7.3 Magnetic tape deterioration: recognition, recovery and prevention

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1. **scope of paper**

For the working career of everyone in this room, and for the lives of most of us, magnetic tape is a part of our everyday world and a carrier of much of the information and entertainment we receive. Even though it has been repeatedly identified as "unacceptable as a preservation medium" while seldom if ever citing an acceptable form - some are now speculating that tape may have a life expectancy exceeding that of many paper documents and equal to safety-based film if handled and stored with similar care, reason, and procedures. Regardless of your opinion of tape as a long-term data carrier, it is a fact of life which audio and video collectors, librarians, and archivists have long accepted and with which we must work.

When compared with the early success of the cylinder, the disc, or motion picture film, magnetic recording had a relatively slow start. The earliest evidence available tells us that magnetic tape was introduced by Vladimir Poulsen in 1893, with a Danish patent issued to Mr Poulsen in 1898. Numerous advances were made in magnetic recording technology throughout the first 4 decades of this century, with some of the most notable findings coming from Germany immediately before and during WWII. Radio companies were using magnetic recorders from early in the process, with such notable landmarks as BBC adding the technology in 1930, the German Radio in 1935. Equipment of significant quality was installed in Radio Luxembourg in 1941. ABC (American) Radio first used the technology in 1948, and the first reel of commercial video tape being used at CBS television in 1956. Still, as far as most collectors, librarians, and archivists are concerned magnetic tape can be considered as simply a footnote to archival history until well after WWII.

From a relative slow beginning, magnetic tape has increased significantly in importance in our world. In a 1993 Library of Congress administered survey of 500 archives it was projected that there were at least 26 million audio and video tapes held in established, working archives through the world. Of these, approximately 17 million carried audio, the rest were video, and, to a significantly lesser degree, sound tracks to motion pictures. Even if these figures are incorrect - even by as much as 50%- we would still find over 13 million tapes in archival collections.

This paper will summarize some of the deterioration problems facing tape, give some idea how to recognize them, what to do to recover the data and/or the tape when they occur and how to reduce the risk of their development and allow tape to live to its full life. Even though the observations will apply to virtually all magnetic tape regardless of base, type of recording, or format, and because of our primary interest here - the conclusions will be limited to that format which the Technical Committees of the International Association of Sound and Audiovisual Archives (IASA) and the Association for Recorded Sound Collections (ARSC), and the Audio Preservation and Restoration Standards Committee of the Audio Engineering Society all cite as being acceptable for audio preservation: polyester-based, open reel analog tape. Excluded are digital, cassette, and cartridge tapes, or magnetic media in its various other forms: disks, wire, et al., and, with one exception which I will cite later, tape on other backings.

Further, as important as is the ability to retrieve data recorded onto the tape the record or playback systems will not be considered, except as they may directly affect the deterioration of the tape itself.

ii what is magnetic tape?

Magnetic tape is two-or-more layers of materials, one of which is capable of retaining a change in magnetic energy. The magnetizable layer rides on a base, with the potential of one or more additional layers added for various purposes (such as reducing friction, reducing static, or aiding in a more uniform tape pack).

The top layer of this sandwich is made up of magnetizable particles suspended within a binder. The binder may be composed of various polymers, such as cellulose nitrate, chlorine bearing vinyls, and sundry epoxy and acrylic resins. In addition to carrying the magnetizable particles in a complete dispersion and to depositing a uniform coating of the mixture by solvent release the binder must, also, provide a smooth surface to ease movement of the tape through the equipment; join the various layers securely to the base; be strong enough not to rub-off during record, playback or storage; not adhere to adjacent winds of tape, even under strong pressure and tension; and not craze, flake, or peel. To aid in its functions the binder has frequently had numerous additives some successful and some unsuccessful- including lubricants to reduce friction, cleaning agents to reduce head-clogs, carbon black to reduce static charges, and fungicides to reduce or prevent mold growth. Currently, the binder typically used for magnetic tape under discussion whether for audio, video, or computer data- is a polyester urethane elastomer.

The magnetizable particles today are most commonly ferric oxide (FEE_2O_3) of uniform shape and size. Various other materials have been used over the years, such as chromium dioxide (CrO_2) and metal particulates (MP). However, due its relative stability, the majority of tapes of concern to us here still use iron oxides.

