AMIA the association of moving image archivists

Videotape Preservation Fact Sheets

Fact Sheet 1 — Magnetic Tape Preservation: An introduction

Since it was developed in the late 1930s, magnetic tape has served as a major means of recording, distributing and preserving information. It is an easy to use and versatile media for the storage of video, audio, computer and other data. Yet despite the substantial resources put into creating recordings and the historical, intellectual and financial assets they represent, tapes often are not perceived and treated as objects of value. Many important and unique recordings have been lost due to a lack of understanding and insufficient resources required to preserve magnetic tape.

Factors that contribute to and complicate the problem of magnetic tape preservation include improper storage and handling, which can affect the physical integrity of magnetic tapes and compromise the future ability to retrieve content. Unlike earlier recording media such as paper and photographic materials, the information recorded on magnetic tape is not directly human readable and requires a machine to render it. The interface between the media and the machine must meet specific conditions in order for the machine interpretation to be accurate. The physical integrity of magnetic tape is critical to achieving a proper interface with the interpreting machinery.

Though no test has been proven to effectively define it, the shelf life of magnetic tape media is finite, and often shorter than expected. Therefore recorded tape documents must be copied to new media before decay precludes access. Repeated use of magnetic tape can cause wear or physical damage that shortens its effective life. Yet it is often impractical and prohibitively expensive to make preservation and access copies of each and every original item. This situation frequently results in unique records being subjected to excessive use and wear without any back-up or other form of protection against loss.

The ability to play back a tape in the future depends on the existence of functional playback equipment. As new recording technologies and tape formats emerge on the market and gain in popularity among consumers, equipment manufacturers discontinue the production and support of older, superseded equipment. Eventually, to find functioning equipment able to play superseded formats becomes a formidable task.

Many archival repositories are becoming increasingly aware of the challenges of preserving magnetic media. These Fact Sheets provide recommendations for the preservation of videotape, though many of the core principles which govern the care and handling of videotape apply equally to the preservation of other forms of magnetic media. Based on practical experience, theoretical investigations, and research and testing, the information provided in the Fact Sheets offers guidance to custodians of archival video collections of any size. The coverage of topics aims to be comprehensive and the discussion uses non-technical language to focus on the fundamental issues. While there can be no guarantee that all information recorded on videotape will remain in pristine condition and permanently accessible, by following the Fact Sheet recommendations archivists will increase the useful life of the information recorded on videotape under their care.

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Fact Sheet 2 — CPR: A definition of terms

The terms "conservation", "preservation" and "restoration" are often used interchangeably. However, while related, they have distinct and specific meanings, especially when used in the context of caring for cultural artifacts such as magnetic tapes.

Preservation

Preservation broadly encompasses those activities and functions designed to produce a suitable and safe environment that enhances the useful life of collections. A preservation program involves environmental monitoring, raising funds, ensuring the security of collections, disaster preparedness, and long-range planning. Examination and documentation of tape holdings are also critical activities in order to responsibly monitor and care for media materials. Preservation also includes conservation and restoration.

Conservation

Conservation is generally considered to be but one aspect of an overall preservation program. The aim of conservation is to stabilize and to prevent further damage or deterioration, thereby allowing a tape to realize a longer useful life. Such measures may include cleaning the media and maintaining playback equipment as well as following proper handling and storage procedures. Providing users with access copies of original materials is a crucial means of protecting the originals from damage through use.

Restoration

In regards to magnetic media, there are two kinds of restoration: restoration of the physical media and restoration of the recorded information.

Restoration of the physical media may involve taking the necessary actions to return a deteriorated or damaged tape as nearly as possible to its original condition. These restorative actions entail treating a failing tape in a manner sufficient to playback the recording to achieve the same level of quality which characterized the tape when it was first recorded. In some cases, restorative measures are necessary in order to access the recorded information, regardless of the level of quality achieved. Restoration of the physical media may be required in order to produce a preservation master copy and a user access copy of the original recording.

Restoration of the signal recorded on an original material for the purposes of improving the quality of the sound or image involves altering the information. Restorative actions involving signal processing should not be carried out on original materials because tampering with original information is a violation of a fundamental principle of archival stewardship. Therefore, in cases where signal enhancement is deemed necessary, restoration actions should only be conducted on copies of original materials.

Fact Sheet 3 — A Very Brief History of Videotape

Developed by the Ampex Corporation in 1956, the first practical videotape recorder (VTR) was the two-inch Quadruplex. It was first used to record network television programs so that they could be re-broadcast later across the multiple American time zones.

In 1969 several Japanese companies produced 1/2-inch reel-to-reel videotape recorders which adhered to the EIAJ standard, a standard developed and established by participating manufacturers. These VTRs were the first affordable recorders and they were primarily used by schools and companies as well as a few consumers. In 1971 Sony introduced the first successful cassette VTR, the 3/4-inch U-matic, which replaced the 1/2-inch reel-to-reel format.

The first successful Video Cassette Recorder (VCR) for the home was the 1/2-inch Betamax, introduced in 1975 by Sony. One year later, JVC introduced the VHS format, which eventually emerged as the preferred consumer videotape format over Betamax.

In the professional arena, the one-inch reel-to-reel (Type C) format was introduced in 1978 and soon replaced most Quad machines. In 1987, the D-1 digital videotape recorder was introduced. Its high cost assured that only the "high-end" market, particularly production studios, could afford to use it. By 1995 new digital videotape recorder formats were priced low enough for the general industrial and educational markets.

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Fact Sheet 4 — Structure and Composition of Videotape

Backcoat

Since the late 1960s, most tapes have been made with a thin carbon-black backcoat that serves three functions:

- It is electrically conductive to prevent the build-up of electro-static charges when the tape is shuttled at high speed.
- During high-speed, the backcoat encourages the layers of tape in the pack to cling to each other, creating a uniform tape pack.
- It deters layer-to-layer slippage during shipping and storage.

Basefilm

The basefilm (carrier or substrate) of videotape is polyester terepthalate (PET). Many thin digital videotapes employ polyeythelene napthalate (PEN) as the basefilem. The basefilm of the first videotape, the 2" Quadruplex, measured 0.0015 inches in thickness (the equivalent of 1.5 mils or 37.5 µm). Contemporary tape substrates measure approximately 0.5 mils (12.5 µm). Polyester will change in length due to changes in tension, temperature, or humidity. Normally these changes are so minute that they do not have adverse consequences. PET is very stable chemically and has an estimated life of several hundred years, provided it is stored under archival conditions: stable, cool, dry and away from ultraviolet radiation.

Magnetic Coating

The magnetic coating of videotape is usually about 200 micro-inches thick, which is much thinner than the coating on audiotape. The magnetic particles are 10 to 20 micro-inches (1/4 to 1/2 µm) in length.

The magnetic coating of magnetic tape is a complex mix of magnetic particles, binder, lubricant, head cleaning agent, surfactant, and other special chemicals. Each tape manufacturer uses a special formulation of magnetic coatings which are considered trade secrets. Some of the formulas used by manufacturers remain constant for a period of several years, but they may be modified several times throughout the life of a given product. This multitude of variables within the formulation makes it impossible to accurately predict the life of videotape brands.

Generally, approximately 40% of the volume of the magnetic coating consists of the magnetic particle itself. The magnetic particle used in the original Quad tape was iron oxide (rust), which had a magnetic strength (coercivity) of about 300 oersteds. Cobalt-doped iron oxide tape (first used for Type C tape) has a coercivity of 600 to 800 oersteds. The coercivity of metal particle tapes used for digital video and Hi-8 is approximately 1500 oersteds. The higher the coercivity, the more data can be packed into a given area of tape and the more difficult it is to erase the recording.

Binder

Binder added to the magnetic coating mixture serves to adhere the magnetic particles to the basefilm. Depending on the type of binder and the environment in which the tape is stored, some binders can degrade in just a few years. In such cases, the magnetic coating, which contains the recorded information, can become damaged or altogether ruined as it is removed from the basefilm during playback. However, it is possible to restore deteriorated binder to a point which enables adequate playback of the tape. See Fact Sheet 6 — Common Tape Problems for more information on binder degradation.

MP and ME Tape

Metal particle (MP) was introduced as a videotape product in 1987. Previously, MP was used by some tape manufacturers for audiotape. Some of these manufacturers did not understand that each individual metal particle had to be "armor-plated" to prevent it from oxidizing, which would result in the weakening or loss of its magnetic properties. As a result, MP had a bad reputation among users for several years. By the time MP was produced for videotape, the major tape manufacturers had developed techniques for "passivating" each particle with a protective coating. Battel Institute, Ampex, and Sony performed extensive tests on MP tape and the general conclusions were that MP tape has a long life expectancy.

Metal Evaporated (ME) tape was originally developed for the Sony Hi-8 format in 1989. Until 1996, ME tape had durability problems. Recent ME tapes may or may not be acceptable as an archival media. Adequate testing must be performed to verify its stability and durability.

Fact Sheet 5 — Estimating Tape Life

Although there have been numerous studies about tape longevity and stability that have produced valuable information, such as the work conducted by the National Media Lab in the mid-1990s, an accelerated aging test that produces meaningful quantitative data about magnetic media longevity does not exist. Hence, no method is known which will indicate the life expectancy of various brands and formulations of magnetic tape. Some experts state that generally magnetic tape "lasts" anywhere from ten to sixty years. Taken alone, the polyester basefilm (also called substrate or carrier) of videotape is estimated to last hundreds of years when stored properly in archival environmental conditions. However other components of videotape, such as binder components, are far less stable and thus form the weak link in the chain. Furthermore, equipment and format obsolescence may pose a greater threat to the life of a tape than the media degradation factors.

The notion of "end-of-life" (EOL) for magnetic tape may be irrelevant. After all, some of the oldest magnetic tapes known to exist—German Magnetophon audiotapes recorded in 1943 currently held in a private collection—are in excellent playing condition.? Furthermore, how do you define EOL for tape when it can be treated by baking or drying and subsequently played over and over? Ampex engineers repeated this cycle with bad sticky-shed tapes many times over a three year period and the tapes were always playable.

The principal means to prolonging tape life is to maintain an appropriate player, to keep original materials in stable, cool and dry storage conditions and to strictly limit the use of original materials. An original tape should be used only for the purposes of making a preservation or secondary master from which additional copies can be produced for access. These are some of the fundamental aspects of a videotape preservation program.

