Acetate Audio Tape

Origins

Acetate audio tape appeared on the United States mass market in 1948 with the introduction of 3M/Scotch 111 tape in 1948. For the next quarter-century acetate tape was manufactured and used both professionally and by home-recording enthusiasts. Millions of hours of audio heritage were recorded onto acetate tape, the vast majority of which is still only on acetate tape. While acetate tape is a high quality recording medium, it is not a permanent carrier. It is a rather robust medium, but due to inherent defects in its permanence and the fact that any acetate audio tape is at least 40-years-old at this point the need to transfer the content of any sound recordings on acetate tape to a more stable medium is critical.

The first developments on acetate audio tape took place in Germany between the years of 1934 and 1943. Herman Buecher and Wilhelm Gaus of German companies AEG and BASF, respectively, made “a ‘gentlemen’s agreement’, later formalized in a written contract, that AEG would build the machines and BASF would make the tape, with their development teams cooperating closely.”¹ The tape transport system developed by AEG set the standard for future audio tape machines and to this day most any tape machine has a similar tape path as well as locations of reels and heads as the original AEG machine (see figure 1).² After some technical problems scratched at 1934 release, BASF and AEG unveiled their audio tape and tape machine, which they decided to call as a whole “Magnetophon”, at the 1935 Great

The “Magnetophonband Type C” tape (C standing for Cellit, the brand name of cellulose acetate) was 30 μm thick cellulose acetate base coated with 20 μm of carbonyl iron powder mixed with more cellulose acetate and it was 6.5mm wide and ran at a speed of 1 meter/second. The thickness of the base and the magnetized layer remain unchanged in today’s professional tapes.

The two-and-a-half years of innovation, sweat and cooperation between AEG and BASF had yielded an entirely new product able to be put into mass production. Dr. Friedrich Matthias, the BASF chemist who first produced the Magnetophon tape, noted in a letter to company headquarters the promising reception of the Magnetophon at the Radio Exhibition:

*The Magnetophon machine created a great deal of interest at the exhibition. The dealers recognized the fact that this machine was the “hit” of the show, something we heard as well. They realized the many important applications of the machine, including its use as a dictation and news gathering device, as well as the perfect replacement for phonograph records.*

The Magnetophon was not cheap – the recorder cost 1350 Reichsmarks and an hour of tape 36 Reichsmarks – but still costs about 1/7th the price of the steel tape for the Lorenz “steel Tape Sound” machine, the main competitor to the new Magnetophon. At this price the technology was too expensive for most consumers and obviously aimed at the industrial and professional markets.

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3 Engel (1988), 608.
4 Ibid., 608.
5 Quote from Engel and Hammar, 1
6 Ibid., 3
Developments and improvements continued on the Magnetophon after its well-received debut. The tape itself saw particularly important improvements in the following years. In the summer 1936 the carbonyl iron in the binder was replaced by the iron oxide Fe$_3$O$_4$. This new magnetic coating on the tape allowed for higher quality recordings due to its higher coercivity and greater remanence.\textsuperscript{7} It also changed the color of the Magnetophon tapes from light grey to deep black.\textsuperscript{8} Shortly after this oxide improvement, the first official public tests of the “Magnetophon Type C” tape arrive when BASF engineers recorded a concert by the London Philharmonic Orchestra in Germany. The recording was successful but the quality of the audio was poor due to the DC-bias electronics still in use and still below the quality of the wax transcriptions discs widely in use at German radio stations.\textsuperscript{9} 1939 brought another change to the magnetic layer of the tape. Fe$_3$O$_4$ was replaced by the considerably smaller particles of γ-Fe$_2$O$_3$ and this successful formula reigned supreme for the next four decades until the introduction of chromium dioxide tape.\textsuperscript{10} Though the tape was still not quite at “broadcast quality” (signal-to-noise ratio 40 dB and frequency response of 50Hz to 5 kHz) the successful use of AC-bias recording in 1943 and

\textsuperscript{7} Ibid., 4
\textsuperscript{8} Ibid., 4
\textsuperscript{9} Ibid., 4
\textsuperscript{10} Ibid., 5
further advancements in the tape production would soon ensure that magnetic tape would be the recoding medium of choice for most of the 20th century.