The first widely distributed magnetic tapes had a paper base coated with iron oxide particles. Paper was replaced by a cellulose acetate base that was used extensively from the 1940s into the early 1960s. Although cellulose acetate is reasonably durable, it is more susceptible than PET to the environment in which it is stored, shipped, and used. The acetate base can change over its lifetime and is known to dry out and become brittle, losing its strength in the process. Since the 1960s polyethylene terephthalate (PET, or polyester) has been adopted by most tape manufacturers because it is strong, chemically inert, and less affected by environmental conditions than its predecessors. Another base material used, especially within Europe, is polyvinyl chloride.

In addition to the base and binder, most tapes produced since ca. 1980 have some type of back coating that acts as an aid to tape packing on the hub and reel.

The dimensions of magnetic tape can vary significantly, from less than 1/4-of a-mil to 1.5-mils in thickness, from about 1/8 of-an-inch to 2-or-more inches in width, and from a few feet to potentially infinite in length.

iii recognition of deterioration

Deterioration problems may be grouped by the part of the tape they seem to most affect: Base, Oxide, or Magnetic particles. Regardless of why or on which part of the tape it occurs, tape-to-head contact is of critical importance, since the vast majority of tape problems known to us today are associated in some manner to the relationship of the tape to the head.

Base

The deterioration problems associated with the base are physical deformation, including stretching, breakage, and theoretically, at least, for acetate based tapes- vinegar-syndrome.

Polyester, or PET, the base of most modern magnetic tape, is very stable and will almost certainly outlast the other parts of the sandwich that make up our package. Nonetheless, if improperly handled, stored, or used, it is vulnerable to

being deformed and, hence, of distorting the data on it and/or of preventing the tape from playing at all. Improperly wound rolls of tape, or tapes with excessive pack stresses are likely to become distorted and to have tracking problems when played.

Physical deformation of the base of the tape can take many forms:

*** Popped strand/s**

When one to several strands or wraps of tape protrude from the edge of a roll of tape. Popped strand/s is/are most likely to occur when the pack is wound improperly. Since popped strand/s is/are uneven winds they can produce edge damage when the tape is played, and since they present more tape surface area to airborne particulate matter which can damage the oxide and/or the backing and reduce tape-to-head contact. Further, deformed tape can cause tape-to-head contact problems, tape- head spacing problems. Tape with popped strands is more easily damaged by improper handling, since the edges of the tape are standing out from the tape pack.

*** Pack slip**

A lateral movement of sections of the tape roll causing high and/or low spots in an otherwise smooth tape pack. Pack slip is most likely to occur when the pack is wound improperly. Like popped strands, since it causes the tape to unwind unevenly, pack slip can cause edge damage when the tape is played or cause the tape to play at an uneven speed because of a shift in pack density, resulting in either data dropout in data tapes, or wow on analog tape. In addition, pack slip presents more tape surface area to airborne particulate matter which can damage the oxide and/or the backing, as well as reduce proper tape-to-head contact.

Though different from pack slip, and though creating other problems, interleaving tape of different widths of tape into a roll - acetate and polyester tape for example where the polyester is slightly narrower that the acetate - or improperly made splices can have a similar effect on tape integrity as 'pack-slip.'

*** Cinching:**

The wrinkling or folding over of tape on itself, usually when a loose tape pack is stopped suddenly. It can cause creasing of the tape, which contributes to peeling or shedding tape and, because of bad tape-to-head contact, to dropouts.

*** Stretched tape:**

The elongation of parts of the tape, across the full width of the tape or -most likely- on one or the other side of the tape, usually results from either improper wind or from faulty equipment. May cause long-edge or curvature problems, and distort the signal, but the data can generally be retrieved from an analog tape, usually with a decrease in signal quality.

*** Breaking:**

The separation of a piece of tape into two or more parts, usually resulting from very sloppy handling or use of equipment.

*** Flange pack**

A state where the tape roll is good (no popped strands, etc., but is wound up against one or the other of the sides of the tape reel. Generally caused by either malfunctioning equipment or loose wind, flange pack can damage the edges of the tape.