Because magnetic media deteriorates, it becomes necessary to establish strategies for prolonging the life of the information recorded on tape, not simply the tape itself. Therefore a migration plan must be play a role in a comprehensive approach to videotape preservation. This plan calls for the periodic inspection of tape materials for signs of deterioration and, for those materials deemed at risk, the migration of recorded content to fresh media and contemporary, well-supported formats. The migration plan serves the goal to have the ability to access preservation masters and other derivative copies of original materials at any given time. Repository staff must design the migration plan to suit the needs of the tape collection and the institution. For information related to inspection and reformatting, see Fact Sheet 7 — Reformatting for Preservation: Understanding tape formats and other conversion issues and Fact Sheet 9 — Tape Inspection.

Notes

For example, see John W.C. Van Bogart, Magnetic Tape Storage and Handling: A Guide for Libraries and Archives (Washington, DC: Commission on Preservation and Access, 1995) p. 28.

To read more about these tapes, see Richard Hess, "The Jack Mullin/Bill Palmer Tape Restoration Project", Journal of the Audio Engineering Society Vol. 49 No. 7-8, July/August 2001, pp. 671-674.

Fact Sheet 6 — Common Tape Problems

Sticky-Shed Syndrome

The binder is the weak point of most videotape. In the late 1960s, polyester urethane became a popular binder for videotapes because of its durability and low cost. Unfortunately, polyester urethane is subject to hydrolysis. It can absorb moisture from the atmosphere, and as a result the water changes its molecular structure. High temperature and relative humidity encourage and accelerate this chemical reaction. The rate at which chemical deterioration occurs varies depending on the chemical formulation used by the media manufacturer. Chemical formulation information, however, is considered proprietary and therefore rarely is it disclosed by manufacturers. The identification of tapes with polyester urethane binder is not easy, so it is recommended that all tapes be stored in a low humidity environment in order to prevent hydrolysis.

The first sign of binder breakdown is usually the presence of a powder or a gummy residue on the surface of the tape. When the tape is played, this residue attaches to the playback heads, resulting in poor playback at best, or a jammed machine at worst. If this situation occurs, the tape should be ejected and all affected tape path parts should be cleaned with isopropyl alcohol and cotton-tipped swabs. The tape can be made playable by using a tape cleaning machine to remove the powder from its surface or by "drying" the tape over a period of time in a controlled environment.

Poor Playback Signal

Sometimes the video playback is poor despite attempts to adjust the tracking control. This problem can often be corrected by cleaning the tape guides and adjusting the tape tension. Other times playing the tape on another machine resolves this problem.

Poor playback signal may result from the use of a machine which is not fully compatible with the tape. Some tape formats have several, improved versions that were developed and introduced during the life of the format. For example, High-Band Quad is not compatible with the earlier Low-Band Quad. While some Quad machines can accommodate both High-Band and Low-Band formats by the flip of a switch, many cannot.

If the video image tears, rolls vertically, or jiggles as it is played, a video processor or a time base corrector (TBC) may be employed to make the video image stable.

Demagnetization

Contrary to what many people believe, demagnetization of a tape recording is an infrequent occurrence. Because of the high coercivity of most magnetic tapes, a very large magnetic field is required to erase the recording. Such a large magnetic field is produced by the erase head on tape recorders. When the "record" button is pressed, the erase head is turned on, and the portion of tape in contact with the erase head will be erased. To prevent accidental erasure of archival tapes, it is recommended that all tapes or tape recorders in the archive be modified so that either the record function is disabled or can be activated only by authorized personnel.

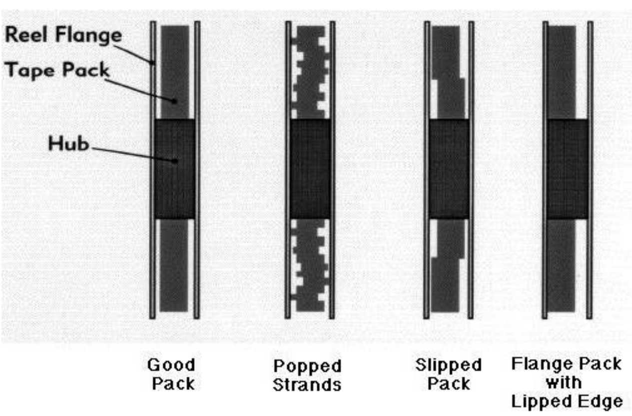
The magnetic fields of motors, transformers, and television sets pose a very slight risk of erasing magnetic tape. These fields are self-contained by design, so a tape would have to be located within approximately one inch of the coils of these devices for them to have a noticeable effect on the tape. Quad tapes are the most susceptible to erasure since they have a magnetic strength of only 300 oersteds. A magnetic field of 20-30 oersteds may adversely affect a Quad tape, however fields of that strength do not commonly occur in an archives setting.

A recommended best practice for archives dictates that a tape can be stored safely in a magnetic field with a maximum strength of 1/10 of the tape's coercivity. A more conservative figure of 1/20 provides a safer margin of error. To determine a tape's coercivity, refer to the product's specification sheet available from the manufacturer.

Some Metal Particle tapes will lose a small percentage of their magnetization if exposed to high temperatures for several months. Tests of the metal particle pigment (not the tape) indicate that the particle has an estimated life of 150 years if stored at 21°C (70°F) and 60% RH. The same metal particle has an estimated life of 700 years if stored at 10°C (50°F) and 60% RH. These data illustrate the effect of temperature on the life of the metal particle itself.

Edge Damage or Warped Tape

The polyester basefilm of videotape can be stretched or otherwise deformed, which may result in playback difficulties. A poor tape pack (see illustration below) leaves the tape edges, and therefore certain tracks, susceptible to damage. Poor storage conditions can cause tape to deform as well. However, polyester is an extremely resilient material and it can usually be returned to its original shape, and hence a playable condition, by a person knowledgeable in the restoration procedure known as "baking." First, the tape should be fast forwarded to the end. Then it should be rewound to the start and played to the end. Carefully observe how the tape is packed on the take-up hub. If the pack is flat, then it can be baked. If the tape pack is not flat after playing it, rewind it again and play it on another tape recorder. The tape may pack correctly on the second tape recorder.



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"Estimating the Archival Life of Metal Particulate Tape" in IEEE Transactions on Magnetics, September 1992, pp. 2365-2367. Baking is a somewhat controversial procedure which temporarily restores tape to a playable condition. It should only be carried out by someone familiar with the process and the risks associated with it, such as introducing skew and mistracking into helical scan recordings. See "Sticky Shed Syndrome: Tips on Saving Your Damaged Master Tapes" by Philip DeLancie in Mix, May 1990, pp.148-155.

Illustration courtesy of John W. C. Van Bogart.

Fact Sheet 7 — Reformatting for Preservation: Understanding tape formats and other conversion issues

Refer to tables: Analog Videotape Formats and Digital Videotape Formats

The term "format" is used to describe the physical dimensions of the recording on the tape as well as the method by which the recording is made. Formats also are distinguishable by such characteristics as the cassette size, the tape width, and the tape thickness. In selecting an appropriate format for preserving archival material on videotape, it becomes necessary to understand fundamental characteristics of the formats available on the market. Foremost among these characteristics is the distinction between analog and digital.

Analog video

The term "analog" describes the method used to record information by means of a continuous electronic signal which alters the alignment of magnetic particles on the tape. Analog recording technology has the advantage of being inexpensive; at the same time, analog formats have the disadvantage of being very susceptible to fluctuations between the tape and tape transports, which may cause playback problems.

The most well known analog format is VHS. Developed to make videotape recording affordable to everyone, VHS was not designed to achieve high resolution and long life. Therefore this analog format should not be used to reformat important archival material. However, VHS does serve as a very practical format for user access copies. If financial limitations necessitate the use of the VHS format for archival purposes, industrial VHS VCRs are preferred over consumer models. The S-VHS (Super-VHS) format is a better format than the VHS.

Sony's Betacam SP ("SP" stands for "Superior Performance") is a popular analog archival format. The equipment varies radically in price and, to a certain extent, in quality. For example, the quality of the audio rendered on the cheaper machines may be inadequate. In late 2001 Sony announced it was discontinuing the production of certain models in its line of Betacam SP recording equipment. This action is considered by many as an indication that it will not be long before this format goes the way of Type C, another strong analog archival format which is no longer in production at all. Despite this news, many archives continue to rely on Betacam SP for its many advantageous features as long as players and tape stock remain available. However, as there is no other analog video format waiting in the wings to supercede Betacam SP, a growing number of archivists and recording engineers alike advocate converting analog video to a digital format, such as Digital Betacam, for preservation and access (see Issues in Conversion below).

Digital video

Like all digital information, the essential elements of digital video imagery are bits. This series of zeros and ones are rendered by a computer as pixels; thousands of pixels compose a single video frame. The problem of preserving digital information in any form is complex, and digital video is no exception. Proven techniques and strategies to effectively and confidently address this challenge are slowly emerging, yet as long as recording technology develops, the problem will persist. The topic of digital video and the preservation of digital videotape formats is introduced here. Digital video file formats, such as the MPEG series of formats used in the encoding digital video for serving over networks, are not discussed.

Digital video has both advantages and disadvantages over analog video as an archival medium. While not all digital formats outperform their analog counterparts, digital video recording has the potential of providing a video image of a higher quality than analog. Digital formats solve two of the main problems that have heretofore challenged archives with analog media: (1) the inability to measure in quantitative terms deterioration of the material, and (2) the loss of image and sound quality as originals are duplicated (i.e., generation loss).

With high quality, professional digital tape recorders, the unprocessed off-tape data error can be measured to assess the quality of the recording. Requiring only a few minutes to complete, the process of periodic testing can be easily incorporated into the organization's practices and routines. The error rate can be tracked over time. A low error count is normal, and these errors can be corrected by sophisticated error correction schemes. After a few years, the error rates in tapes may increase. Once the error rate reaches a certain level, error concealment comes into play. Concealment is the process by which the electronics hide irrecoverable information by "guessing" at what the missing bits should be. While the results of concealment are not usually visible on a video monitor, this process should be avoided in the case of archival video materials. Therefore digital archival tapes should be copied when their error rates are just below the level where concealment kicks in. The digital machine manufacturer can supply information about the level of error rate required to trigger the concealment electronics. During the copying process, the error correction circuits are employed to ensure that the copy is a clone of the original. No generation loss occurs as digital files are replicated.

One of the drawbacks associated with digital videotape formats is cost: the high quality, professional digital videotape recorders are more expensive than analog recorders. Another concern is that many digital videotape recorders use sophisticated electronics to "read" the video in search of redundant information which can be eliminated. For example, a blue sky does not require thousands of data points to produce a large expanse of the color blue. The entire area is mapped and all points with the same level of blue are represented by a few bits of data. This process is called compression. Digital videotape recorders that use compression should not be used for important archival material because this kind of compression, called "lossy", involves the deletion of some of the original information, and that information can never be recovered, only interpolated. The Digital Videotape Formats table includes the compression ratios employed in most formats.

