SMPTE ENGINEERING GUIDELINE

Care, Storage, Operation, Handling and Shipping of Magnetic Recording Tape for Television

Table of contents

Forward
Introduction
1 Scope
2 Storage conditions
3 Operating conditions
4 Shipping conditions
Annex A Applicable media types and when introduced
Annex B Magnetic recorder / reproducer error sources
Annex C Supplemental information on tape failure, operating and storage conditions
Annex D Periodical inspections
Annex E Air pollution tests
Annex F Definition of magnetic field strength needed to specify the magnetic field required to erase a magnetic recording
Annex E Bibliography

Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Administrative practices.

SMPTE Engineering Guideline EG 44 was prepared by Technology Committee V16.

1 Scope

This document provides guidance to technical managers, archivists, and technicians for the care, storage, operation, handling, and shipping conditions that help maximize the life expectancy of television (video) magnetic recording tape.

Approved November 30, 2005

2 Storage conditions

2.1 Temperature and humidity

Tapes should not be stored in areas of extreme temperature and/or extreme humidity for long periods of time (see table 1). Temperature and humidity in the storage area should be selected as follows:

For short- and medium-term storage (up to 10 years):

Temperature	+15°C to +23°C
Humidity	40% RH to 55% RH

For long-term storage (greater than 10 years):

Temperature	+17°C
Humidity	30% RH

NOTE – Supplemental information on impact of temperature and humidity see annex C.

2.1.1 Variation from selected storage temperature and humidity from above values should be kept within ± 2°C and ± 5% RH throughout the storage period.

2.2 Storage area pressure and airborne contaminants

Air pressure in the storage area shall be maintained at a positive pressure relative to adjacent hallways and rooms. Air entering the storage area should be filtered to ensure or approach a class 100,000 environment as defined by Federal Standard 209E.

INFORMATIVE NOTE 1 – It is recommended that clean air conditions in operations and storage areas be periodically measured and benchmarked, especially around potential sources of debris, using a particle concentration meter and particle counter.

Floors should be finished so that dust and debris are minimized due to pedestrian traffic. (See informative notes 1 and 2.)

2.2.1 Cement floors should be sealed.

2.2.2 Tile floors should not be waxed.

2.2.3 Floor covering materials should be selected to minimize airborne debris and static generation.

INFORMATIVE NOTE 2 – Various types of airborne pollutants, including toxic gas, exist in the general environment. They may be generated as a result of combustion (automobile, cooking, etc.) by-products, from furniture, floor and garment cleaning agents, or by means of out-gassing from furniture, woods and internal office walls, insulating materials etc. Some of these pollutants are chemically reactive to components of magnetic storage media. Chloride, used in many cleaning and bleaching agents, is particularly reactive to magnetic materials used in metal evaporated (ME) and metal particle (MP) tape. Cobalt used as the main magnetic recording material for metal evaporated (ME) tape, reacts with chloride, sulfur dioxide and hydrogen sulfide. High temperature and high humidity accelerates chemical reactions.

Table 1 – Summary of environmental conditions

	Storage			
	Operations	Medium term < 10 Years	Long term > 10 Years	Shipping
Temperature*	+17ºC to +25ºC	+15ºC to +23ºC ± 2ºC	+17ºC ± 2ºC	-20ºC to +45ºC
Humidity*	30% to 70% ± 5%	40% to 55% ± 5%	30% ± 5%	5% to 80%
Temperature gradient per hour	10ºC per hour	N/A	N/A	10ºC per hour
Humidity gradient per hour	10% per hour	N/A	N/A	10% per hour
Stray magnetic fields	800 A/m (10 Oe)	800 A/m (10 Oe)	800 A/m (10 Oe)	4000 A/m (50 Oe)

***** NOTE – For operations or medium term storage, the center point for temperature and humidity can be selected anywhere within the allowable range, but the variation cannot exceed the allowable range.

2.3 Physical characteristics

2.3.1 To minimize the possibility of the tape taking an unwanted set due to stepped or scattered winding, the tape should be given a continuous, full-length wind or rewind at the transport manufacturer's recommended wind tension and speed before storage. All magnetic recording cassettes may be stored in a fully wound or rewound condition, with the exception of SMPTE type E (3/4-in video cassettes) which must be stored in a fully rewound condition.

