, and an automatic gain control to keep a constant recorded flux even if the tape sensitivity varies a little during the recording.

The Ampex Standard Tapes had one format—announcements and standardized tones and levels. At MRL, we have experienced considerable demand for tapes with more (or fewer tones), shorter or longer duration, and customized features including sweeps and pink or white noise. With the computer control, we have the ability to program many combinations of voice-announced tones.

Standards for sound recording are now written and published by the International Electrotechnical Commission (IEC). The standard for magnetic tape recording (originally issued as IEC Publication 94) is now called IEC Publication 60 094 and is in several parts. Part 2 is "Magnetic tape recording and reproducing systems, Calibration Tapes" which gives specifications for standard Calibration Tapes (including frequencies, levels, and tolerances). We at MRL have adopted the IEC name "Calibration Tapes" although many people still call them "standard alignment tapes."

There are unfortunately no published standards for the measurement of Calibration Tapes.

4 THE VOICES

People often ask us "Who are the voices on the Standard Alignment Tapes?" I don't have exact dates, but here are the names and approximate times:

Around 1948, according to the Model 200A manual, there were "taps" (not voices) to identify the tone frequencies.

Around 1948 or 1949, Frank Lennert [18] , Ampex engineer and Manufacturing Manager, is reported to have recorded the voice for the tapes. I've never seen (nor heard) one of these tapes. This may be the tape referenced in the 1949 June 15 manual.

The 1952 manual for the Model 300 mentions the #4494 Standard Alignment tape (quarter-inch, 15 in/s). This was packaged in a small round gray-painted metal can; the announcements were the voice of Ross Snyder [19] , Ampex engineer and Product Manager. The 1952 December Ampex price list has this listed for US$11.

Around 1960, a new voice track was recorded for Ampex by audio engineer Bob Morrison. The package was also changed from the metal can to a rectangular cardboard box. The part number was changed to 01-31321-01 for the quarter-inch, 7.5 in/s tape. I have a sample dated 1961 April.

When Morrison left Ampex to found Standard Tape Lab around 1968, the Ampex voice tape was again newly-recorded, this time by Tony Bardakos (who was then working at the Ampex Standard Tape Lab). Bardakos was to go on to found Magnetic Reference Lab in 1972; he then recorded all MRL voice tapes used from 1972 to 1990 (when we introduced a new computer-controlled signal-generation system).

The current (1990…2019) MRL voice tape was recorded in 1990 at the Menlo Park (California) studios of *Music Annex* by Tim Enos, a professional voiceover artist. These announcements were formatted so that they could be flexibly assembled into the necessary announcements "on the fly" as the Calibration Tapes are recorded.

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5 REFERENCES

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http://www.aes.org/aeshc/docs/ampex200a/ampex-200a-instruction-book.pdf

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[13] Robert Keith Morrison obituary

[18] Frank Lennert obituary

[19] Ross Snyder obituary