Many of the smaller digital videotape formats use very thin tape. An advantage of thinner magnetic tape is that it allows for increased information storage capacity per cassette, however this feature does not outweigh the risks associated with thin tape. The thinner tapes are more susceptible to damage and, once damaged, are more difficult to repair. Tapes thinner than approximately 10 microns are not advisable for archival material.

To obtain a high quality copy of a digital recording, a knowledgeable technician should be consulted, particularly regarding whether a special converter is required. The different digital tape formats use different digital "language" and they usually require a "translator" box if you want to keep the information in digital form. The analog video output of the digital recorder should not be used for transferring to another digital format, because the signal will be inferior.

The decision surrounding the selection of a format for archival masters can be difficult to make. Financial and other technical and administrative factors must influence the process in order to ensure that the present and future needs of the organization are met. It is also necessary to keep abreast of the practices of leading media production studios, which drive the market, as well as those of peer institutions, in order to anticipate technological developments as well as trends in format adoption and obsolescence.

There are two critical points to remember when selecting a format:

- Choose a format with a large installed user base so that the equipment is plentiful and the parts will be available for years after the format is no longer being produced.
- Purchase the best quality equipment available that is fit to purpose. Best quality does not always mean the most expensive. The highest priced models may have features, such as editing and slow motion capabilities, which may be unnecessary in the archival context. Professional technicians can offer advice regarding which brands and models are more durable and reliable than others.

Issues in Conversion

Tape conversion aims to produce a faithful reproduction of an original work. Archival preservation master copies should be as indistinguishable from the original as possible. The ethics of archival practice and of the conservation of cultural materials dictate that original information should not be altered or manipulated in any way. Only tape copies produced for viewing or distribution may be processed or enhanced to improve the image or sound if such improvements are deemed necessary. The work of creating faithful copies requires skills, experience, and, often, expensive and precision equipment. Video labs offer the highly specialized expertise and facilities required to meet these demands, and their fees to perform reformatting or reproduction services are usually high as a result.

Many archives use Digital Betacam as an archival format. However, the lossy compression and weak physical structure inherent in digital videotape formats makes many archivists wary of converting analog video to digital tape for preservation. Optical disk media, such as DVD, is also considered risky as an archival format. It is possible, however, to convert analog video into digital file formats which can be stored on hard drive disks in either uncompressed form or using acceptable (open source, non-proprietary) lossless compression schemes. The files can be managed by digital asset management systems and protected from loss by redundant back-up copies. This practice is increasingly common among the libraries of large production facilities, but remains prohibitively expensive for many other institutions with video archives of value.

When making archival preservation masters, tape should not be copied to film (similarly, film should not be copied to tape). The two media have different color spectra and frame rates, so a transfer from one medium to the other will not be result in a faithful reproduction. Cross-media transfers should only be done for distribution purposes, for particular viewing situations (such as a special event), or as a last resort for preservation.

Whether the reformatting process is being completed by an outside video lab or in-house using the repository's staff and equipment, there are several important aspects which should be considered and integrated into the process.

- The tape guides of the equipment involved in the transfer process must be cleaned regularly as described in the maintenance manual.
- Tape guides must also be checked for proper alignment by using an alignment tape.
- Certain tape brands and types are preferable to use over others; for advice, consult a professional technician.
- Buy tape in quantity and sample several for dropouts before beginning a conversion project.
- Always record a preservation master on new tape stock.
- Always start a new recording with approximately one minute of color bars and a tone of 1,000 cycles per second on both audio tracks.

• Commonly there are differences in tape tension between the original material and a copy derived from the original, revealed by the top few horizontal lines of the video "hooking" to the right or left. This problem can be corrected by using a time base corrector.

• Do not discard originals materials after they have been reformatted. A preservation master copy can stand in for an original material, but it can never replace one.

Table: Analog Videotape Formats

The following table outlines the most popular analog video formats produced between 1956 and 1989. All formats are helical with the exception of Quad tape.

This information, including the obsolescence ratings, is adopted with gratitude from the creators of *The Video Format Identification Guide*.

YEAR INTRODUCED	TAPE WIDTH	CASSETTE/ OPEN REEL	USE	OBSOLESCENCE RATING	ORIGINATING COMPANY	COMMENTS
1956	2"	OR	P	CE	Ampex	2" Quad (several versions were introduced until 1971)
1962	2"	OR	IE	CE	Ampex	First popular helical scan
1963	2"	OR	IE	Ext	Sony	2" Helical
1964	1"	OR	IE	Ext	Sony	
1965	1"	OR	IE	CE	Ampex	SMPTE Type A
1965	1"	OR	IE	Ext	PI (Precision Instruments)	
1965	1/2"	OR	IE	CE	Sony	CV, the first low cost VTR
1968	1"	OR	IE	Ext	IVC	
1968	1/2"	OR	IE	Ext	Sony	
1969	1/2"	OR	IE	End		EIAJ-1
1969	1/4"	OR	IE	Ext	Akai	Small portable
1970	1/2"	C	IE	Ext	Philips	First cassette VTR
1971	3/4"	C	IE	T	Sony	3/4" U-Matic
1972	1/2"	C	C	Ext	Cartravision	Consumer VTR
1972	1/2"	C	IE	Ext	Sanyo	V-Cord
1973	2"	OR	IE	Ext	IVC	2" Helical
1975	1"	OR	P&IE	End	Bosch	SMPTE Type B
1975	1/2"	C	C	End	Sony	Betamax, the first popular consumer format
1976	1"	OR	IE	Ext	Sony	
1976	1"	OR	P&IE	CE	Ampex	SMPTE Type A with Slo-Mo

YEAR INTRODUCED	TAPE WIDTH	CASSETTE/ OPEN REEL	USE	OBSOLESCENCE RATING	ORIGINATING COMPANY	COMMENTS
1976	1/2"	C	C	OK	JVC	VHS
1978	1"	OR	P	End	Ampex/Sony	SMPTE Type C
1983	1/2"	C	P&IE	Ext	Panasonic	SMPTE Type M
1984	1/2"	C	P&IE	Ext	Sony	Betacam
1984	8mm	C	C&IE	Ext		8mm (.315")
1986	1/2"	C	P&IE	End	Panasonic	M-II
1987	1/2"	C	P&IE	T	Sony	Betacam SP
1987	1/2"	C	C&IE	OK	JVC	S-VHS
1988	1/2"	C	P&IE	Ext	Sony	ED-Beta
1989	8mm	C	C&IE	T		Hi-8 (.315")

Key to Uses

P Professional
IE Industrial/Educational
C Consumer

Key to Obsolescence Ratings

OK OK: Format is still in production and widely used
T Threatened: Machines are still in production, but a competing format makes this one unlikely to survive
End Endangered: Manufacture of the machines has ceased
CE Critically Endangered: Only a small population of machines are available with a dwindling supply of spare parts
Ext Extinct: Only one or two players may exist

Table: Digital Videotape Formats

NAME	YEAR INTRODUCED	MANUFACTURERS	TAPE WIDTH	TAPE THICKNESS	TAPE TYPE	COMPRESSION	BITS	QUANTIZATION
D1	1986	Sony, BTS	0.75"	13 µm	iron oxide	N/A	8	4:2:2
D2	1988	Sony, Ampex	0.75"	13 µm	MP	N/A	8	composite
D3	1992	Panasonic	0.5"	11-13 µm	MP	N/A	8	composite
D5	1994	Panasonic	0.5"	11 µm	MP	N/A	10	4:2:2
D5 HD	1999	Panasonic	0.5"	11-13 µm	MP	5:1	10	4:2:2
DVCPRO (D7)	1996	Panasonic	0.25"	8-9 µm	MP	5:1	8	4:1:1
D9 Digital-S	1995	JVC	0.5"	13 µm	MP	3.3	8	4:2:2
DCT	1992	Ampex	0.75"	13 µm	MP	2:1	8	4:2:2
Digital Betacam	1993	Sony	0.5"	13 µm	MP	2.3:1	10	4:2:2
Digital Betacam SX	1995	Sony	0.5"	13 µm	MP	10:1	10	4:2:2
DV, MiniDV	1996	consortium of 10 companies	0.25"	7 µm	ME	5:1		4:1:1
DVCAM	1996	Sony	0.25"	7 µm	ME	6:1		4:1:1

Fact Sheet 8 — Environmental Conditions

The conditions in which magnetic tape is stored and used are crucial to its preservation. Temperature and relative humidity play a very large role in defining what is meant by "proper environmental conditions" for preservation, but there are other important factors which also define environmental conditions. These additional factors include light, level of cleanliness, presence of various contaminants, as well as the physical design and the features of the space where videotape is stored and used. All of these factors contribute to the life expectancy of videotape.

Recommended Temperature and Relative Humidity Levels

Like all materials used to record information, magnetic tape is influenced directly by temperature and relative humidity. Life expectancy increases when magnetic tape is stored in a cool, dry environment characterized by stable temperature and relative humidity levels. Exposure to high humidity in particular can contribute to binder hydrolysis, a chemical reaction in which the tape binder takes on moisture from the air, altering its chemical structure with typically adverse results which manifest in a condition known as Sticky Shed Syndrome (see Fact Sheet 6 — Common Tape Problems).

Acceptable extended-term storage conditions for polyester-based magnetic tape, such as videotape, are: 20°C (68°F) and 20-30% RH; 15°C (59°F) and 20-40% RH; or 10°C (50°F) and 20-50% RH. The best long-term storage temperature is approximately 8°C (46°F) (never below) and 25% RH. Humidity variation should be less than 5% RH and the temperature variation should be less than +-2°C (+-4°F) within a 24-hour period.

The importance of the stability of temperature and relative humidity levels in the storage environment cannot be overemphasized. Magnetic media materials respond to fluctuations in atmospheric conditions by expanding and contracting, resulting in changes in their physical dimensions which may inhibit the ability to playback the tape accurately. Therefore it is very important to monitor constantly the environmental conditions by taking several readings per day. Monitoring consistently throughout the entire year will reveal how seasonal changes may be affecting the conditions within the storage area. There are several affordable electronic environmental monitoring devices available on the consumer market. These units can be programmed to automatically take periodic readings which can then be downloaded to a desktop computer for analysis.

For many reasons, it is usually not practical to use tapes under the same environmental conditions (cool and dark) as those in which tapes are stored. Tapes with a liquid lubricant should not be played back at the coldest and driest levels acceptable for long-term storage. In determining the appropriate set point for temperature and relative humidity levels in the areas where tapes are used, a compromise between energy consumed by the air handling system, longevity of the media, access time, and the comfort and health requirements of operating staff or users must be reached.