2.3.2 Tape destined for long-term storage should have very few record / playback passes to maximize playback performance and minimize the probability of head clogging and physical damage.

2.3.3 Open reel and cassette tapes should be stored in such a manner that they are supported by the hub by maintaining the plane of the flange perpendicular to the horizontal storage surface.

2.3.4 The tape should be stored in a clean, inert plastic container that provides protection from dust, atmospheric pollutants, and excessive moisture. Sealed plastic bags, cardboard containers, and sleeves are not recommended for storage. Except for labels, paper should not be stored inside a storage container.

2.3.5 The outer end of open reel tapes should be secured by an adhesive tab which leaves no residue on the tape after removal. Tab material is usually obtainable from the tape manufacturer.

2.3.6 No splices, other than the splices attaching the leader and trailer to the tape, shall be used in tapes that are placed in long-term storage.

2.4 Stray magnetic fields

The stray magnetic field at any point on the surface of the tape should not exceed a field strength of 800 A/m (10 Oe).

2.5 Environmental pollutants

Certain gaseous impurities commonly found in the atmosphere should be filtered out of the long-term storage environment in order to minimize the deterioration of the recording media and the paper labels and other documentation stored with the media. The recommended maximum levels are as follows:

Sulfur dioxide ($S0_2$)	1.0 µg/m^3	0.35 ppb
Nitrogen dioxide ($N0_2$)	5.0 µg/m^3	2.43 ppb
Ozone (0_3)	25.0 µg/m^3	11.70 ppb
Acetic acid (CH_3COOH)	Use best control technology.	

INFORMATIVE NOTE – For supplemental information see annex E.

2.6 Storage shelves

2.6.1 Shelving used for storage of magnetic media should allow the tapes to be stored vertically in their shipping and storage cases with the tape identification label visible from the front.

2.6.2 Shelves should allow for adequate airflow so that the conditioned environment can be maintained throughout the storage area.

2.6.3 To avoid catastrophic damage, shelves should not be placed too close to heat sources, water pipes, and sprinkler heads.

2.6.4 Shelves should be designed to support the weight of tape when fully loaded. Additionally, the shelves should be placed on a floor that can support the weight of a fully loaded shelving system.

2.6.5 The shelves should possess a lip of sufficient depth to prevent dripping of melted plastic and burning plastic onto lower shelves in case of fire.

2.6.6 Magnetic latches on tape storage cabinets should not be used, since they could cause partial erasure of tapes if brought closer than 7 cm to the magnetic latch.

2.7 Periodic physical inspection

Every tape in an archive should be physically inspected at least every 3 to 5 years for such things as tape playback performance, debris, contaminants, container gasket deterioration, or other problems. This can be carried out by inspection of one-third to one-fifth of the archive each year. A full-length wind/rewind should be completed on each tape at least once in every ten years, preferably during the periodic physical inspection. For extended care of archived tapes see annex D.

2.8 Identification

Records containing proper date, control-number information, location, title, and other required information shall be maintained.

2.9 Smoking

To minimize airborne debris and reduce fire hazard, smoking should not be allowed in the tape storage area.

3 Operating conditions

3.1 Temperature and humidity

The temperature and humidity in the operations area should be selected and maintained as follows:

Temperature	+17°C to +25°C
Humidity:	30% RH to 70% RH

3.1.1 Variation from selected operating temperature and humidity from the above values should be kept within ± 2°C and ± 5% relative humidity.

3.1.2 Tapes that have been exposed to environmental conditions that are significantly different from planned operating conditions should be allowed to acclimate in the operating environment for at least 24 hours before usage. The maximum temperature and humidity gradient during transition should not exceed 10°C/hour or 10% RH/hour. This gradient refers to the maximum temperature and humidity change that the tape (not the reel, cassette, or container) is subjected to. The tape should remain in its container during acclimation to help control humidity and temperature gradient extremes.

