Magnetic Tape Deterioration: Tidal Wave at Our Shores

By Jim Lindner

It is perhaps the ultimate irony that some of the last interviews with Bing Crosby need to be restored less than 20 years after being recorded. Crosby was largely responsible for funding the development of magnetic tape recording in the United States at the end of World War 2. It is a shock that the video taped interviews that were made just months before his death need a significant restoration effort just to be played back.

The magnitude of the problem of magnetic tape deterioration is just starting to be realized. Virtually all of the magnetic tape ever recorded older than as little as 10 years may be in serious jeopardy. The threat comes from several sources, but the largest threat is chemical in nature, coming from the breakdown of the binder, or glue, that holds the magnetic particles to the polyester base of tape. As this hydrolysis process (sometimes known as "Sticky Shed Syndrome") occurs, the tape often gets coated with a tenacious adhesive that makes it extremely difficult to play. In some cases the problem can be so severe that the magnetic material literally falls off or sheds from the base leaving a pile of dust and clear backing. The problem of hydrolysis has been known for some time, but the extent of both the problem and catastrophic effect it has on magnetic media is just now reaching widespread public visibility.

At risk is virtually the entire inventory of recorded media, from master audio recordings of symphonies to videotape recordings of the news gathered over the last 40 years. Virtually our entire audio and visual heritage from the 1940's to the 1980's is in serious jeopardy. No tape is safe from the multiple threats that vary from accidental erasure and physical loss due to fire and flood, to the slow disappearance of the machines that are required to play the tapes back. Coupled with Sticky Shed Syndrome, the threat is far greater than anticipated. Realistically, some of the vast inventory of tapes are of little value being copies of other materials, but many others are masters, original recordings, that cannot readily be duplicated. And the amount of tapes needed to be restored is so huge, that it would take decades, even if facilities, techniques, and funding were readily available.

A quick look at consumer video tape sales gives some indication of the magnitude of the coming tidal wave of problems. In each of the past 10 years, an average of approximately 300 million blank VHS videocassettes have been sold in the US alone. This huge number does not include sales of "Pancake" stock sold normally used for duplication, or sales for camcorder stock. If only 1% of the materials recorded on this blank stock is of value to their owners, over 3 Million cassettes a year will need restoration. Of course, most VHS tape is not used professionally for mastering purposes. The sales numbers for this type of stock are much harder to find. Perhaps an indicator is that in a recent sales letter from

SONY, an announcement was made of sales of 100 Million Beta cam cassettes. Clearly the number of the masters made on professional equipment are smaller, but the percentage of important material is far higher, and the loss of the masters have real and tangible costs for the owners as well as the general population.

If consumer blank videocassette tape sales indicate the size of the problem, the fact that virtually all broadcasters transitioned from film to videotape for news gathering and on air programming in the 60's and 70's indicates the depth. From situation comedies to oral histories, to records of congressional hearings, our recent history is on tape, and is likely to continue to be archived in this manner for at least several more years. Original masters languish on shelves with their owners under the mistaken assumption that "everything is OK in our collection", because no one has noticed the magnitude of the problem. The tape manufacturers have not gone out of their way to point out the problems for obvious reasons, and many of those who "inherit" the job of safeguarding the materials have been trained in paper conservation, not in magnetic media conservation. In a sense, those least prepared to technically solve the problems of tape deterioration's are the ones who have inherited the collections that need very technical help. In addition, there is very little if any training in the professional production or post production communities on correct long term tape handling and care. In short no tape is truly safe from an array of multiple assaults that threaten the survivability of virtually all magnetic media.

While most consumers are aware of the outcome of the Bet Amax and VHS format war, few are aware of the diversity of formats and sub-format varieties that have been available over the years. New formats allow manufacturers to implement superior technology as well as to respond to competition. In fact, it may be more cost beneficial for a manufacturer to introduce a new proprietary format than to compete directly with another manufacturer’s format, thereby establishing an uneven playing field. New market segments and opportunities allow the introduction of different feature sets as well as the ability to position different technology at different price points for each market segment. As each manufacturer introduces newer formats to take advantage of additional features, earlier formats fall by the wayside, and both parts and machines eventually become scarce. Some formats fail by their own accord due to lack of commercial success. Still others fall victim to planned or evolutionary obsolescence. The introduction of software based formats that do not require media specific formatting can only accelerate the issues at hand. Without the specific application software that has created the format in the first place and a careful process of migrating the material as new formats become popular, decoding obsolete software based formats will become a practical impossibility even if the media lasts forever.