Magnetic recording tapes should be handled at temperatures between 18°C (64°F) and 25°C (77°F) and at a relative humidity level between 15% and 50%.

Time out of the recommended storage environment should be kept to a minimum in order to prevent the acceleration of tape degradation.

The absolute maximum relative humidity to which a tape may be exposed is 65% RH; above that level, the possibility of fungus growth increases substantially.

In tropical climates, temperature and relative humidity levels slightly higher than the recommended levels for the handling environment may be unavoidable. In such cases, the storage and handling environments must not differ substantially unless acclimatization is properly carried out.

Acclimatization

Environments may vary slightly from the general recommended guidelines depending on the specific use, the duration of exposure during specific use, and the practical realities of use in environments where human control of the environmental conditions is severely limited. Tapes stored in such conditions must be acclimatized to a different set of environmental conditions for playback to be both safe and successful.

Magnetic recording tape will expand and contract when exposed to different levels of temperature and humidity. Moisture condensation can occur when moving tapes from cool, dry conditions to warmer, more humid environments. Depending on the format, tapes recorded at one temperature/humidity level may suffer from mis-tracking if playback is attempted at a substantially different temperature/humidity level. If the differential between the initial environment and the destination environment is particularly great, it may be necessary to acclimatize gradually or in steps. Acclimatization is the process of slowly altering the temperature and moisture content of magnetic recording tape so that it can be used at a substantially different temperature and/or humidity level. Acclimatization requires an isolated, controllable environment, such as a small, closed room with a stable environment similar to that of the conditions to be reached. Failure to acclimatize tapes can result in pack slippage, creasing during handling, mis-tracking during playback and moisture condensation. Tapes exposed to temperatures above 25°C (77°F) or relative humidity levels above 50% should be acclimatized before playback.

Controlling Humidity

If the storage facility is equipped with an air handling system, it may be beneficial to consult with facilities management staff to explore ways to augment humidity control in the storage area. If the tape storage room is well insulated and relatively small, a stand-alone dehumidifer unit may be effective at maintaining a drier climate. In case of a major power failure, the storage room should be designed to be able to retain the proper environment for about two days.

Facilities

Aspects of the physical space in which tapes are stored and used should be carefully considered.

- The areas where materials are stored and used should be well insulated and sealed in order to maintain proper temperature and relative humidity levels as well as to keep out pests and animals.
- The storage room should be without windows in order to keep out ultraviolet rays from natural light, which can damage tape.
- Tapes should be stored off the floor on shelves. Shelving should provide for ample air circulation around the tapes.
- All work and handling surfaces should be elevated off the floor.
- Precautions must be taken to mitigate possible incursion of water due to condensation, floods, leaks and faulty sprinklers. Storage and use areas should not be below ground level where water damage is most prevalent.
- Carpet, which retains moisture and traps insects and dust, should not be used. Floors should be tiled and provided with sufficient drainage or other means of water removal. Drains should be equipped with features, such as a flapper valve, to prevent liquids or sewage from backing-up into the area and to keep insects and animals out of the facility.

• The room must be fireproof and should not contain wooden boxes, cardboard boxes, wooden shelving or other easily combustible materials. If an overhead water sprinkler system is installed, the shelving should be designed so that sprinkler water will not contact any tapes.

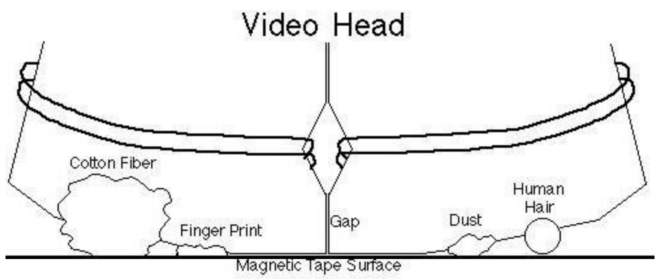
• A sticky floor mat, like those used in "clean rooms," should be placed in the doorway of the entrance to the tape storage room. This mat will prevent debris from being tracked into the area.

• The walls, floors, and ceiling should be made of a dust-free, easy to clean material. Walls and enclosures in areas where materials are used and handled should be designed to prevent condensation of moisture on interior surfaces.

• Clean the floors with either a "water" vacuum cleaner, a vacuum with a hose which diverts the exhaust out of the immediate area, or a vacuum cleaner equipped with a HEPA filter rated 95% or better.

Contaminants

Magnetic tapes are highly susceptible to contamination in many forms, including biological, particulate, and gaseous. The figure to the right shows the size of debris commonly found on magnetic recording tapes and in tape machines, relative to the head-to-tape spacing. It is clear from this diagram that even the smallest particles can result in playback errors if the debris gets between the head and the tape.



Debris on the surface of the tape

Small flakes of skin and oily fingerprints are among the most common contaminants on tape. Human skin constantly sheds and epidermal oils and artificial substances such as lotions are transferred easily to magnetic recording tape. Such oils can be destructive to the tape; they also may carry other damaging contaminants and debris.

Food and drink pose a threat to magnetic recording tape because they may contain destructive agents and they can attract and hold other pollutants. Many foods, especially those containing sugars, have adhesive characteristics that will cause tape to stick to itself and other objects. Decaying food also may promote mold growth or attract unwanted vermin.

Gaseous pollutants may be harmful to magnetic tape. The air in many urban areas contains contaminants harmful to archival material. In such cases, the outdoor air intake should be filtered with a 99.5% HEPA filter. Other airborne pollutants, such as certain perfumes, exhaust fumes, and fumes from ammonia and chloride-based cleansers, may cause harm. Consult an expert to test for harmful gases and to determine how to reduce them.

Magnetic recording tapes are highly susceptible to harm by particulate matter. Dust, smoke and debris-generating objects or materials, such as carpet, draperies, unsealed insulation, packaging materials, as well as fibrous wall coverings and furnishings, shall not be present in any use or handling area. Special non-debris generating material should be used to sound-proof areas where sounds levels must be minimized.

The most common biological contaminant of tape is fungus. Fungus should be considered toxic and treated with great care. If fungus smears when rubbed, it is active. Dormant fungus appears as a dry powder. A tape with active fungus shall not be cleaned. The tape must be stored in a dry environment until the fungus is dormant. Surface cleaning of fungus does not kill it. Personnel must wear protective gloves and masks in order to handle tapes with fungus. A professional tape expert should be consulted to address the cleaning of mold on tape. Cleaning moldy tapes should only be undertaken by staff trained in proper procedures. Cleaning machinery shall be decontaminated after each tape is cleaned. Both the immediate area and the equipment used when cleaning fungus shall be decontaminated after all cleaning is complete.

Guidelines to reduce or prevent contamination of magnetic tapes include the following:

- General cleanliness of the tape use and storage areas, including the area around playback equipment and the equipment itself, is of paramount importance.
- Magnetic tape use and handling areas shall be kept free of food, beverages and smoke. Consumables, as well as their wrappers or containers, shall not be stored, consumed, or disposed of in tape storage and handling areas. After contact with consumable items, personnel should wash their hands before handling magnetic tapes or their protective cases.
- Protective cases shall not be opened and magnetic recording tapes shall not be removed from their cases in environments where a large amount of particulate matter is present or is likely to be generated such as in shipping rooms or machine shops.
- Prevent the unnecessary exposure of tapes to dust by providing a clean area where boxes of tapes can be opened.
- Positive air pressure in use and handling areas shall be maintained relative to adjacent hallways, rooms, and facility exteriors to minimize contamination from outside sources.

Light

Magnetic recording tapes and their protective cases can be damaged by exposure to ultraviolet (UV) light. Therefore tapes and their housings should not be exposed to direct sunlight. Use areas should not have outside windows, skylights, or other sources of natural lighting. Artificial UV light sources such as florescent lighting should have appropriate UV filters installed in accordance with manufacturers guidelines. To minimize UV damage, tapes should be kept in their protective cases except when in active use. To reduce UV damage to protective cases and labels, lights shall be turned off in use and handling areas when the areas are not occupied.

In the Field

Care should be taken to control the environmental conditions in which tapes are recorded and to prevent unnecessary damage to original master recordings before they are deposited in the archive. In the field, tapes should always be transported in their protective cases and stored in the remote recorder only during active use. Tapes and tape cases shall be shielded from direct exposure to moisture, temperature extremes, dust and sunlight at all times. When possible, tapes not needed for immediate use shall be kept in an air-conditioned space (e.g., hotel room, office, electronic news gathering (ENG) uplink van). As recording equipment is an integral part of the field use environment, these precautions shall be applied to the equipment as well as to the tape.

Magnetism

(See also "Demagnetization" in Fact Sheet 6 — Common Tape Problems)

Within use and handling areas, the peak intensity of external study state (DC) fields shall not exceed 4 kA/meter (50 oersteds) and the peak intensity of external varying (AC) fields shall not exceed 800 kA/meter (10 oersteds). External magnetic fields most frequently are observed near motors and transformers (e.g., elevators and lifts), but potentially damaging fields can be generated by some headphones, speakers, microphones, magnetic cabinet latches, and magnetized tools. Most sources of magnetic fields are localized and the field intensity falls off rapidly with separation (a few centimeters separation from the source will usually provide adequate protection).

Care should be always taken during handling and transportation to avoid placing tapes in close proximity to potential sources of magnetic fields.

Fact Sheet 9 — Tape Inspection

A comprehensive plan for the inspection of magnetic tape is essential to prevent damage to the tape itself and to the machinery on which it is transported for playback. Tapes should be inspected thoroughly before every major change in status, such as before or after shipment, playback, or placement in storage. Periodic inspection during storage also is essential to prevent premature loss of materials. See standards AES 22-1997 and ISO 18923 for information regarding inspection as it relates to storage of magnetic tape.

At a minimum, the following physical inspection routine is recommended. While this examination may not identify all the problems that can occur, if a tape fails any one of these inspection criteria, it can be considered to be in danger and in need of further attention. Attempts to play back such tapes before treatment place the tapes and the playback machinery at risk.
The following inspection procedure shall be performed in the order listed.

1. The physical container (box, case, and/or cassette) shall be examined for damage that compromises the structural integrity of the container itself. Breakage is a strong indication of improper handling. If the container, reel or cassette is damaged, the tape inside also is likely to have suffered damage or contamination.

2. The tape shall be inspected for odor as soon as the container is opened. If a musty odor is detected, the inspection shall be terminated as this inspection may indicate the presence of fungus. Hydrolytic breakdown of polyurethane binder creates esters that have distinctive odors but dissipate quickly. The most common odors can be characterized as "waxy," "dirty socks," "astringent" or "pungent," depending on the binder. Tapes with binder hydrolysis are in the process of self-destruction and can stick in the machine during playback, causing additional damage. Some early tapes made with acetate will emit a vinegar odor if the basefilm is afflicted with "vinegar syndrome," a serious form of decay.