3.2 Physical conditions

The operations area should be maintained as closely as possible to clean-room conditions. The following guidelines will ensure that clean-room conditions are met:

3.2.1 Airborne debris

Air entering the operations area should be filtered to ensure or approach a class 100,000 environment, as defined by Federal Standard 209E. Air pressure in the operations area shall be maintained at a positive pressure relative to adjacent hallways and rooms.

3.2.2 Floors

Floors should be finished so that dust and debris due to pedestrian traffic are minimized. Cement floors should be sealed. Tile floors should not be waxed. Carpeted floors shall utilize carpeting that minimizes debris and static generation.

3.2.3 Surfaces

All playback equipment shall be maintained and operated according to specifications provided by the manufacturers. Before replaying the tape, all surfaces of the tape transport that touch either side of the tape or carrier shall be cleaned in accordance with the method and frequency recommended by the tape transport manufacturer. Isopropyl or ethyl alcohol is an acceptable cleaning fluid for routine cleaning. Other cleaning agents may be acceptable. Care shall be taken so that the cleaning fluid does not contact the tape. For other than routine cleaning, such as removal of head clogs, use the transport manufacturer’s recommended cleaning procedures.

3.2.4 Tapes

Tapes should be kept in appropriate containers that provide a barrier to water and debris when not on the tape transport.

3.2.5 Restrictions

Smoking, eating, and drinking should not be allowed in the operations area.

3.2.6 Threading

For threading open reel tapes, the tape should only be handled by the ends. Doors on cassette and cartridge tapes shall not be opened unless the tape is inserted into the transport.

3.2.7 Cassette and open reel tapes

Tape containers shall be wiped clean prior to transportation and opening in the operations area.

Cassette and open reel tapes shall be transported so that the tape is supported by the reel hub. Open reel tape flanges shall never be squeezed together. The cassette loading door shall never be used as a carrying handle.

3.2.8 Tape ends

Frayed or wrinkled ends of open reel tapes should be cut off, using nonmagnetic scissors, prior to thread up.

3.2.9 Opening cartons

Cardboard cartons, such as master shipping cartons, should not be ripped open in the tape operations area, and cardboard use in the operations area should be avoided.

3.2.10 Dust and debris

Tape containers should be wiped clean prior to opening or transportation to the operations area.

3.3 Stray magnetic fields

The stray magnetic field at any point on the surface of the tape should not exceed a field strength of 800 A/m (10 Oe).

3.4 Winding

All tapes should be uniformly wound or rewound as described in 2.3.1 whenever the tape comes out of long-term storage or has been subjected to significant temperature and humidity variations.

3.5 Cassette removal from transport

Cassettes should be fully wound or rewound before removal from a transport. In cases where this is not immediately possible, such as during an editing session, cassette load/eject cycles should be minimized. Cassettes should be fully wound or rewound at the end of the day.

4 Shipping conditions

4.1 Winding

All tapes should be uniformly wound or rewound before shipment, as described in 2.3.1.

4.2 Containers

Tapes should be shipped in containers designed to withstand rugged handling and adverse environments, and should contain adequate shock-absorbing material. Heavy reels, such as those used for 1-in and 2-in open reel television magnetic recording tapes, should be supported by the hub and allowed to rotate freely inside the container. SMPTE type E (3/4-in) cassette tapes that do not provide self-locking reels shall be shipped in containers that provide hub locks.

4.3 Fastening

Open reel tapes should be secured at the outer end as specified in 2.3.5.

4.4 Shipment marking

Shipment of tape shall be marked with appropriate symbols or wording to indicate that the package should be handled with care, protected from excessive heat, cold, and moisture, and protected from magnetic fields.

4.5 Vibration and impact loads

Handling and transporting tapes should be done in a manner that will prevent excessive mechanical loads that would distort or damage the tape or components.