All of these different magnetic materials were applied to the same base film material – cellulose acetate otherwise known as BASF product “Magnetophon Tape Type C”. Though eventually replaced by PVC in Germany and later polyester (Mylar) worldwide acetate based tape was produced until 1972/1973 and people were using it to record well into the 1970’s.11 Part of the reason for this longevity was simplicity and cost-effectiveness of the manufacturing process.12 The acetone used in the process was inexpensive and widely available, and all three parts of the tape: base film, magnetic coating, and binder used cellulose acetate.13 The tape was produced and coated in 700mm wide strips (Figure 2) and then cut to the desired width and length (Figure 3). Cellulose acetate had its known drawbacks at the time in that it was brittle and easily affected by changes in humidity. But, it was ultimately a factory explosion at the BASF Magnetophon tape plant on July 29, 1943 that forced increased research and development of other types of tape base material - at first PVC and later polyester.14 This R&D work led to the modern polyester type magnetic tapes that are used for data, audio and visual storage around the world.

12 Engel and Hammar, 5
13 Ibid., 5
14 Ibid., 5
Coming to America

Throughout the development, refinement and exhibition of Magnetophon Tape Type C, the United States, specifically the U.S. Army, seemed completely unaware of the German advancements being made in magnetic tape recording. The Germans made no secret of the invention, yet the US military took little or no notice and used AC-bias wire recorders throughout the war.\textsuperscript{15} The U.S. captains of industry also paid no attention to magnetic tape and its overseas advancements. It was the curiosity and foresight of U.S. Army Signal Corps officer, Major John T. “Jack” Mullin who brought the German's magnetic tape achievements to America. Mullin joined the army right before the start of WWII. He had background in electrical engineering and was stationed in England working on radar-caused radio interference problems all over Britain.\textsuperscript{16} While doing this work, Mullin would often listen to music on German radio stations since the BBC broadcasts went off the air at midnight. Mullin writes,

“I had some experience with broadcast music and knew what "canned" music sounded like. The American networks wouldn't permit the use of recordings in the early 1940s, because they claimed the quality was inferior. You could always spot the surface noise and the relatively short playing time of commercial 78-rpm discs. Even transcriptions had some needle scratch and a limited frequency response. There was none of this in the music coming from Germany. The frequency response was comparable to that of a live broadcast, and a selection might continue for a quarter of an hour or more without interruption.”\textsuperscript{17}

\textsuperscript{15} Engel and Hammar, 8
After the war ended, Mullin led a team investigating and inspecting captured German equipment.\textsuperscript{18} It was during these investigations the Mullin had the curiosity and luck that led him to a castle north of Frankfurt where German radio station was housing an intact Magnetophon.\textsuperscript{19} After asking for a demonstration Mullin realized it “was the answer to my question about where all of that beautiful nighttime music had come from.”\textsuperscript{20}

Realizing what a special machine he has just stumbled upon, Mullin started photographing all the manuals and schematics. He made sure the Signal Corps got two Magnetophons and he kept two for himself, which he disassembled and shipped back to San Francisco.\textsuperscript{21} He also grabbed 50 reels of tape.\textsuperscript{22}

Once back in the U.S. he reconnected with his shipped Magnetophons\textsuperscript{23} Mullin he began the months-long process of reassembling the Magnetophon electronics (wiring them anew with American parts when necessary) and started inviting audio professional to experience them. It was now mid-1946. Over the next 3 years Mullin would work with ABC and Bing Crosby bringing about the first commercial live recordings to magnetic tape in the U.S. The story of their collaboration is beyond the scope of this paper, but it represents an interesting and key moment in recording history, to say the least.\textsuperscript{24} He would also work closely with a small Californian electronics manufacturer named Ampex, helping to launch the development and production of magnetic tape recorders in the U.S.\textsuperscript{25}