Although outside the scope of this paper. I feel it imperative to mention a potential problem with acetate based tape, used extensively in the 1940s and 50s. I say "potential" since I am not personally aware of actual examples where acetate-based magnetic tape as distinct from magnetic-stripe or magnetic sound tracks of motion picture film- have actually been shown to suffer from vinegar syndrome. For those of you who have not experienced it, vinegar-syndrome in motion-picture film is an autocatalytic self-decomposition process of acetate cellulose based materials under the evaporation of acetic acid. Affected thus far are motion picture films and some microfilms, but the presumption is that all cellulose acetate based materials will go through the same process. Some have said that it gives off a 'faint-odor' of vinegar. My experience is very different: motion picture film with vinegar-syndrome gives off a very strong smell of vinegar. There is absolutely no question that you are smelling acetic acid - vinegar- when you are around film that is decomposing in this manner. If you are unsure, sniff a little vinegar, wait a few minutes so that your sense of smell can properly recover, and then smell your tape: if the smell isn't very, very similar your tape probably does not have vinegar syndrome.

Since I have not seen vinegar syndrome in magnetic tape I can not describe it with confidence. However, in motion-picture films it first makes itself known by a very strong smell of vinegar, then progresses to the point where the film is discoloured and frequently unable to support the emulsion, advances to a state

where the emulsion is very brittle, and finally gets to a point where the emulsion breaks if handled or jarred.

If you locate vinegar syndrome in your collections remove the 'sick' objects and store them separately to prevent the contamination of other materials by acetic acid. To slow the on-set and/or the advancement of vinegar syndrome, the consensus is that all acetate based materials will eventually develop vinegar syndrome, but it can be delayed for literally hundreds of years if properly maintained - store the materials at temperatures below 40EF, and below 25% relative humidity (RH) (do not freeze tape, as some manufacturers used a lubricant which reportedly solidifies on the surface below 32EF). There is no known method of reversing vinegar syndrome once it begins. If found in time before the base shrinks too much, or is unable to support the oxide, or becomes too brittle- with any luck you should still be able to play and re-record the information.

Binder

Even though all of the physical parts of magnetic tape will deteriorate and can breakdown over time, it is universally agreed that with modern PET-based tape the binder is the weak link, and is generally the part of the tape which creates the most problems. It should be noted that the term 'binder' is used here to mean the adhesive which is used to hold two layers of the tape together: ie. oxide to base, and/or backside coating to base. Deterioration of the binder can cause many problems and can take many forms, including blocking, creasing, friction problems, lubricant loss, oxide loss, sticky-tape, sticky-shed, and tape squeal, to name a few.

*** Blocking:**

The sticking together of two or more winds in a tape pack, most often resulting from deterioration of the binder, storage at high temperature and/or under excessive pack pressure.

*** Creasing**

The folding of sections of tape such that it is ridged or wrinkled; can be caused by hub-slots, by cinching, or by mishandling of tape. Creasing can cause oxide loss and/or tape-to-head contact problems; these, in turn, can lead to dropouts and data loss.

*** Lubricant loss:**

The depletion of that substance or substances that allow the tape to move through its necessary path with a minimum of friction. Like sticky- shed, lubricant loss appears to be an inevitable part of the aging of modern magnetic tape, with the rate and severity of the loss being related to storage and use conditions. Lubricant loss will cause increased friction of the tape, resulting in increased headwear, contributing to sticky tape, sticky-shed, oxide loss, tape squeal, and head clog; the results can include mistracking. This can sometimes be temporarily corrected by judicious application of lubricants, such as a silicone solution or Krytox applied with a wicking or cotton ball applicator.

*** Mistracking**

The inaccurate adaption of tape to its intended path through the tape machine, usually because of some physical deformation or damage to the base or edge of the tape, such as curvature. If severe, the tape will not play properly - or at all - and recorded information may either be distorted or, in extreme cases, lost. Rewinding and environmental staging of the tape may help. In some cases improperly slit tape can produce hardbands which can cause the tape to mistrack.

*** Oxide loss**

The separation of the oxide from the base. It may result from a number of different things, including poor binder adhesion and unnecessary friction and scratching of the tape. Once oxide loss occurs it is not easily - if ever - correctable and generally meets even the most stringent definitions of 'tape failure.'

*** Sticky tape:**

The adhering of one or another parts of the tape to other surfaces. Generally caused by breakdown of either the back coating or the binder, it may cause nitpicking, blocking, head clogs, oxide loss, and, like sticky-shed, alternate sticking and slipping of the tape as it goes across the heads, and tape squeal. Tapes reported in 1988 by Kent Scott' as having sticky problems include Ampex 406, 407, and 456; AGFA 369 and 469; and 3M 226, 250,' and 256. Like sticky-shed, tape can generally be recovered for a short time by either cleaning or various environmental treatments (extended storage at low temperature and RH, placing tape under a vacuum, or baking).