3. The container and the edges of the tape shall be inspected for patterned black, brown, or mustard-colored contamination and for fuzzy or thread-like growths that indicate the presence of fungus. Fungus can grow on magnetic tape and tape containers after exposure to high humidity. Tapes with fungus should be isolated and treated by professionals as soon as possible. Mold can present a health hazard: if an outbreak is suspected, routine inspection procedures should not be continued until the scope of the outbreak is understood.

4. With a light source above and slightly behind the inspector, the tape should be tilted edge-on at an angle of approximately 45° away from the light source. In this position the tape pack shall be inspected for popped strands, stepped pack, flange pack, pack slip, edge damage, cinching and gaps in the pack. These terms, defined below, refer to irregularities in the way the tape is wound onto the hub and are indications of improper handling, improper storage or a badly adjusted machine.

- Spoking describes a distinctive pattern of lines radiating out from the hub, like the spokes on a bicycle wheel; this condition results from improper tension.
- Popped strands and stepped pack (also known as slipped pack or pack slip) refer to individual or groups of tape wraps that stick up from the edge of the pack (see figure on Fact Sheet 6 — Common Tape Problems).
- Flange pack occurs when the whole tape pack rests against the flange.
- Gaps in the tape pack are caused when the tape is loosely wound on the hub. Often a gap indicates an area where the tape is folded back over on itself, a condition known as cinching. Torn, worn or folded tape often shows up as an area of greater light reflection in the pack.

If these conditions are found, document the condition of the tapes and contact a restoration expert.

5. The tape edge and the reel/cassette/cartridge shall be inspected for particulate contamination and for signs of staining that may indicate liquid contamination. Any visible contamination is an indication of poor storage or handling. Particulate contamination can block the signal during playback and can scratch both the tape and the playback heads. Liquid contamination may accelerate tape decay and often results in tape wraps sticking together.

6. The tape edge shall be examined for white powder or crystalline residue and the interior of the container shall be examined for black or brown flakes of oxide. These symptoms are caused by a variety of conditions and indicate that the tape has started to degrade.

If this condition is identified, the tape may be treated by drying (see Fact Sheet 11— Rejuvenating Unplayable Tapes).

7. With open reel tapes, a loose vertical stand shall be inspected for surface contamination, physical distortion and binder/base adhesion failure. Dust, dirt, or other foreign deposits on the tape indicate surface contamination. Physical distortion caused by improper tension of the tape wind often appears as wavy or "scalloped" edges. Sections of tape which appears to have a different color may indicate binder/base failure, where magnetic pigment material has separated from the backing.

Fact Sheet 10 — Tape Cleaning and Equipment Maintenance

Magnetic tapes can be damaged by improper usage. One of the most common forms of damage is caused by running tape on a machine that has not been properly maintained. Debris on the tape or tape path components will cause scratching, scoring, or abrasion of the tape (see figure on Fact Sheet 8 — Environmental Conditions). Minute debris between the tape surface and the head can cause loss of signal. Large particles of foreign debris and heavy residues from tape deterioration can cause permanent damage to the tape or playback machinery, or can alter playback characteristics.

Playback Equipment

Tape recorders shall be regularly cleaned and maintained according to the manufacturer's recommendations. For tape machines that use cassettes, cleaning cassettes can be used. Directions accompanying the cleaning cassette shall be followed. Cleaning cassettes will not remove debris that is encrusted or embedded in tape path components. Encrusted or embedded debris must be removed by using a cotton swab and a chemical listed in the tape recorder maintenance manual. When cleaning a tape recorder by hand, the procedure in the tape recorder maintenance manual shall be followed.

Cleaning a tape recorder manually can damage precision components, such as rotating heads. Hand cleaning shall not be attempted unless performed by a skilled person knowledgeable about the equipment, proper procedures, and potential pitfalls.

If tape recorder maintenance personnel are unavailable, a highly-qualified service company should be hired to conduct maintenance procedures on a regular basis.

When to Clean Tape

If the physical condition of the tape is unknown or the tape is known to be contaminated, tape cleaning should be performed to remove foreign debris and decay residues from both sides of the tape. Cleaning also may be performed to evaluate a tape for the presence of these contaminants.

Before using, tapes should be inspected (see Fact Sheet 9 — Tape Inspection). If evidence of debris on the tape or in the container or shell is discovered during inspection, appropriate cleaning shall be done. If the tape transport must be stopped during playback due to head clogging, sticking, or skidding, careful cleaning shall be carried out prior to resuming playback. If the tape did not originate in-house or the physical condition has not been confirmed recently as acceptable, tape should be cleaned before placement in extended-term storage conditions. Regular and frequent cleaning is unnecessary unless addressing a specific problem.

The Tape Cleaning Process

Tape cleaning is a precise and difficult process and must not be done without proper training and equipment. Cleaning of dry-particulate debris, such as dirt, dust, or shedding binder, shall be done with long-fiber, lint-free, non-abrasive tissues. Both surfaces of the tape shall be wiped. For contaminants other than dry-particulate debris, a professional expert shall be consulted.

It is essential that debris collected during cleaning is removed entirely from the tape surface so that it is not re-deposited back onto the tape. Thorough cleaning can be accomplished by using, for example, a vacuum designed for the purpose or by moving a non-abrasive tissue across the tape surfaces.

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Razor blades, playback heads, and abrasive materials shall not be used to clean tapes. Burnishing the tape surface may be used to enhance the cleaning process; however, only burnishing mechanisms designed specifically for cleaning magnetic tape shall be used.

All equipment used for cleaning tape shall have a tape path that is fully visible and accessible to the operator during tape transport. Any surface that comes into contact with the tape during cleaning shall be accessible and shall be cleaned before each tape is placed on the machine.

Some contaminants may cause adjacent tape wraps to adhere. The two most common are the oligimer residue from hydrolytic chemical decay of the tape binder and residues left on the tape from exposure to liquids, splices and other foreign contaminants.

If tape layers are adhering, tissue wiping or burnishing on a mechanical transport shall not be carried out until tapes have been treated to reduce layer-to-layer adhesion. Refer to Fact Sheet 11 — Rejuvenating Unplayable Tapes.

Fact Sheet 11 — Rejuvenating Unplayable Tapes

Tapes which are unplayable due to deterioration can be dried in order to restore them temporarily to a playable condition. This simple procedure, which effectively removes any moisture absorbed by the media, will not harm tape provided that the steps outlined below are followed carefully. The process can be repeated as necessary over the course of many years in order to renew failing tapes.

This treatment is not intended for tapes which are wet due to a liquid-related disaster. Wet tapes must be cleaned, rinsed, and dried at room temperature. In the event of a liquid-related disaster, see Fact Sheet 13 — Disaster Preparedness and Response and consult a disaster recovery service or a tape restoration specialist.

Drying procedure

For a few tapes:

Place each tape, removed from its container, in a zipper plastic bag along with a desiccant such as silica gel with a color indicator. (This dessicant is recommended because it can be baked in an oven to remove the moisture it has absorbed; the dessicant is ready for reuse when it reverts to its original color.) Isolate the silica gel by placing it in a small pouch that is porous and permeable but will not allow the silica gel to come into contact with the tape. Place the bag containing the dessicant and tape in a refrigerator, NOT a freezer.

For a large quantity of tapes:

1. Find a small enclosed room with clean shelves.
2. Use a portable dehumidifier unit (such as Sears or Oasis models) to maintain a level of approximately 30% RH in the room.
3. Place a hygrothermograph, datalogger, or other device capable of recording temperature and relative humidity levels in the room.
4. Remove each tape from its container, and remove any condensed moisture or debris evident in the container.
5. Place each tape in a vertical position on a shelf next to its container. The vertical position is important because it allows the dry air to circulate evenly inside and around each tape.
6. Keep the tapes in this clean and dry environment until the treatment is complete, consistently monitoring the environmental conditions for changes.

The time required to effectively dry the tapes depends on several unknown factors. A minimum of one week is generally required; in some cases as long as one month may be necessary. To check the progress of the treatment, remove the tapes from the refrigerator or cold room, allow them acclimate to room environment for a day or two, and then try to play them. If they still have exhibit playback difficulties, return them to the cold environment for a few weeks. Repeat the process until no playback difficulties are experienced.

When it has been determined that the drying treatment is completed, place each tape in a tape machine and fast forward to the end and then rewind back to the start. The tape machine should be in an environment with ambient conditiions similar to those in which the tapes will be stored. Remove each tape from the machine, place them back into their containers, and transfer them to their permanent storage area.

Fact Sheet 12 — Staff Training

The preservation and effective use of videotape is enhanced by a staff training program. Because of the particularities unique to the medium, it is important that only trained personnel handle magnetic tape. The purpose of a training program shall be to achieve the following goals:

- A high level of technical competence among staff
- Familiarity with the proper operation of equipment, including its capabilities and limitations
- Awareness of required safety procedures, including fire control and chemical, biological and electrical hazard avoidance
- Knowledge of policies and procedures governing work
- The stability, if not improvement, of the condition of the collection.

While each organization must develop a program suited to its particular circumstances and needs, an effective training program shall consist of at least two paths: one for new staff and one for continuing staff. Whether staff members are paid employees or volunteers, they shall receive regular training. New employees shall commence training as soon as possible after the commencement of employment. Continuing employees shall receive updated training sessions at least once each year. The formal training program shall be supplemented by day-to-day supervision. The training program shall be revised regularly as systems and equipment are updated, as procedures and services are modified, and as the collection grows.

A thorough training program shall include the following components:

- The mission, goals and objectives of the organization
- Job descriptions stating the roles and responsibilities of each staff member
- Published standards and a bibliography of other information relevant to the work of the repository
- Guidelines governing access to the materials
- Maintenance schedules and procedures for equipment used in the facility
- Cataloging, labeling and shelf arrangement information
- Instruction on the handling of magnetic tape
- Occupational health and safety
- Key information about the facility (e.g., appropriate temperature and relative humidity levels, location of fire alarms and emergency shut-off valves)
- Disaster response procedures.

Fact Sheet 13 — Disaster Preparedness and Response

Magnetic tapes are highly susceptible to damage in the event of a disaster, such as a fire, flood, or earthquake. The three most common results are physical deformation, chemical decay and surface contamination. Short-term exposure to most disaster situations usually causes no detectable alteration of the recorded signal. The notable exceptions are the increase in print-through on analog audio tape that is exposed to high temperatures, the possible degradation of metal particle tape and metal evaporated tape by contact with water, and direct or close proximity with electro-magnetic fields.