\textsuperscript{18} Engel and Hammar, 8
\textsuperscript{19} Mullin, 1976., 1
\textsuperscript{20} Ibid., 1
\textsuperscript{21} Ibid., 2
\textsuperscript{22} Engel (1988), 8. The tape turned out to be Type L, a homogenous (as opposed to coated) PVC tape that had been developed by BASF in October, 1943. It remained the only professional tape in America for over a year.
\textsuperscript{23} Army regulations stipulated that shipped packages had to fit inside a mailbag. The Magnetophons pieces had to be shipped in 35 separate containers to comply. Fortunately, all 35 arrived unscathed. (Mullin, 1976)
\textsuperscript{24} “John T. “Jack” Mullin.” Museum of Broadcasting. \url{http://www.pavekmuseum.org/jmullin.html}
\textsuperscript{25} Engel and Hammar, 8
As American industry quickly adopted the new recording equipment and its new role as post-war superpower, it created very favorable conditions for a magnetic recording development boom and continuous improvements were made as the technology spread rapidly around the world. The emerging American recording industry also put its stamp on the acquired German technology. The standard width of the tape (6.5mm) and speed (77 centimeters per second) were slightly adjusted to a quarter inch width (6.35mm) and a 30 inches-per-second speed (76.2cm). The almost negligible differences became the standard worldwide, even in Germany. With all of the German patents invalidated after the war, 3M’s “Scotch 111” acetate audio tape became the world sales leader and Ampex became the dominant tape machine maker. This rapid development also gave rise to the development of videotape recording. As Engel and Hammar note:

All of today’s video recorders and tapes are direct descendants of that first Ampex machine and 3M tape, which are, in turn, the offspring of

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\[26\] Ibid., 8
the first AEG Magnetophon and BASF tape – as are all data tape
recorders, compyter floppy and hard disks......The decision of AEG and
BASDF/I.G. Farben in the 1930s to build high-quality audio recorders and
tape.....showed tremendous foresight.27

Technical Difficulties

Magnetic tape is an unstable medium. It is not necessarily a fragile medium, and when properly taken
care of it is actually quite hardy. But, it is ultimately unstable and over time will disintegrate and take
whatever recordings it has with it. Magnetic tape has been produced on three different bases since its
development in 1930s Germany – paper, acetate, PVC and polyester. This paper is focusing on the
unique qualities and problems of acetate tape as they relate to archiving and preservation. It will also
cover a few basic storage and handling issues that are a concern of most magnetic tape. Paper tape is
quite rare and due to its distinct difference from the other three base materials should be thought of
separately in most instances. PVC tape is also uncommon, especially in the U.S. where it was never
manufactured. But, its preservation issues are similar to polyester. Acetate and polyester bases make up
the majority of audio tapes being held in archives. There are definite similarities between acetate and
polyester tape and a modestly equipped archive should be able to handle both quite easily assuming the
tapes are not already extensively damaged. But each base has enough of its own unique preservation
problems that Steve Smolian refers to them as “different species.”28

Three distinct components make up most magnetic tapes produced in the last 60 years:

- Base film
- Binder/oxide coating (including lubrication)
- Back coating (not on all tapes)29, 30

27 Engel and Hammar, 9
The base film keeps the structural integrity of the tape. Acetate base was in production from 1935 to 1972/73 and was highly popular during the beginning of its production before being eclipsed by polyester tapes as they became the preferred base for most applications. In all likelihood, audio recording was the last outpost of magnetic tape recording to still actively use acetate-based tapes. Each type of base poses its own preservation difficulties as each type fails in its own unique ways. Before getting into the specific ways acetate base tape degrades I want to first look at the ways in which they can fail similarly. These consist mostly of variations of improper winds and the damaging effects they have on tape. Poor tape winding and poor tape pack on the reel “is one of the most underrated risks for magnetic tapes...and prolonged storage of badly wound tapes causes irreversible deformations, which may lead to severe replay problems, specifically with thin tapes and high density recordings...” Below are some photos of various poor winds and packs taken from Mike Casey’s FACET report.