4.6 Temperature and humidity

Tape should be protected from excessive temperature and excessive humidity during transportation. The following limits should not be exceeded and the extremes of these limits should be very short in duration:

Temperature	–20°C to +45°C
Humidity	5% RH to 80% RH

4.6.1 The maximum temperature and humidity gradient during transportation should not exceed 10ºC/hour or 10% RH/hour. This gradient is the maximum temperature and humidity change that the tape is subjected to, not the reel, container, or cassette

INFORMATIVE NOTE – This implies that insulating packaging should be verified as capable of maintaining such conditions, using inexpensive commercially available temperature and humidity monitors that are enclosed with the tape. To monitor actual transit conditions, it is recommended to enclose inexpensive irreversible temperature and humidity indicator monitor cards that change color to show the highest RH and/or temperature and cumulative time for such conditions reached during shipping and subsequent storage. If an enclosed monitor indicates that a tape has been subjected to severe conditions, it should be rewound at real-time speed to release the excessive stresses it has encountered.

4.7 Stray magnetic field

The stray magnetic field at any point on the surface of the tape should not exceed a field strength of 4000 A/m (50 Oe).

4.8 Packing for transportation

Sealed cardboard boxes are recommended for packing approved tape containers for transportation. While shipping video magnetic tape in the tape manufacturer's shipping container assures that the tape will arrive undamaged, shipping that container inside a cardboard box assures that the tape container itself will arrive clean and undamaged.

4.9 Packing fill

If packed in cardboard boxes, use large, clean packing material such as bubble sheets for fill. Do not use styrofoam peanuts, shredded paper, or other small packing material, as the material can cause contamination and/or static problems.

5 Other conditions

5.1 Health and safety

The operation, storage, and transportation of television magnetic recording tape shall be conducted in a manner that is consistent with the appropriate health and safety regulatory agencies.

5.2 Tape pack wind

Tapes should be uniformly wound or rewound as described in 2.3.1 to minimize physical damage.

5.3 Labels

Tape labels should be sufficient in size to adequately identify the tape. Labels should have adhesive backings that will continue to adhere the label to the shell, reel, or container during long-term storage. Labels should be constructed of inert materials. Label marking should be accomplished with non-fading ink.

5.4 Electrostatic charge and discharge

Maintaining the relative humidity within the operating conditions specified in 3.1 will minimize the impact of electrostatic charge and discharge on tapes and cassettes.

6 Definition of terms

6.1 ampère (turn) per meter (A/m): A unit of magnetizing force (magnetic field strength). Ampère turn per meter (usually called *ampère per meter(A/m)*, is the SI unit of magnetic field strength. The ampère per meter in the interior of an elongated uniformly wound solenoid that is excited with a linear current density in its winding of one ampère per meter of axial distance. One ampère-turn per meter is 4 (symbol phi) X 10 –3 or 0.01257 oersteds (oe). One gauss (G) is 1 ten thousands of one Newton/ampère meter or one kA/m + 4 πOe. (See also annex B).

6.2 archiving control: Archiving control must ensure the extended-term integrity of the archived material beyond the life of any particular storage system, its content or essence. It requires effective indexing to allow fast and unambiguous retrieval of archived assets. This is often achieved by placing the data essence and metadata associated with the material in a database that is separate from the audio and video essence. The control system must manage the relationship between the user, the data essence, the metadata and the archived audio / video essence or content.

6.3 asset: An asset is any material (or the content thereof) of which the rights have been cleared. It then acquires value and can be exploited. An asset can be a complete program, or it can be a part of a program, individual sound, images, etc.

6.4 cassette: A device containing magnetic tape on one or two reels within a protective shell.

6.5 container, shipping: A box or case that is designed to protect a magnetic tape from shock, moisture, and debris during transportation.

6.6 container, storage: A box or case that is designed to protect a magnetic tape from shock, moisture, and debris during storage.

6.7 content: Program content can be video essence, audio essence, or data essence and supplemented by metadata. Examples of content are finished television programs or program segments, individual clips, open captions, and data in the form of software applications.

6.8 dew point: (a) The surface temperature at which moisture begins to condense on a surface. The more humid the air, the higher the dew point temperature. (b) The temperature corresponding to saturation for a given absolute humidity. See also *relative humidity.*

6.9 extended-term storage conditions: The storage conditions suitable for preservation of recorded information for a defined minimum number of years beyond ten years.

6.10 life expectancy (LE): The length of time that information is predicted to be retrievable in a system when stored at 21°C (70°F) 50% RH.