The steady procession of obsolete formats and sub-formats leaves thousands of irreplaceable tapes in their wake. If the shear volume of different formats were not bad enough, the fact that there are different international standards of each

video format multiplies the problem. In the case of some reel to reel stocks, many different formats used the same width tape and identical reels. One often must be a detective to try to figure out the correct format and standard. Only the machine designed to play back the specific format can properly play back the recording. The list below indicates some of the many videotape formats in current use. Note that this list does not include Laserdisc or CD formats, Digital Video files stored as digital data on computer storage media, Military formats, Medical Formats, Instrumentation formats, Proprietary formats used for special applications, and the international varieties of each format. It does not list sub format varieties either, such as the different speeds within a format (VHS - SP, EP, or SLP) or audio variety sub-formats such as Dolby Versions, High Fidelity encoding of audio in video bandwidth, or Digital encoding of audio within a given format at a given speed or international standard. The permutations probably number in the thousands.

Current Videotape Formats In Subjective Quality Order as of January 1, 1995 This is a subjective listing of overall video quality, and utility listed from best to worst quality. This listing does not include obsolete formats, nor formats in discussion with no general equipment availability (HDTV, Consumer Digital), nor CD-R and LaserDisc based formats (see article for more exclusions).

Digital HDVS (Component Digital HDTV System) Reel to Reel / Cassette
D5 - Component Digital Cassette (Panasonic only - Composite digital and HDTV compatible)
DCT - Component Digital Cassette (Ampex only)
D1 - Component Digital Cassette
Digital Betacam - Component Compressed Digital Cassette (Sony Only)
D2 - Composite Digital Cassette
D3 - Composite Digital Cassette (Panasonic Only)
1" Composite Analog Reel to Reel
Betacam SP 1/2" ENG Component Analog Cassette
M2 1/2" ENG Component Analog Cassette
Betacam Component Non-Enhanced
3/4" SP Umatic Composite Enhanced Analog Cassette
Hi-8 Component Enhanced Analog Cassette
3/4" Umatic Composite Analog Cassette
SuperVHS Component Enhanced Analog Cassette
8mm Composite Analog Cassette
VHS Composite Analog Cassette

For the most part, the formats above are also available in international versions which always includes PAL, and usually includes SECAM, and sometimes includes PAL M & PAL N.

The first commercial use of videotape in broadcasting was for delaying broadcasts for later replay in different time zones, or what we now call time

shifting. In this "time shifting" practice by the networks, many tapes we re-recorded with the following days programming. In this way, each successive day shows were cannibalized by the next over recording, leaving only the legacy of the last surviving recording, often one of little value. Only a small percentage of daily news broadcasts which numbered in the thousands have survived due to this common engineering practice. Many shows that were taped earlier in the day for later broadcast have similarly been destroyed forever by over erasure.

Because the archives and libraries that eventually inherit old tapes buy very little tape themselves, manufacturers have paid less attention to long term life than other selling points, and the ruler applied for "useful life" by the manufacturers is at best self serving. Indeed, in a recent sales brochure of one of the largest magnetic tape manufacturers in the world a paragraph entitled "Archival Stability" proclaims "In these tests, BCT-MA hardly varies in coercivity and retentively over the course of three years!". While such a statistic may seem admirable to a producer who has a deadline on Monday and will never see or use the material again, these proudly touted "Archival Stability" achievements are a mere blink when compared to paper documents and are ludicrous considering the importance of some of the material that will eventually be recorded on the tape.

There have been many changes in the evolution of the electronics used to record and play back video signals as well as the industry reference standards applied to the signal. As a result, earlier equipment necessarily had more electronic variance or "play" while current equipment requires a signal that conforms to much tighter specifications. Current specifications are much tighter than the older equipment could ever conform to, even if the equipment was in perfect working order, and the tapes in perfect condition. In addition, certain formats were never designed for broadcasting, industrial quality signal performance, or even editing. The signals must be considerably upgraded to conform to these tighter contemporary specifications that are expected by current equipment. This process, then, requires a daisy chain of both old and new equipment to step up the quality of the electronic signal to the point where it can be properly recorded on finicky contemporary equipment. This process is made more complex in the case of video tape because of the intimate relationship between the tape itself and the playback electronics. Unlike most audio tape recorders whose speed is more or less independent from the tape being transported, the speed of the videotape is critical to proper playback. Delays in timing are measured in microseconds, which separate a tape that can be properly played back from a tape that will never be able to be played back at all.