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30 One issue that arises in researching magnetic tape is a confusion of terms. The three components often have different names in papers and reports that may have been written decades apart. The problem also stems from the physical makeup of tape changing over the decades, most notably with the widespread use of back coatings starting in the 1960s. Often one will find the base film being referred to as the backing. I have seen papers refer to the back coating as the backing as well. There are also cases where the binder/oxide coating is referred to simply at the coating. For the purposes of this paper, I will be sticking strictly to the terms as Richard Hess uses them. I find his terms and use of them to be very clear and well defined. If I cite and author’s work whose terms differ from Hess’s, I will conform his or her terms to this paper’s and not the changes.


These photos represent several different ways a reel can be damaged by poor or careless winding. Poor windings also leave a tape extra exposed to any environmental changes in humidity or temperature, a big concern for acetate tape. 3M recommends a tape tension of three to four ounces per quarter-inch of tape width. A tape that is wound too loosely could suffer from cinching (Fig. 5) and one that is wound too tightly could easily suffer from spoking (Fig. 8). To reduce the chances of either of these happening tapes should be wound at a slow speed, never at fast-forward or rewind speed, with constant tension. Many people also suggest winding tape “tails out” or in the “played” not “rewound” position. All of

these damages will lead to the tape not sitting properly in the playback machine and not having good contact with the heads. If this happens, both playback and recording will be significantly compromised.

**Acetate Specific**

Acetate tape can be differentiated from polyester tape by simple visual inspection. When held up to a light source, acetate tape is translucent while polyester tape is opaque (Figure. 9 & 10). This test may not work as well on the thinner base tapes (1.0mm and under) because the polyester tapes may begin to show some light as well. As an alternative but more invasive test tearing a piece of acetate tape can help identify it. If the tape breaks cleanly it is acetate and if it stretches it is polyester. The possible damage that can happen to information on the tape with this test is obvious, so great care should be taken whenever it is necessary to tear a tape for identification. Always choose a small piece at the tail or head of the tape. Never rip in the middle of a reel.

![Figure 9. Translucent acetate tape (Source: Casey)](image1)
![Figure 10. Opaque polyester tape (Source: Casey)](image2)

One of the major concerns with the stability of acetate tape is its sensitivity to moisture. Acetate is eight times more sensitive to moisture than polyester. At high humidity acetate tape will absorb moisture and lengthen. A 60% increase in relative humidity will cause a 2400 foot long acetate tape (1.5 mils in
thickness, recorded at 7 ½ ips and playing for 60 minutes on a standard 10.5 inch reel) to lengthen by about 14 feet and increase running time by 23 seconds. This is very significant. A similar polyester-based tape will lengthen by about a foot. Having a properly wound tape with a good tape pack can mitigate these effects, but storage in a proper temperature and humidity controlled environment is essential to avoiding damage to tapes. Even properly wound acetate tape at %50 relative humidity will become very loose if humidity rises to %95 and very tight is humidity falls to 5% - this is a property known as wind stability. A loose wind makes handling a reel difficult as it could more easily unwind or start slipping off of the reel. A tight wind can start a whole host of problems. Physical deformation of a reel is easily caused by an overly tight wind and if left too tightly wound for an extended period of time this deformation could become permanent.

Keeping temperature and humidity stable is essential for proper tape maintenance. Fluctuations in temperature and humidity cause problems for all tapes, not just acetate. Because tape is not homogenous the binder and base react differently to variations in temperature and humidity. This has come to be a big problem for polyester tapes where many of the tapes produced in the 70s and 80s (after acetate stopped being produced) have started to suffer from binder failure. Fortunately for acetate tape, more stable vinyl binder systems were used during its lifetime. So, most acetate tapes face little chance of binder failure that is currently plaguing polyester tapes. Instead acetate tape faces risks to its base from its sensitivity to moisture in the air. To reduce this risk, acetate tapes should be stored in a low-temperature low-humidity environment. Lower humidity will decrease the occurrence of hydrolysis, which is a chemical decomposition caused by the influence of water.