The majority of losses from disaster is due to alterations in the physical characteristics of the tapes. These alterations result in an inability to run the tapes properly on a transport in order to accurately read the recorded signal. Many of these physical alterations are extremely time sensitive. Therefore, problems should be corrected as soon as possible after the disaster and before attempting to play back tapes. Otherwise, permanent damage can occur that is more severe than the immediate effects of the disaster.

The most common type of disaster is exposure to water, which may result from many sources such as roof leaks, flooding, broken pipes, malfunctioning bathroom fixtures, municipal sewer problems, fire sprinkler systems, and spilled drinks.

Exposure to water and various other liquids can seriously weaken the structural integrity of magnetic tape and can alter the frictional coefficient of the tape surface. If tapes are wet or retain a high level of moisture content, standard stresses and tensions encountered during playback may result in permanent deformation. Furthermore, if wet tape dries unevenly, deformation can occur. During drying, chemical impurities in the liquid may concentrate and accelerate destructive reactions with the tape. Wet tape in contact with other surfaces, such as guide posts in a cassette shell, may adhere to those surfaces as it dries. Some tapes in close proximity to standing water can absorb sufficient moisture to increase hydrolytic breakdown of the binder. Moisture can also promote fungus (mold and mildew) growth.

In the event of a fire, tape is threatened by exposure to heat, smoke, water, fire suppression chemicals, and debris in addition to the danger posed by the fire itself. Each of these potential contaminants has a different effect on the tape. If exposed to sufficient heat, tape will melt or burn, but the most frequent damage during a fire is caused by smoke. Smoke will affect most tapes in the general vicinity of a fire, and leaves an oily film on the tape surface that interferes with signal retrieval. Fire also produces airborne particulate debris that may become deposited on the tape surface.

In an earthquake, in addition to the dangers of fire or flooding, the primary concerns are the impact from falling from storage shelves and the exposure of the tape to dry particulate debris. Most dry debris will not interact chemically with magnetic tape. However, debris that adheres to the tape may interfere with signal retrieval during playback. Debris that is wound into the tape pack can scratch or otherwise deform the tape surface.

Disaster Preparedness

Most tapes exposed to disasters are not destroyed by the initial exposure. Often the damage results from improper handling after a disaster or from a delay in rescue work. For this reason it is imperative that all repository staff are prepared to take the appropriate actions if disaster occurs. Disaster preparedness should be an integral part of the organization's staff training program.

It is important to be familiar with certain aspects of the tape storage facility, such as the location of circuit breaker boxes and shut-off valves. The condition of water pipes and other potential sources of water or chemical damage should be checked regularly.

Contact information for key individuals, such as recovery service providers, professional tape experts or labs, as well as the organization's supervisory staff with administrative and fiscal authority, should be available.

Keep emergency supplies, such as plastic buckets, gloves, and plastic sheeting, on hand in a location readily accessible to the tape storage area.

Disaster Response Procedures

The steps indicated below shall be taken as soon as possible to minimize loss. If possible, both the handling and the decontamination shall be performed by specialists with a record of success in salvaging tapes from disasters. It is recommended that a professional tape expert be consulted as soon as possible after the disaster occurs.

As soon as a disaster site has been secured against possible injury to personnel, tapes shall be removed from the site to avoid further contamination and damage. If sewage is involved, salvage workers must wear protective clothing when handling affected materials. Tapes shall be moved carefully in plastic containers or cardboard boxes lined with plastic bags. They should be oriented in a vertical position at all times so that they are supported by the hub. Where liquid is present, changes in orientation that spread contamination shall be avoided. Tapes shall be cushioned against shock and insulated against sudden changes in temperature.

Wet tapes are particularly vulnerable to damage. Mold can grow within twenty-four hours; to prevent the growth of mold, keep wet tapes in a cool environment until they can be treated appropriately. Before they are allowed to dry, wet tapes must be cleaned of chemical and particulate contaminants which may be present as a result of a water disaster.

Use only cold, distilled water to rinse water-damaged tape. All wet paper and cardboard, excluding labels, shall be removed from the vicinity of the tape as quickly as possible to reduce water retention and potential fungal growth. If fungal growth is detected, only trained personnel should treat the tapes.

Dry particulate debris, such as soot from a fire or dust from an earthquake, can become airborne and spread quickly and easily throughout its surroundings. Contaminated tapes shall be isolated until decontamination is completed. Liquids shall not be used to remove dry particulate debris. Do not open tape boxes when the risk of contamination by dry particulate matter remains, because the tape stored inside may not yet have been exposed to the debris.

Proper decontamination may require that tapes be removed from their hubs. Hubs, cassettes, cartridges, and reels may need to be disassembled and decontaminated or replaced. Tape is extremely vulnerable to physical damage while off the hub. Disassembly and decontamination shall be performed only by personnel with proper training. They shall not be spooled, played back or returned to long-term storage before cleaning. Temporary storage shall be in a stable, cool environment. Tapes shall be acclimatized before placing them on cleaning or playback machinery.

Furthermore, maintaining intellectual control over the materials may be challenged when tapes are subjected to a disaster. Label information may become lost due to either bleeding inks or destruction or loss of the label or container itself. An effort to salvage containers and labels that have become detached from tapes should be made, but not at the expense of the tape salvage effort. If it is necessary to remove tapes from their cases or cassettes during the decontamination process, careful notations should be maintained in order to document the relationship between tapes and any identifying information on their housings.

Fact Sheet 15 — Video Processors and Time Base Correctors

Many analog tape playback problems can be "cleaned up" by using a video processor or a time base corrector (TBC). A video processor can be used to correct black-white level problems, color problems, and horizontal and vertical sync errors. A TBC is used to remove or mask variation in the synchronizing signals, which can result in "skewing" and other distortions in the video image "generated by unavoidable mechanical inaccuracies in helical scan recorders. This is accomplished by automatically delaying the video signal so that each line starts at the proper time. The TBC can be an integral part of the recorder (professional) or may be an external stand-alone device (industrial/consumer)."

A good video processor and TBC are necessities for anyone planning to produce high quality viewing copies of archival footage. Most professional video labs will have this equipment. Depending on several factors, a video processor or a TBC can actually introduce unwanted artifacts into the copy tape. The two most common are over-enhancement and velocity errors.

Over-enhancement appears as ghost images to the right of a vertical line. The proper level of enhancement will produce a single, sharp vertical line. In contrast, a mild over-enhancement will produce a faint ghost while severe over-enhancement will produce several reflections.

Velocity errors usually show up as several horizontal "bars" on the video monitor. These bars, consisting of several horizontal lines each, are characterized by alternating dark and light bands. They are caused by a mismatch between the playback video heads and the video heads that made the recording. These velocity errors can be suppressed or eliminated by finding a video recorder with a better match of video heads or a TBC that can suppress the velocity errors.

Signals recorded to preservation master copies of archival materials should never be "cleaned up" using signal processing techniques of any kind.

Notes

"Time Base Error" from the Association of Cinema and Video Laboratories' Glossary of Video Terms and Definitions. (Available from: http://www.acvl.org/9f.htm#Time Base Error; accessed 26 April 2002).

Fact Sheet 16 — The Do's and Don'ts of Magnetic Tape Care: Minimum requirements for proper handling

The following guidelines are the minimum handling requirements that summarize best practices based on experience and testing. In many cases, the guidelines follow common sense logic. Failure to adhere to these guidelines should be considered misuse of the medium and may cause premature loss of information or deterioration of magnetic tapes. Explanation and expansion of the ideas outlined in the recommendations are available throughout the other Fact Sheets.

DO

- Learn and use correct procedures for operating equipment.
- Handle tapes gently.
- Keep tapes in protective cases when not in use.
- Keep tapes vertical when not in use.
- Make sure machine alignment is correct before use.
- Clean tapes before playback if they show any evidence of dirt or contamination.
- Ensure that the tape is properly seated in the machine before use.
- Wind tape at low speed (library wind) entirely onto one reel after use.
- Leave analog audio tapes on the take-up reel after use (tails out).
- Secure tape ends on open reel tapes.
- Package tapes adequately for protection before shipment or transport.
- Use only new tape when recording a tape for long-term storage.
- Activate the Record Protection feature of all master cassettes immediately after they have been recorded..
- Inspect tapes for damage or contamination before use.
- Seek experienced help as soon as possible in the case of a disaster.
- Protect both tapes and machinery from dust and debris.
- Keep tapes in a stable an environment.
- Acclimatize tapes before use if they are hot or cold.
- Store tapes in a cool and dry place; see ISO 18923.

DO NOT

- Touch tape surfaces with bare hands.
- Put pressure on reel flanges.
- Stack or place objects on top of unprotected tapes.
- Force tapes into cases or machines.
- Drop or throw tapes.
- Splice any portion of a video tape.
- Place tapes on or near sources of magnetic fields.
- Play or spool tapes that are dirty, contaminated or wet.
- Play or spool tapes on a dirty, misaligned or malfunctioning machine.
- Store tapes in an area subject to dampness or possible pipe leaks (e.g., basements).
- Expose tapes to food or beverages.
- Expose tapes to temperature extremes.

- Expose tapes to UV radiation, including the sun, for extended periods.
- Attempt to clean tapes contaminated with adhesives, fungus or unknown substances unless you have the necessary training or experience.
- Expose tapes to high power biological decontamination scanners. High levels of radiation can produce sufficient heat capable of melting or deforming tapes or their plastic containers.