In some formats, interchange error, sometimes between different specific machines of the same format can cause a tape not to play back properly. A favorite story of experienced broadcast engineers is that in the early days of broadcast video, the specific heads that were used to record a tape were often transported with the tape itself so that it could be properly played back. In more

recent years, first generation models of new format tape recorders are notoriously poor in areas of interchange. This means that tapes recorded early in a formats life may not interchange well between different manufacturers equipment designed to play back the same format.

It is important to note that in the restoration mastering process we are not trying to improve the visual "quality" of the signal with digital noise reduction or similar techniques. Rather, the goal is to make a restoration master that is electronically superior to the original while not tampering with the visual quality of the material itself. It is important not to preserve 70's visual content with 90's eyes. Such an effort would do the work a long term injustice of potentially pre-empting other future technology that may do a superior job of image restoration, noise reduction, or image enhancement as compared to today's equipment. By removing high frequency noise, for example, one can achieve a generally more pleasing image. Unfortunately removing this information may rob future technologies of the very information required to reconstruct the image.

Perhaps the bigger ethical issue is that the way television looked and sounded in earlier years is different than it is now due to the technology available. It is extremely important to be faithful to history and preserve these materials as close to the viewing experience of the original viewer in the original time period as possible. Changing this viewing "experience" in a very real way distorts the way we will view our history.

The choice of which format to use for re mastering is also a major issue, because there is no single clear solution. Although digital recording offers many obvious advantages, potential problems of catastrophic loss due to obsolescence of format or uncorrectable data errors make the choice much more difficult. Additional problems of re mastering solely on digital media is that it is reasonable to expect that this media too will show signs of chemical deterioration during its life time. The fact that digital tape is often far thinner than analog tape and uses azimuth recording which depends on precise angle and phase relationships for proper play back may create a problem in future years when the tape has stretched, contracted, and potentially become affected by binder breakdown of one sort or another. For this reason, both analog and digital simultaneous restoration masters are recommended when economically feasible. This two solution, solution, offers the added security of a first generation restoration backup which should be located at another physical location to insure recovery from natural disasters and loss. Spreading the risk over two competing formats also lessens the risk of having a tape that cannot be played back due to lack of equipment or format obsolescence.

Consistent cool temperature and low humidity seem to be the key to longevity of all magnetic media, but it is too late for materials that have already been exposed to the real world of non-temperature controlled environments and abusive handling. Too little is known real information is known, and many of the

accelerated aging tests undertaken by the magnetic media manufacturers have proven to be poor indicators of performance in real world production.

Many aspects of magnetic media handling are based on intelligent guessing and general industry practice handed down from technician to technician with little real data to back up what procedure should be followed or why.

A simple example of this is found by every professional opening a new box of tape stock. Virtually all stock is shipped in a box inside of which the tape is enclosed in a plastic bag. One of the first things that is done when a box of new stock is opened is to throw out the bag. Should the tape be stored in this bag instead of having the bag thrown out? Many have opinions and theories, but there is virtually no data to either support this accepted industry practice or suggest that the material is better served through the years by staying in the bag.

Many of the containers that were designed to hold magnetic tape have actually contributed to their demise. Early versions of so-called "shippers" which are the most sturdy and sealed types of containers often were made of materials that we now know degrade badly. Neoprene foam gaskets that were designed to keep the shipper air and water tight have degenerated badly leaving pieces of themselves deposited all over the tape. Still other containers used masonite to hold the reel in place within the container. Over time, particles of wood similarly distribute themselves on the edges of the tape and leach other unknown chemicals directly into the tape. Many other reels not lucky enough to be put in a shipper may be kept in very high acid content boxes, that offer little if any physical protection to the physical abuse received in less then perfect handling over the years. Other containers are so tight that they do not allow a tape to "outgas" thereby stewing a tape in its "own juices" over the years. Many other tapes masters are not even afforded the protection of the flanges of reels being stored as "pancake". Other tapes are stored on styrene reels that deteriorate rapidly with age and offer little if any physical protection, and still others on warped reels that cause edge damage every time they are played.

Once a given production has been completed, the masters and production elements are often placed into other high acid content cardboard boxes and sent to a storage facility where little if any monitoring of temperature and humidity has taken place over the years. Information about the individual production elements is rarely kept, and terse descriptive labels on the media itself that made perfect sense during production become a guessing game 10 years later. Because it is sometimes difficult to determine content without playing a tape back, a double bind is created whereby one cannot determine if the expense to restore a given tape is warranted without knowing the content..... and one cannot know the content without being able to view the tape (which requires restoration).