35 Smolian, 39
36 Eilers, 304
38 Van Bogart
39 Breen, 6
Specific temperature and humidity recommendations have fluctuated between groups and over the years. There is a forming consensus that past recommendations have been too conservative when it comes to storing tapes in colder temperatures. This has been the case because the recommendations were often made on what was good for recording and playback as opposed to storage and archiving.\textsuperscript{40}

Current industry standards recommend storage conditions of 65-70˚ F and 40 – 50% relative humidity. These standards are fine for magnetic tape that will need to be readily accessible for playback. But for tape that is intended for long-term archival storage a lower temperature and humidity is thought to be best. This is especially true for acetate tapes that are starting to show signs of “vinegar syndrome”.\textsuperscript{41}

This graph (Figure 11) shows that a temperature of 59 ± 5˚ F and 40% maximum relative humidity (RH) to be safe for reasonable storage.\textsuperscript{42} UNESCO recommends a temperature of 45 ± 5˚ F with %30 RH for preservation storage.\textsuperscript{43} There are even some suggestions where freezing tapes may be beneficial.\textsuperscript{44}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure11.png}
\caption{Figure 11. (Source: Ampex)}
\end{figure}

\textsuperscript{40} Van Bogart
\textsuperscript{41} Hess (2006), 248
\textsuperscript{42} Van Bogart
\textsuperscript{44} Hess (2006), 248. Though industry standards indicate never to freeze tape because of possible damage to the lubricants it is well known from film work that freezing acetate film substantially reduces the speed of vinegar syndrome. Hess refers to a study by the Canadian Conservation Institute (CCI) that will be a small-scale evaluation of tape freezing. I could find no results or mention of this study other than by Hess. If the study is happening the results would be much needed information. Hess notes that “conservators face a difficult decision: store the tapes cool and dry and maybe they will last a few decades, or freeze them and risk destroying them and maybe the will last a few centuries.”
While low humidity storage situations are always recommended due to the sensitivity of acetate to hydrolysis, it must be noted that acetate is also susceptible to becoming brittle and dry and shrinking. Eilers phrases it nicely, “In other words, acetate tends to ‘breathe’ moisture and, depending on ambient conditions, will tend to either plasticize or embrittle.” UNESCO reports:

Cellulose acetate has a tendency to become brittle through hydrolysis caused by the moisture contained in the atmosphere. This brittleness generally causes serious problems when playing old audio tapes. Tapes with severe cases of hydrolysis can suffer from the so-called ‘Vinegar Syndrome’, an auto-catalytic process whereby acetic acid is set free in ever increasing quantities and thus creates an accelerating effect on the decay process. This has been particularly experienced in film archives, especially in hot and humid climatic areas. Affected films become soft and limp, ending up as powder or slime. While, in theory, this may also happen to acetate audio tapes, no disastrous losses similar to those in the film world have been reported.

Why vinegar syndrome has destroyed an untold number of acetate films over the years yet not had nearly close to the same effect on acetate audio tape is not fully known. One idea is that the higher percentage of cellulose acetate per given weight/length/width of film causes decomposition to happen at a faster rate than with audio tape. Another hypothesis is that audio tape will never be the problem for audio tape as it is for film due to structural differences. This second theory is unlikely. Richard Hess notes that another reason vinegar syndrome may be less of a problem in audio tape is the different