*** Sticky-shed**

Deposits from magnetic tape - usually the oxide or the backing - that rub or wear off onto the various parts of the equipment when a sticky tape is played. Sticky-shed can cause mistracking, blocking, head clogs, oxide loss, and, alternate sticking and slipping of the tape as it goes across the heads. It may result in tape squeal.

*** Tape squeal**

The high pitched noise that is made when sticky tape or sticky shed tape alternately sticks to then rapidly releases from the various stationary surface in its path, including record or playback heads and guides.

Magnetic Particles

The primary problems which occur with recorded signals during storage are demagnetization and the introduction of magnetization other than that originally recorded.

*** Print-through:**

The recording of low frequency signals from one or more windings of tape onto adjacent layers. It is described as a 'ghost signal' heard slightly before the actual audio recording. The strength of such a signal is generally proportional to the strength of the original signal which it is copying.

*** Demagnetization**

The loss of recorded signal, can generally be dismissed fairly easily for tape in storage: it does occur, but it is not common. If it occurs it will, most normally, affect the high frequencies of the recording, and not its intelligibility. If a tape is properly recorded and stored - even if only in normal office environment - the amount of magnetic field decrease will be unnoticeable.

*** Dropouts**

Brief signal losses caused by either a tape head clog, missing oxide, a defect in the tape, debris on the tape or machine and any other situation that reduces the head-to-tape contact. I am always surprised when I review the comparative size of the tape and tape head with some of the materials flying around in the air. When we realize that even the smallest of airborne particles can cause a dropout it is amazing that this technology works at all. The solution appears to be to keep the tape as clean as possible, storing and using it only in a clean

environment, and cleaning and maintaining the equipment as recommended by the manufacturer.

Recovery

Recovery of deteriorated tape and/or signal is an intricate process: what works on one problem may well destroy, or at least exacerbate a seemingly similar problem. Sticky tape can be caused by either binder breakdown, lubricant loss and exuding, or problems with the backing. Don't assume that all problems are the same just because they create similar complications. When carrying out any actions that might reasonably be irreversible - such as baking, or chemical treatments, or buffing the tape - be sure that you are treating the correct 'illness' and are not destroying the very thing you are trying to save.

*** Baking**

One of the methods used to temporarily improve binder problems, allowing sticky tapes to be played. The information from Ampex - the developer of the tape-baking procedure - on how long and at what temperature to bake has been variously quoted at several conditions. I checked with Quantegy/Ampex for this paper and they tell me that their recommendations are to a) leave the flanges on the hubs/reels, b) use a high- quality convection type oven or an environmental chamber, and c) bake a sticky tape at 113EF/45EC to 131EF /55EC for up to 36 hours (no R/H given) will sufficiently firm up the binder so that the tape can be played. For 1/4" audio tape, baking for 6 to 8 hours is normally adequate; the longer baking times are for wider tape widths, such as 2" video or audio multi-track masters. Quantegy/Ampex warn, however, that the effect of the treatment is temporary, and it is recommended that the tape be copied within one to two weeks. Although some report having 20-or-more successful 'bakes', there is no published or documented information on how many times a tape can be baked, cycling back and forth between the sticky-firm-sticky succession before it fails completely or before the signal is distorted or altered beyond use. Care should be taken that the temperature is well controlled. One of the specific questions raised is about the potential affect of increased print-through from the baking process. There have been no reports of significant problems, but one source recommends lowering the heat (for example, from 55EC to 45EC) and extending the baking time if there is concern. Regardless of the time and temperature selected, do NOT, I repeat NOT, rewind the tape before baking as this will almost certainly increase print-through problems, according to Quantegy/Ampex. Specifically, unless there is absolutely no other option, the hair-dryer-in-a-box solution does not give adequate environmental controls and is not a recommended solution.

Regardless of the sophistication of the oven used, be sure and allow the tape to re-acclimatise before handling it, much less playing.

*** Environmental conditioning/staging**

Some have reported notable success with environmental conditioning/staging tape instead of either baking or treatment with chemicals. If time allows, try staging sticky tape at 40EF/4.4EC and 20- to-25% RH (the environment that is being considered for long term storage by a number of the collections represented here today) for several weeks to several months before undertaking more aggressive measures.