Like so many lemming leaping off a cliff, hopeful technicians continue the search for a single "Holy Grail" cleaning solution for master recordings. Despite the fact that the chemistry, design, composition, and technology of different tapes, and the damage received over the years is totally different from one reel to the next many are looking for a simple recipe to cure their magnetic media ills. Currently baking the tapes at 130 degrees Fahrenheit for a period of several hours is a favored solution to temporarily reverse some of the effects of Sticky Shed. Such treatment can destroy the master forever, but in some cases will allow a playback to occur for a very limited period of time before the tape becomes unusable. Even with the knowledge that they may be ruining the master for ever, well intentioned magnetic media "chefs" don their toque and happily place their masters in a convection oven hoping for the best. The fact that there is no field test to determine the level of hydrolysis damage, or to determine whether the tape even has this damage at all does little to dissuade those from using a process that at best is a highly questionable remedy for all the ills that can befall tapes. Tapes that have uneven pack stresses, chemical contamination, edge damage, or other physical maladies may find that these defects are made much worse by the baking procedure. Indeed, imagine the reaction if one were an art conservator and recommended to a museum curator that the solution to restoring a work of fine art was to possibly destroy it forever in order to make a copy which may or may not be an accurate representation of the original. Yet, this technique is being recommended daily as the "cure all" to magnetic media problems. As most find out, the solution to most complex problems is usually complex. Unfortunately, single minded shotgun approaches applied by desperate media owners will seal the fate for many tapes.

Although there is no way to stop the deterioration due to the causes outlined above, there are many steps that can be taken to minimize damage and hopefully extend the life of the media. Although some of these procedures may verge on draconian, what is at risk is the ability to play back the tapes at some future date. The following recommendations for the storage and preservation of magnetic media are a combination of manufacturer’s recommendations, experience with old and obsolete tapes, and good common sense.

Keep tapes clean, cool and dry... and away from curious fingers. Dirt, humidity, and heat are the main enemies of ape and can make the tapes impossible to play back in very short periods of time. You are better off keeping the tape in a place which has constant temperature and humidity then in a cooler place with lots of traffic. Tapes left for the curious to handle WILL be destroyed, it is only a matter of time.

Check the tape pack for a smooth and consistent wind. Tapes that have individual edges raised above the pack as a whole are exposed to damage. Any gaps in the tape probably indicate uneven pressure which will get worse over time.

Stay away from video tape rewinders. Most reminders are very inexpensive and subject the tape to questionable tension. Simply use your VCR and fast forward and rewind the tape. It is a good policy never to leave a tape stopped in the middle of the cassette. Always rewind or fast forward the video tape fully. Audio tape should be stored "tails out" to minimize print through.

Protect your tapes from physical damage. Cardboard sleeves and inexpensive "library" cases provide little protection for either the cassette or the tape inside. Often these inexpensive cases are made of materials that deteriorate over time. Protect your investment with a high quality shipping case or inert plastic sleeve. These cases are inexpensive, reusable, and will last many years.

When in doubt, make a copy. You cannot recover from a lost single master. If you only have one copy of a tape, NEVER allow that copy to circulate, and try to play it back only when necessary (hopefully only to make a back up copy). Copies are inexpensive to make and are your only absolute protection against the loss of the program. Often you can recover if you have made copies, even if the quality is lower. Ideally keep copies in different places, and make copies at different times so that they do not all age together.

Make sure the machine works BEFORE you insert a tape. One of the biggest causes of damage to tapes is machines in bad condition. If you are uncertain about a machines condition, insert a tape that is not valuable to ascertain that condition. If a tape is damaged, do not insert it into a videotape recorder, the tape may damage the machine.

If you can - know what type of machine the tape was recorded on, and keep the machine! It may not seem important now, but 20 years from now, it may make matters much simpler. The practical reality is that there are many videotape formats that become obsolete quickly. Knowledge, and ideally possession, of the machine that recorded the tape originally can be extremely valuable.

Always label your tapes. Unless a tape is properly labeled, the only way to know the contents is to play the tape, and if the tape cannot be played back without restoration, how do you know whether the contents are valuable enough to justify restoration cost? Even a simple card system can go a long way in helping to know the contents of a tape, long after the tape has been completed.

Know when you need professional help. Many times local expertise is simply not qualified to deal with videotape restoration issues. Damage to a tape that is caused by well meaning people "trying to help" may be permanent. Become the organization expert, and know when to call for help.