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45 In an email exchange with Tom Fine (of Tom Fine Custom Recording) and Richard Hess, Tom had this to say “One other point about acetate tapes. My own experience is that they shouldn’t be stored in bone-dry conditions because they get more brittle faster and, more importantly, they can get edge curl. Edge curl is especially bad for 1/4-track tapes (i.e. consumer-made, mass-duplicated, some radio-distribution tapes from the late 60’s, etc.). This runs against the grain of some modern archiving practice. Because low humidity is thought to help (in what way?) against sticky-shed (as I understand it, you can’t prevent sticky-shed and all baked tapes go back to sticky no matter how dry the storage conditions), many archives keep their humidity levels below 50%. My own experience in a typical northeast US environment is that acetate tapes want to be stored closer to 60% relative humidity, and then they can last a very long time as long as they don’t grow mold or develop vinegar syndrome.” This is a very interesting point (which seems to make logical sense to me) but I have found no published, reliable reports that corroborate Tom’s experience and suggestions.
46 Eilers, 3. My note: The ambient conditions determining whether acetate will plasticize or embrittle are not determined.
47 UNESCO (2000)
48 Hess (2006), 246
49 Hess (2006), 246
storage methods. Film was stored largely in sealed metal cans that allowed little if any of the acetic acid gas to ventilate. This lack of ventilation increased the auto-catalytic properties of vinegar syndrome to catastrophic levels. Acetate tape “was most likely protected by the buffering and acid absorption properties of the cardboard boxes almost universally used to store tapes since 1948. In addition, the cardboard boxes are not sealed, allowing at least some ventilation to remove the build-up of degradation products.”50 (see Figure 12) Hess also worked on restoring a reel of Magnetophon Type C tape that had been stored in a sealed metal can for over 60 years. The damage from vinegar syndrome on this tape is extreme. (see Figure 13)

![Figure 12. (Source: Hess)](image1)

![Figure 13. (Source: Hess)](image2)

### Conclusion

Any tape on acetate base with important information should be transferred immediately. Even if the tape appears great right now, its condition will undoubtedly deteriorate. There is reportedly current research underway into whether freezing acetate tape can provide a long-term storage solutions is underway, but until those results are available. So, for now, freezing tapes cannot be recommended as a storage solution. The best practice is to store tapes in a cool and dry location.

50 Hess (2006), 247
Annotated Bibliography


Recommended. The information here is readily available in more recent publications and some of its suggestions are no longer considered best practice. But much of it is still relevant and worth reading as a complement to more contemporary guidelines for handling & storage of magnetic tape. Bonus: It has a section on nuclear fallout – “As a general statement, it can be said that magnetic tape will be unaffected by Nuclear Radiation until the dosage approaches a level 200,00 times greater than that which would cause death in %50 of the exposed humans.” Okay….good to know that. Also the opening paragraph says that magnetic tape coatings have the ability to retain the information recorded on them for and “infinite amount of time.” Seeing as no physical tape can last an infinite amount of time the claim seems moot, but it is still an interesting claim nonetheless. I haven’t read much that supports or refutes that claim.


Essential. This is an excellent report that has a good combination of expository descriptions and graphical technical information. Similar to Casey’s paper this report proposes a systematic way to assess magnetic tape collections. Though not a fully realized as Casey’s, the system in this report is much more technical. The report also has results from several tests conducted on tape collections – incubation, acetone extraction, etc. Its scope is perhaps overly broad but I applaud the ambition. At only 6 years old, this is a must read.


Focused on sound recording. A good read for someone interested in how to set up a recording studio and wanted information on mics, recording techniques and acoustics theory.


Recommended. As the title suggests this report is more concerned with selection criteria for preservations purposes, of which carrier degradation is just one criteria – although a highly important one. Cover multiple formats but has a few nice paragraphs about the dangers facing acetate tape. Also most any publication by IASA should be considered required reading for people interested in audio preservation.


A highly detailed account of digital audio preservation at Indiana University and Harvard University. This paper does not focus on the concerns or problems of preserving the physical
tapes of analog audio recordings, but for anyone interested in the digital preservation of such tapes this is essential reading.


Essential. This is the second most useful paper in this list. It is a very practical way to assign points to various media based upon a system developed by the author. Also, there is lots of great information about audio tape use and production and it has great diagrams for illustrating the track various track setups for quarter-inch tape. Fantastic pictures as well.


A very nice history of magnetic recording. This book contains the Engel essay. Only about 60 pages of the book deal with audio recording onto magnetic tape, but they are good pages. The rest of the book contains chapters on the magnetic capture and storage of video and data. I didn’t read them.


Recommended. Eilers’ paper is a short but in depth study of the differences, advantages and disadvantages between the two tape bases. Though completed in 1969, several years before the problems associated with polyester tapes began to appear, the paper still has useful analysis of things like surface smoothness and expansion coefficients... if you are into that sort of thing.