*** Chemical treatments**, including addition or replacement of lubricants, is another process that has been developed to recover tape with sticky oxide or loss of lubricants. Like baking, it should be used with the greatest of care. The only such processes known to me are proprietary and have not been made available for public use in any detail.

*** Cleaning**

In general, tape cleaning should follow the same basic premise as for any other delicate item: use ONLY as much effort and force as is absolutely necessary. To do even that will probably shorten the life expectancy of the tape; to do more will probably actively destroy it. In general, clean with soft, lint-free cloth, such as 3M's Pellon or 3M's #610 Tape Cleaning Fabric. Use moisture and chemicals sparingly, and only after testing on disposable tapes. Buffing/scraping tape is generally rejected by all with whom I have spoken, unless all other efforts have failed.

*** Rewinding:**

Careful rewinding of physically deformed tape (warped, wrinkled, or creased tape, as well as tape with popped strands, pack-slip, cinching, or flange packed tape) should be attempted before more aggressive measures - such as pressing or ironing the tape - are tried. If the tape is really important to you or your collection, get professional advice, don't wing it alone. Rewinding is useful for resolving another problem: Print-through can generally be removed by rewinding the tape before playing and is frequently given as an additional reason for storing audio tapes tails-out. If rewinding fails to remove enough of the ghost signal, selective erasure is possible, although it should not be used indiscriminately or carelessly. NB If the tape has sticky problems and baking is

the chosen solution to make the tape playable, it should be baked before the tape is rewound!

*** Splicing**

Though it is not recommended for archival or master materials, splicing is available to mend broken or cut tapes, as well as those so badly damaged in other ways that portions of the recording must be sacrificed and discarded in order to salvage the greater part. If splices are necessary, always use tape specifically made for this purpose, make the splice as neat as possible, and -if the recording is really important- make an un-spliced copy of the repaired tape for archival storage.

Prevention

Since magnetic tape is a physical object, and since all - yes ALL- physical objects deteriorate, magnetic tape will deteriorate regardless of what is done to it or with it. As Pickett and Lemcoe observed in their 1959 study, Preservation and storage of sound recordings:' "the resistance of an article to degradation is built into [it] at the time of its manufacture." While we can not change the article after it is received, we can do things which will allow it to realize its full life potential rather than shortening it. For example, the methods we use and the manner in which we handle, package, store, record, and/or play a magnetic tape will almost certainly have a significant effect on whether that tape develops sticky-shed problems in five years or in the lives of our great- great-grandchildren.

To have the greatest confidence that your tape will last, I suggest the following:

*** Selection.**

Use only good quality, low-print through, polyester based tape, 1.5 mils thick, no splices, even for leader, heads or tails.

*** Handling.**

Handle a tape as little as possible, preferably always wearing clean, lint free gloves. Never touch the actual surface of the tape or the edges of the tape unless absolutely necessary. Handle a tape reel carefully, be sure not to press the flanges to the edges of the tape or to damage the flanges. Replace packaging box, reel, hub and flanges immediately if they become bent or out of line. Do not drop or throw a tape, regardless of how well it is packaged.

*** Packaging.**

Use only open reels with an unslotted hub of NAB design of the largest possible diameter, preferably 10.5" or larger. Be sure that the flanges of the reel are easily removable so that they can be replaced without doing unnecessary damage to the tape if they become deformed or out-of-plane. Leave tape -ALL tape, even cassettes- in the play-through, or tails-out, position. In other words, do not fast forward or rewind a tape that is going into storage. Play-wind 1.5 mil tape on a well adjusted machine at no more than 30-ips from start-to-finish before placing it in storage (Pickett and Lemcoe specify a wind of constant-torque the type of wind most often used as tape leaves the factory- of 3-to-5 ounces at the hub of a 10.5" reel).

Secure the ends of the tape with either a tape made specifically for this purpose (such as 3M's #8125 Hold Down Tape, common called zebra-stripe tape, or by a tie-down collar that is wrapped around the tape and secured inside the tape flanges. Do not use such as adhesive, cellophane, or most plastic-based tapes.

Place the tape in a good quality container, preferably one that will not shed or breakdown. The 3M Library Box is one of the best designed audio tape boxes I know. Unfortunately, it is unclear whether 3M will continue to make this box available, or will allow others to do so, after they leave the magnetic tape business later this year. A call to your local 3M representative or Quantegy - the U.S. company which took over Ampex.