Fact Sheet 17 — Selected Bibliography and Web Resources

Books and Articles

Bertram, H.N. and Cuddihy, E.F. "Kinetics of the Humid Aging of Magnetic Recording Tape". In *IEEE Transactions on Magnetics* MAG-18 (1982).
Mee, C. Dennis and Daniel, Eric D. *Magnetic Recording Technology* (New York: McGraw-Hill, 1995).
Smith, Leslie E. et al. "Prediction of the Long-term Stability of Polyester-based Recording Media". National Bureau of Standards, *Report No: NBSIR 86-3474* (1986).
Van Bogart, John W.C. *Magnetic Tape Storage and Handling: A Guide for Libraries and Archives* (Washington, DC: Commission on Preservation and Access, 1995).
See also Conservation OnLine: Video Preservation (http://palimpsest.stanford.edu/bytopic/video/)

Standards

American National Standards Institute (ANSI) (http://www.ansi.org/)

Audio Engineering Society (http://www.aes.org/)
AES22-1997: AES recommended practice for audio preservation and restoration -- Storage and handling -- Storage of polyester-base magnetic tape

International Organization for Standardization (http://www.iso.org/iso/home.htm)
ISO 18923:2000: Imaging materials -- Polyester-base magnetic tape -- Storage practices

Society of Motion Picture and Television Engineers (SMPTE) (http://www.smpte.org/home)
SMPTE RP-103: Care, Storage, Operation, Handling and Shipping of Magnetic Recording Tape for Television
SMPTE RP-190: Care and Preservation of Audio Magnetic Recordings

Moving Image Organizations

Academy of Motion Picture Arts and Sciences (http://www.oscars.org/)
American Film Institute (http://www.oscars.org/)
American Insitute for Conservation of Historic and Artistic Works, Electronic Media Group (http://aic.stanford.edu/sg/emg/)
Experimental Television Center's Video History Project (http://www.experimentaltvcenter.org/history/index.html)
Video Preservation -- The Basics (http://www.experimentaltvcenter.org/history/preservation/preservation_toc.php3?id=1)
Independent Media Arts Preservation (IMAP) (http://www.imappreserve.org/)
International Federation of Film Archives (FIAF) (http://www.cinema.ucla.edu/)
International Federation of Television Archives (FIAT) (http://fiatifta.org/)
National Association of Broadcasters (NAB) (http://www.nab.org/AM/Template.cfm?Section=Home)
National Film Board of Canada (http://www.nfb.ca/splash/splash.php)
National Film Preservation Board: Film, Preservation and Cultural Organizations, Television Resources and Television and Videotape Study 1997 (http://www.loc.gov/film/)
National Media Lab (http://www.nta.org/)

National Archives and Libraries

National Archive and Records Administration (NARA) (http://www.archives.gov/index.html)
Library of Congress (http://www.loc.gov/index.html)
ScreenSound Australia (http://www.screensound.gov.au/)
National Archives of Canada (http://www.collectionscanada.ca/)

Magnetic Media Restoration Specialists

Specs Brothers (http://www.specsbros.com/)
VidiPax (http://www.vidipax.com/index.php)

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Fact Sheet 18 — Glossary

A

Access storage: Storage conditions at or near room ambient conditions that allow tape collections to be readily accessed for immediate playback.

Acetate: A type of basefilm used for making audio tapes until the 1960s. Also called cellulose acetate and it is related in chemical composition to cellulose diacetate.

AES: Abbreviation for Audio Engineering Society.

Analog recording: A recording in which continuous magnetic signals are written to the tape, representing the voltage signals coming from the recording microphone or the video camera.

Analog-to-digital: The process in which a continuous analog signal is quantized and converted to a series of binary integers. Sometimes called A-to-D.

ANSI: Abbreviation for American National Standards Institute.

Archival storage: Storage conditions specifically designed to extend or maximize the lifetime of stored media. Generally characterized by levels of temperature and relative humidity lower than those in access storage conditions and with minimal fluctuations. Access to archival storage by personnel is limited for security reasons.

B

Backing: See "Basefilm." Also called base, basefilm, substrate.

Basefilm: Backing film layer that supports the magnetic layer in a magnetic tape. Polyester Terephthalate (PET) has been the most commonly used tape substrate for analog videotape. Polyeythelene Napthalate (PEN) is commonly used for digital videotapes. Also called backing, base, substrate.

Binary number: A number that can be represented using only two numeric symbols, 0 and 1. Binary numbers are used by computers because they can easily be represented and stored by hardware that utilizes switches, magnetic fields, or charge polarities that are normally in one of two states. The on/off, north/south, or positive/negative states can easily represent the 1s and 0s of a binary number, respectively.

Binder: The polymer used to bind magnetic particles together and adhere them to the tape substrate. Generally, a polyester or polyether polyurethane based system. See "Polymer."

Bit: In digital terms, a single numeric character. Each bit of a binary number can either be 0 or 1. An e-bit number is composed of exactly n numeric characters. An e-bit binary number has a set number of distinct values; that number is derived by calculating 2 to the nth power. For example, an 8-bit binary number has 2 to the eighth power, or 256, distinct values, namely all the numbers between 00000000 (0 in decimal) and 11111111 (255 in decimal), inclusive. Eight-bit quantization would discretely sam-

ple a signal and assign each sampling a value from 0 to 255, permitting 256 possible values.
8 bits=1 byte
1,024 bytes=1 kilobyte (KB)
1,048,576 KBs=1 Megabyte (MB)
1,024 MBs=1 Gigabit (GB)
1,024 GBs=1 Terabyte (TB)

Blocking: The sticking together or adhesion of successive windings (layers) in a tape pack. Blocking can result from (1) deterioration of the binder, (2) storage of tape reels at high temperatures, and/or (3) excessive tape pack tension.
Byte: One byte is one computer "word" and is usually equal to 8 bits. See "Bit."

C

CAV: Constant Angular Velocity. The disc speed remains constant while the head-to-disc speed changes. Magnetic discs spin at a Constant Angular Velocity.

CLV: Constant Linear Velocity. The disc changes speed as the head moves from the inner track to the outer track. Compact discs (CDs) spin at a Constant Linear Velocity.

Carrier: The physical medium on which the video/data is recorded.

Cinching: The wrinkling, or folding over, of tape on itself in a loose tape pack. Normally occurs when a loose tape pack is stopped suddenly, causing outer tape layers to slip past inner layers, which in turn causes a buckling of tape in the region of slip. Results in large dropouts or high error rates.

Coercivity: The level of demagnetizing force that would need to be applied to a tape or magnetic particle to reduce the remanent magnetization to zero. A demagnetizing field of a level in excess of the coercivity must be applied to a magnetic particle in order to coerce it to change the direction of its magnetization. Coercivity is the property of a tape that indicates its resistance to demagnetization and determines the maximum signal frequency that can be recorded by a tape. Hc is the common abbreviation for coercivity.

Cohesive force: The force that holds a material together.

Component: A Component TV system has multiple, separate signals and requires two or three cables.

Compression: The term used to describe the method of eliminating redundant information in each frame of digital video. Low-level compression of about 2:1 is usually considered "lossless." Over about 5:1, compression is "lossy."

Composite: Composite is the combination of sync, black/white video and color video signals and uses only one cable. Consumer TV and VCRs are examples of composite video.

Container: The enclosure that contains a reel or cassette of tape.

Copy: The process of copying the information on one tape to another tape of the same or different format. The term "refreshing" is commonly used by some archivists and librarians to refer to the process of copying information from one tape to a newer tape of the same format (e.g., VHS to VHS). When the information is copied to a different format (e.g., Betamax to VHS), the terms "reformatting" and "converting" have been used. Also called migrate, refresh, transfer.

Curvature error: A change in straight-line track shape that results in a bowed or S-shaped video track. This becomes a problem if the playback head is not able to follow the track closely enough to capture all of the information on the recorded track.

D

Diacetate: Also referred to as cellulose diacetate. The type of basefilm used for making audio tapes until the 1960s. It is related in chemical composition to cellulose acetate.

Digital recording: A recording in which binary numbers represent quantized versions of the voltage signals from the recording microphone or the video camera. On playback, the numbers are read and processed by a digital-to-analog converter to produce an analog output signal.

Digital-to-analog: The process in which a series of discrete binary integers is converted to a continuous analog signal. Sometimes referred to as D-to-A.

Disc: Commonly the term used for optical media, such as Compact Discs, as well as analog sound recordings, such as LPs and transcription discs.

Disk: The term used for magnetic media in non-tape format, such as a computer hard disk or a floppy disk.

Dropout: A term used with analog videotape recorders. A brief signal loss caused by a tape head clog, defect in the tape, or debris that causes an increase in the head-to-tape spacing. A dropout can also be caused by missing magnetic material. A video dropout generally appears as a white spot or streak on the video monitor. Most tape recorders have a Dropout Compensation circuit which approximates the missing information and makes the dropout difficult to see. The frequent appearance of dropouts on playback is an indication that the tape or recorder is contaminated with debris and/or that the tape binder is deteriorating.
DTV: Digital TV refers to the high resolution standard adopted by several countries in 1998-1999. Uses a picture aspect ratio of 16:9 rather than the old standard aspect ratio of 4:3.

F

Flange pack: A condition where the tape pack is wound up against one of the flanges of the tape reel.

Format: The arrangement of information tracks on a tape as prescribed by a standard and the way the signal is processed. The two most common categories of recording formats are longitudinal and helical scan.

H

Hard Drive: HD. A magnetic disk drive used as the main memory of most personal computers.

Head: Sometimes called tip (video only), play head, record head, read head, write head, magnetic head. The device that is like an extremely small horseshoe magnet with the north and south pole bent at 90 degree angles and almost touching. Wire is wrapped around each arm of the horseshoe and the recording signal is connected to these wires during the recording (write) process. This produces a magnetic field across the north-south pole gap. Tape passing next to this gap will be magnetized according to the magnitude of the signal. During playback (read), the process is approximately reversed. Some consumer machines combine record and play in the same head but this is very crude and inefficient. "Record" and "play" are terms commonly used in the audio and video field, while "write" and "read" are terms commonly used in the context of digital data.

Head clog: Debris trapped on the playback head of a video recorder. Clogging of the playback head causes dropouts on analog tape machines and errors on digital tape machines.

Helical scan recording: The recording format in which a slow moving tape is helically wrapped around a rapidly rotating drum with small embedded record and play heads. The tape is positioned at a slight angle to the equatorial plane of the drum. This results in a recording format in which recorded tracks run diagonally across the tape from one edge to the other. Recorded tracks are parallel to each other but are at an angle to the edge of the tape.

Hydrolysis: The chemical process in which scission of a chemical bond occurs via reaction with water. The polyester chemical bonds in tape binder polymers are subject to hydrolysis, producing alcohol and acid end groups. Hydrolysis is a somewhat reversible reaction, meaning that the alcohol and acid groups can react with each other to produce a polyester bond and water as a by-product. In practice, however, a severely degraded tape binder layer will never fully reconstruct back to its original integrity, even when placed in a very low-humidity environment.

Hygroscopic: Said of a material which has a tendency to absorb water. An effect related to changes in moisture content or relative humidity. The hygroscopic expansion coefficient of a tape refers to its change in length as it takes on moisture from the ambient environmental conditions.

Interchange: The ability to exchange recordings made on machines made by one manufacturer with those recorded on machines made by another manufacturer without affecting the playback of video.

I

ISO: International Standards Organization is the central world organization which adopts standards submitted by recognized standards groups like SMPTE, AES, and ANSI.

L

Leader: The first part of a magnetic tape before the start of the recording. For a VHS tape, this is a clear, non-magnetic material used to determine where to stop the tape during rewind. For other tapes, the leader may be a non-magnetic material spliced on the beginning of the tape (like VHS) or it may be the beginning section of the tape before the program material. This section may be unrecorded, it may contain metadata, or it may have color bars and/or audio tones.