Essential. This is a great history of magnetic recording. A must read for a good basis of where this technology came from and how it was developed. Has a lot of good technical information as well. Also, great pictures.


Very similar to Engel’s paper with Hammar (see above)


I was hoping this would be a more useful paper for my purposes. Unfortunately, it is both extremely short and extremely technical. A layman’s paper about the chemical makeup of various magnetic tapes would be useful – though perhaps violate some copyrights held by tape manufacturers who see the chemical makeup of their various binders and oxides to be highly proprietary. But, this paper uses words like trixylyl phosphate and polypropylene sebacate in every sentence with no helpful explanations. Good reading for the ambitious home chemist.
http://www.richardhess.com/tape/history/index.htm

A case study of restoring the tape of Jack Mullin. It is a very interesting read.


Essential. This paper is the most in depth and useful of all the readings on this list for someone interested in understanding the issues facing the preservation of audio tape.

http://www.pavekmuseum.org/jmullin.html

A history of John Mullin and his involvement with bringing magnetic tape technology from Germany to the U.S. after WWII.


Dissertation. This has more of a socio-economic take on things. Rather dry from what I read and the type-setting is painful to look at, let alone read.


Highly technical. Lots of math. Most of it is over my head just on browsing it. There is a little bit about magnetic binders that could be of use, but Engels paper covers that information in a more digestible form.


Easy read. This was the first book I read when beginning my research. On hindsight it is not the essential. He focuses mostly on vinyl records and the information on open reel tapes is rather vanilla. He does have some good information of tape recorder and playback machines and rattles off the make and model of several of them.


Highly technical. Recommended if you want to understand the physics of magnetic recording. Similar to Mallison’s book, this tome is incredibly dense.


Recommended. A fun read written in the first person about Mullin’s encounter with the Magnetophon in post-war Germany while serving in the US Army. Great history of bringing the technology to the US and a nice respite from what can be some rather dry reading on the subject of acetate tape.
A helpful reference. A list of hub sizes and technical standards.

Useful for polyester tape but not acetate. I liked her pictures.

The information in this paper is available in many other publications. Comparisons are made between polyester and acetate tape for stress strain, temperature, wear and dimensional stability. Incredibly short, so worth the read if time permits.

Essential. Even if over 50 years old, it was the first independent, scientific study concerning the challenges of preserving magnetic audio tape, and its thoroughness and attention to detail are very impressive. While some of the finding and suggestions are now considered to be questionable at best, others remain the industry standard best practices. This is an essential read for anyone interested in the developments of audio preservation thought and technical studies.

Worth reading since it is from IASA. But, there is no specific information about acetate taper and not much specific to any one medium.

The discussion about print-through in Pickett is far superior.

Recommended. I don’t rate this as essential because I feel most of what he talks about is covered elsewhere in a better manner, i.e. Hess, Casey, even Pickett. I also find his writing style and presentation of information to have an unpleasant ‘rushed’ quality about it. Still, worth reading as a part of corpus about magnetic tape preservation and storage.

This information is available elsewhere. What he does provide is rather generic information about a variety of formats. It would be nice to have as something that could fit into your pocket and a quick reference guide.

Recommended. This is a nicely put together collection of information about the vulnerabilities of magnetic media. It reminds me of a shorter and less in depth version of Van Bogart’s paper. Has only a small amount of information specific to acetate tape.


Essential. This paper is a very concise and well put together guide covering most areas of tape storage and handling. He also goes into various ways to restore tapes that have been damaged.


Recommended. This paper talks up the advantages of 1 mil thick tape over the standard 1.5 mil thick tape. It is no longer an argument in archiving discussions of whether thinner bases are at a disadvantage for preservation – they are. I recommend this for the corporate spin on the amazingness of thin based tapes since any current reading about tape thickness inevitably regards the thinner tapes as substandard products.


Very short. Wheeler is well-known in the audio preservation world, but this paper has the feeling of being an abstract and offers little useful or original information.