*** Storage.**

Store tape standing upright -not laying flat or leaning- on solid shelving in a dark, clean, dust-free area -don't allow any food, drink, or smoking in the area of tape preparation, use, or storage. Store at an environment as low as you can manage: 40EF/4.4EC and 25% relative humidity for archival storage. Keep the environment as stable as possible, preferably with a maximum fluctuation of ± 5EF and 10% RH in a 24 hour period. In fact, if the storage area is not this stable, or if you cannot get the environment down to these settings, select an environment up to 65EF/18.3EC and 50% RH -an acceptable environment for working collections - where stable environment is possible. If you select a warmer and/or wetter environment be aware that the warmer and/wetter the conditions the shorter the life of your tape. For example, the IPI Storage Guide for Acetate Film estimates that new acetate based motion picture film will develop vinegar-syndrome in less than 20 years if stored at 80% RH and 70EF/21EC, or it will be postponed for over 1,200 years if stored at 20%RH

and 35EF/2EC. All indications are that similar life-extensions of magnetic tape will occur under similar storage conditions.

Though accidental erasure or damage to the signal is almost unheard of, the storage area should be free of external magnetic fields (nor should they be allowed in playback or packaging areas). Maximum flux density permitted should be 10 gauss. Airport walk-through metal detectors, like x-rays and radiation from radar antennas (unless strong enough to be damaging to people) are reported to have no effect on recorded or unrecorded magnetic tape. The only reported problems come from some hand-held metal detectors with powerful magnetic fields -used in some airports: these may partially erase recorded information. A separation of even 2 or 3 inches is adequate to protect tape from all but the strongest of electrical fields.

*** Playing**

To play or inspect the tape, stage it out of the storage area for from 1 to 50 days, dependent upon the width of the tape and the storage environment. An audio cassette can acclimatize in approximately 6 hours, a 1/4" open reel tape in 24 hours, and a 2" reel-to-reel tape will require up to 50 days. The chart shown at the end of the paper from John van Bogart's book, *"Magnetic Tape Storage and Handling,"* is very helpful. If you are using the 40EF/4.4EC and 20%RH environment recommended above, stage in a two-step operation: first move the tape to a controlled environment area (with the temperature mid-way between the colder and dryer area and the intended use area) for the specified period of time, then stage in the environment of the, intended use area for a similar period of time.

Keep your playback area clean, cool and dry. The temperature should never exceed 75EF/23.8EC and 60% RH, and should, preferably, be 65EF/18.3EC and 50% RH, making sure that the RH does not drop too much below 20% to help insure against static discharge problems.

Playback equipment should be maintained per manufacturer's recommendations.

Take the tape from its container only when needed, and return it as soon as it has been played (and, of course, properly wound). Use the time that the tape is out to inspect for all the things that can go wrong: bad wind, sticking, bad reel, flanges, or hub, print through, dirt or debris on the tape, etc.

*** lnspection/rewind.**

Even after 50 years, the jury is still out on periodic inspection of tape. Some say it places the tape in greater danger since the most damage will usually occur during handling and/or playing. Others strongly recommend that tape be inspected every two to three years.

The debate may be a moot point, since the reality of the matter is that most of us do not have the time or the resources to periodically go through our tapes and inspect, clean, repackage, and/or retension them. Possibly the compromise solution may be to monitor the environment of the storage area daily -or at least weekly- basis; when the occasion calls for the tape to be pulled, always handle, package, and clean it as though you were carrying out a scheduled inspection, keeping your eyes and ears open to potential problems. Properly rewind, clean as needed, package, and shelve any tape that is pulled from storage for any reason. Use the pulled items as a sample of the items around it: if you see something unusual, for example, if you notice the -hopefully- first signs of sticky-shed, examine other tapes in the area, particularly those that are from the same manufacturer and the same stock, especially if they were recorded and placed in storage at about the same time. If you find problems, take care of them as soon as possible, since they will probably only get worse.

If all else fails, schedule a periodic blind-sampling of the collection. There are several sources that can help you assure that you are not subconsciously pre-selecting materials.

Conclusion

Thus, within the maximum life built into the tape at its manufacture, it is up to you how long you want your tape to last. Like all other data dependent upon the life of an object to carry the data, magnetic tape is not permanent and is susceptible to physical and chemical breakdown. The rate at which such decay takes places is directly connected to how such carriers are packaged, handled, used, and, especially, to the environment in which they are stored.