Longitudinal recording: A recording format in which a slow or fast moving tape is passed by a stationary magnetic record or play (write or read) head. The recorded tracks are parallel to the edge of the tape and run the full length of the tape.

Lubricant: A component added to the magnetic layer of a tape to decrease the friction which occurs between the head and the tape during playback.

M

Magnetic particles: The materials incorporated in the binder to form the magnetic layer on a magnetic tape. Iron oxide, chromium dioxide, barium ferrite, and metal particulate are various examples of magnetic pigment used in commercial tapes. The term "pigment" is a carry-over of terminology from paint and coating technology--the magnetic coating on a tape is analogous to a coat of paint in which the magnetic particle is the paint pigment.

Magnetic remanence: The strength of the magnetic field that remains in a tape or magnetic particle after it is exposed to a strong, external magnetic field and the external field is removed. The property of a tape that determines its ability to record and store a magnetic signal. Mr is the common abbreviation for magnetic remanence. Magnetic remanence, Mr, and magnetic retentivity, Br, both refer to the ability of the tape to retain a magnetic field; however, the latter is expressed in units of magnetic flux density.

Metadata: The information used to describe, identify and classify recorded information, such as audio and video content.

Micron: A unit of measure for the thickness of magnetic tape. Symbol is µm.

Migrate: To copy recorded information to a newer format and/or media. Migration is a key strategy used in the preservation of digital information. See "Copy."

Mistracking: The phenomenon that occurs when the path followed by the play (read) head of the tape recorder does not correspond to the location of the recorded track on the magnetic tape. Mistracking can occur in both longitudinal and helical scan recording systems. The head must capture a given percentage of the track in order to produce a playback signal. If the head is too far off the track, recorded information will not be played back at a level adequate for proper reproduction.

Movies: Common term used to describe 35mm and 70mm productions primarily made for showing in a movie theater. Most movies are eventually copied to VHS and distributed for home rental market. The international standard film rate is 24 frames per second (fps). The U.S. television standard is 30 fps. Conversion from film to TV or TV to film requires dropping or adding frames. See "TV" and "Video."

N

NTSC: The 525 line/60 Hz television system used in the U.S., Canada, Japan and several other countries. Stands for National Television Standards Committee. European countries use either PAL or SECAM standards and are 625 line/50 Hz. See "SDTV", "HDTV", "Television", "Scanning."

O

Oersted: The unit of magnetic field strength. Abbreviated as Oe.

Original: The earliest generation in the archive. The source recording or final edited master.

P

Pack slip: A lateral slip of selected tape windings causing high or low spots (when viewed with tape reel laying flat on one side) in an otherwise smooth tape pack. Pack slip can cause subsequent edge damage when the tape is played, as it will unwind unevenly and may make contact with the tape reel flange.

Passivate: A chemical process which forms a protective coating on a metal. Used to coat and protect each particle in a Metal Particle (MP) tape.

PEN: Abbreviation for polyeythelene napthalate.The base used for thin digital videotapes.

PET: Abbreviation for polyethylene terephthalate. The polymeric substrate material used for most magnetic tapes.

Pixel: The smallest unit of a digital picture/video. Derived from "Picture Element".

Polymer: A long, organic molecule made up of many small, repeating units. Analogous to a freight train, where each individual unit is represented by a freight car. At very high magnification, a chunk of polymer would resemble a bowl of cooked spaghetti. Plastic materials are polymers. The strength and toughness of plastics is due, in part, to the length of its polymer molecules. If the chains (couplings in the freight train) are broken by hydrolysis, the shorter chains will impart less strength to the plastic. If enough polymer chains are broken, the plastic will become weak, powdery, or gooey. See "Binder."

Popped strand: A strand of tape protruding from the edge of a wound tape pack.

Print through: The condition where low frequency signals on one tape layer imprint themselves on the immediately adjacent tape layers. It is most noticeable on audio tapes where a ghost of the recording can be heard slightly before the playback of the actual recording.

Q

Quantization: A process in which a continuous signal (analog) is converted to a series of points at discrete levels (digital). The quantized version of a ramp, a continuum of levels, would be a staircase, where only certain distinct levels are allowed.

R

Refreshing: This term can refer to periodic retensioning of tape, or the rerecording of recorded information onto the same tape (or different tape) to refresh the magnetic signal. In the audio/video tape community, refreshing generally refers to retensioning of the tape, but it can also refer to the copying of one tape to another. See "Copy." Also called transfer, migrate.

Relative humidity (RH): The amount of water in the air relative to the maximum amount of water that the air can hold at a given temperature.

Restoration: The process where a tape degraded by age and wear is temporarily or permanently restored to a playable condition. Tape cleaning or baking are examples of tape restoration procedures.

Retensioning: The process where a tape is unspooled onto a take-up reel and then rewound at a controlled tension and speed. In performing this procedure, tape pack stresses are redistributed and, thus, the tape is retensioned. This has sometimes been referred to as exercising the tape.

RF: Radio Frequency. The term used for the signal of the video play head during playback. RF is not used to describe an audio head playback signal.

RH: Abbreviation for Relative Humidity.

Room ambient conditions: The temperature, relative humidity, and quality of the air in the room. Those conditions generally found in a library, studio, or office facility with a controlled environment (heating and air conditioning).

S

Scanning Line Rate: The U.S. TV NTSC Standard since the 1940s uses a scanning rate of 525 lines per frame. Each frame (picture) is scanned twice at 262.5 lines per scan. The second scan is in between, or interlaced, the lines of the first scan. This complex system saves valuable frequency bandwidth. Computers do not have the problem faced by limited airwave bandwidth so conventional computer monitors use progressive scanning at 30 or 60 fps with no interlace.

Scission: The process in which a chemical bond in a molecule is broken either by reaction with another molecule, such as water, or by the absorption of a high energy photon.

Serpentine recording: A form of longitudinal recording where track one is written near one edge of the tape, and when the end of tape is reached, the head moves (or another head is used) and the recording proceeds in the opposite direction. When the tape returns to the starting point, the head moves inward one track (or another head is switched on) and the recording continues. This process is repeated until the last track (near the other edge) is reached.

SDTV: Standard Definition TV refers to the TV systems commonly used around the world since the 1940s. See "NTSC," "HDTV," "Television," "Scanning Line Rate."

Signal-to-noise ratio: The ratio of the recorded signal level to the tape noise level normally expressed in decibels. Commonly abbreviated as S/N. See "Tape noise."

SMPTE: Abbreviation for the Society of Motion Picture and Television Engineers.

Stick slip: The process in which (1) the tape sticks to the recording head because of high friction; (2) the tape tension builds because the tape is not moving at the head; (3) the tape tension reaches a critical level, causing the tape to release from, and briefly slip past, the read head at high speed; (4) the tape slows to normal speed and once again sticks to the recording head; (5) this process is repeated indefinitely. Characterized by jittery movement of the tape in the transport and/or audible squealing of the tape.

Sticky shed syndrome: The phenomenon whereby a tape binder has deteriorated to such a degree that it lacks sufficient cohesive strength to prevent the magnetic coating from shedding during playback. Causes dropouts on videotapes and will clog video and/or audio heads.

Sticky tape: Tape characterized by a soft, gummy, or tacky tape surface. Tape that has experienced a signficant level of hydrolysis so that the magnetic coating is softer than normal. Tape characterized by resinous or oily deposits on the surface of the tape.

Stress: Force per unit area, such as pounds per square inch (psi). A tape wound on a reel with high tension results in a tape pack with a high interwinding stress. See "Tension."

Substrate: See "Basefilm." Also called film, backing, carrier.

T

Tape baking: A process in which a magnetic tape is placed at an elevated temperature for a brief time in order to firm up the tape binder. This procedure can be carried out as a temporary cure for sticky shed or sticky tape syndrome.

Tape noise: A magnetic signal on the tape resulting from the finite size and nonuniform distribution of magnetic particles in the magnetic layer of the tape. Tape noise is inherent in any magnetic tape but can be reduced by using smaller pigment sizes in tape formulations. The iron oxide pigments found in less expensive tapes have the largest tape noise level. For analog, the noise increases each time the tape is copied (each generation). See "Signal-to-noise ratio."

Tape pack: The structure formed by and comprised solely of tape wound on a hub or spindle; a tape reel consists of a tape pack, the metal, plastic, or glass hub, and flanges.

Tape transport: The mechanics used to guide and move the tape through the recording system and past the magnetic heads of the recorder. The tape transport consists of the tape guides, capstan, rollers, tension controllers, etc.

TBC: Time-Base-Corrector. An electronic component used with analog playback machines that reduces the video errors created by changes in the head-to-tape speed.

Television: Refers to video/audio material transmitted via airwaves or via cable. Also called "TV." Sometimes referred to as "video" but video has a special meaning. Television material is sometimes live (as with most newscasts) or from a videotape or a disc or from a feed from the network. The TV signal is connected to the antenna terminals on the rear of the TV set and a channel selector is used to select the desired TV program. The U.S. Television standard is 30 frames per second (fps). Conversion from film to TV or TV to film requires dropping or adding frames. See "Movie," "Video."

Tension: Force, or force per tape width. The force on a tape as it is transported through a recorder. A tape wound on a reel with high tension results in a tape pack with a high interwinding stress. See "Stress."

Thermal: An effect related to changes in temperature. The thermal expansion coefficient of a tape refers to its change in length upon a change in the ambient temperature.

Track angle: The angle that the track of a helical scan recording makes to the edge of the tape. This corresponds with the scan angle of the helical recorder--the angle that the tape makes to the equatorial plane of the rotating drum head. If the track angle and scan angle do not correspond, mistracking will occur. See "Curvature error."

Transfer: See "Copy." Also called migrate, refresh.

V

Video: The term used to describe visual material in a standard 30 frames-per-second electronic form. A video monitor is a unit that looks like a TV set but does not have antenna terminal connections. Instead, one or two cables are connected directly, that is, without the need to select a specific channel because there are no channels. See "Movies," "Television," "Scanning Line Rate."

Vinegar syndrome: Characteristic of the decomposition of acetate-based magnetic tape where acetic acid is a substantial by-product that gives the tape a vinegar-like odor. After the onset of the vinegar syndrome, acetate tape backings degrade at an accelerated rate. The hydrolysis of the acetate is catalyzed further by the presence of acetic acid by-product.

AMIA the association of moving image archivists

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The Videotape Preservation Fact Sheets, written by Jim Wheeler with Peter Brothers and edited by Hannah Frost, are a publication of the AMIA Preservation Committee. Feedback from readers is invited.

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