Table 1: Recovery Techniques of Optical and Magnetic Media from Water, Fire, Dust, Mold, and Shock

General Principles:

If in doubt, apply the same methods you would use for the recovery of microfilm or movie film to magnetic tape since it is chemically similar and uses same or very similar film substrates.

Do NOT automatically use methods employed for books and paper since there are different chemistries involved, wet tapes are less critical than wet books (i.e wet tapes are less critical than wet paper and do not need the immediate attention generally associated with wet paper), and tapes are more sensitive to damage b heat and/or cold than paper.

WET PAPER RECOVERY PROCEDURES APPLIED TO WET TAPE

Action	YES	NO
Air drying	X	
Dehumidification	X	
vacuum drying	X	
Freezer drying		X
Vacuum thermal drying (@ >75 F/24 C)		X
Vacuum freeze drying (@ <32 F/0 C)		X

Recovery Techniques of Optical and Magnetic Media from Water, Fire, Dust, Mold, and Shock

Problem	**Tape**	**Compact Disks**
Water Damage: Fresh water	keep in clean, cool water until ready to work rinse in distilled water at room temperature dry at ambient storage conditions or use dehumidification	rinse in room temperature distilled water avoid rubbing the disk as grit can scratch the surface dry at ambient storage room conditions or use dehumidification take care not to scratch the media always brush/wipe radially (from center of disk to edge)
Water Damage: Mud/Sewage	place in clean, cool water until ready to work use soapy water at room temperature to remove debris rinse with distilled water dry at ambient storage conditions or use dehumidification	use room temperature soapy water to remove debris avoid rubbing the disk as grit can scratch the surface rinse with distilled water dry at ambient storage room conditions or use dehumidification take care not to scratch the media always brush/wipe radially (from center of disk to edge)
Water Damage:	place in clean, cool water until ready to work **As Soon As Possible**	place in clean cool tap water **As Soon As Possible**

Sea Water	place tape in mild HCI solution to remove debris left by sea creatures rinse with tap water dry at ambient storage conditions or use dehumidification	rinse with distilled water dry at ambient storage room conditions or use dehumidification
Fire Damage: Heat	spool tapes onto new reels if flanges are warped/replace damaged or warped cassette housing if tape is badly blocked, use back-up	a slightly warped CD may still be playable recovery of a badly warped CD is probably impossible
Fire Damage: Smoke/Soot	vacuum soot/ash from tape package and/or tape pack if package is not wet, avoid getting it wet wipe remaining soot/smoke residue from package and/or cassette housing with damp cloth, changing cloth often avoid direct contact with tape as much as possible use of a winder/cleaner may be necessary to remove remaining soot/smoke residue	vacuum or brush soot from the surface use special care to avoid scratching the disk wipe remaining debris from disk with a clean soft cloth dampened with distilled water always brush/wipe radially (from center of disk to edge)
Dust/ Debris	vacuum as much of the dust/debris as possible from the package/reel if package is not wet, avoid getting it wet wipe remaining dust/debris residue from package and/or cassette housing with damp cloth, changing cloth often avoid direct contact with tape as much as possible use of a winder/cleaner may be necessary to remove remaining dust/debris	vacuum or brush dust/debris from the surface use special care to avoid scratching the disk wipe remaining debris from disk with a clean soft cloth dampened with distilled water always brush/wipe radially (from center of disk to edge)
Mold/ Fungus	isolate tape and its package from unaffected materials keep at humidity <50% RH and at temperature <75 F/24 C vacuum loose mold from tape package and tape pack,	isolate disk and its package from unaffected materials keep at humidity <50% RH and at temperature <75 F/24 C vacuum loose mold from disk and package

	avoid direct contact with the tape avoid blowing on the tape to clean it as this will only spread the mold, and may be harmful to staff gently brush remaining debris from package and tape pack run the tape through a winder-cleaner with a suitable fungicide copy the tape, thoroughly cleaning the machine immediately afterward with a suitable fungicide	avoid blowing on the disk to clean it as this will only spread the mold, and may be harmful to staff gently brush remaining debris from package and disk
Shock	re-tension the tape pack re-spool onto a new tape reel/cassette splice tape fragments together use thermal conditioning to flatten wrinkled tape	a shattered CD can not be repaired