6.11 magnetic field strength: Symbol *H.* Magnetic field strength is that vector point function whose curl is the current density, and which is proportional to magnetic flux density in regions free of magnetized matter. It is expressed in ampère per meter (A/m) a mks rationalized unit of magnetizing force. *Ampère per meter* (*A/m),* is sometimes called *ampère-turn per meter or At/m,* and is the International System (SI) unit of magnetic field strength. mks (Giorgi) means "rationalized system of units" and is a subsystem of SI. One *gauss (G)* is 1 ten thousandths of one Newton/ampère.meter. (See also Annex B).

6.12 magnetic flux: Field lines building the magnetic field. Symbol: **Φ** (Phi) Unit in SI (mks): **Wb** (Weber). 1 Wb = 1 Vs. Unit in cgs: M (Maxwell). 1 Wb = 10^8 M. (See also annex B).

6.13 magnetic induction: Density of magnetic flux per area unit. Symbol: **B.** Unit in SI (mks): **Ts** (Tesla); 1 Ts = 1 Vs/m^2. Unit in cgs: G (Gauss). Ts = 10^4 G

6.14 magnetizing force: Symbol *H.* Magnetic field strength is that magnetic vector quantity at a point in a magnetic field which measures the ability of electric currents or magnetized bodies to produce magnetic induction at the given point. The magnetizing force *H* may be calculated from the current and the geometry of certain magnetizing circuits.

For example, in the center of a uniformly wound, long solenoid $H = C\frac{NI}{l}$

where:

H = magnetizing force:
C =constant whose value depends on the system of units;
N = number of turns,
I = current,
l is axial length of the coil, expressed in meters;

then C = 1 in order to obtain H in the MKSA units, ampère-turns per meter (At/m).

If it is expressed in ampères and l is expressed in centimeters, then $C = 4\pi / 10$ in order to obtain H in the cgs-em units, *oersteds*. The preferred expression of magnetizing force is A/m.

6.15 maximum life expectancy: The length of time that information is predicted to be retrievable in a system under extended-term storage conditions.

6.16 medium-term storage conditions: The storage conditions suitable for preservation of recorded information for a minimum of ten years.

6.17 oersted: A unit of magnetizing force (magnetic field strength) in the cgs electromagnetic system. One oersted equals an mmf of 1Gb/cm of flux path. One oersted equals 1 000/4 Φ or 79.58 A/m (At/m), or 1kA/m = 4πOe. (See also annex B).

6.18 open reel tapes: Tape that is wound on a hub that is not enclosed in a shell.

6.19 relative humidity (RH): The ratio, defined as a percentage, of the existing partial vapor pressure of water to the vapor pressure at saturation. (It is usually, but not always, equal to the percentage of the amount of moisture in the air to that at saturation).

6.20 short-term storage conditions: The storage conditions suitable for preservation of recorded information for less than two years.

6.21 storage: Storage requires reliable control of all parameters influencing the usable lifetime of individual storage media. The storage devices to be controlled range from disk servers to tapes kept in robotics tape library systems, as well as systems that use conventional videotape.

6.22 television magnetic recording tape: Magnetic recording tape used to record video and synchronizing signals. The tape may also record other signals such as audio, time code or metadata.

6.23 tape transport: A device designed to carry and guide magnetic recording tapes.

NOTE – The recommendations contained herein assume that all tape transports and recording tapes meet appropriate format specifications and that the transports are set up and are operating properly.

Annex A (informative)
Applicable media types and when introduced

A.1 Metal particle (MP) formula

Common name	Chemical composition	Year introduced	Coercivity range
MP (1)	Fe	1980	1200-1400
MP+, MP++ (2)	Fe	1988	1500-1800
Dual coat (3)	Fe	1992	2000+

NOTES

(1) Also known as first generation MP.

(2) Known as second generation MP.

(3) Composed of a thin (less than 0.5µm) main recording layer and a second, non-magnetic, or low coercivity magnetic support layer of substantial thickness.

A.2 Metal evaporated (ME) formula

Common name	Chemical composition	Year introduced	Coercivity range
ME (1)	Co (80%), Ni (20%)	1981	900-1100
ME, AME (2)	Co	1996	1300-1500
NCS ME (3)	Co	1999	1500+

NOTES

(1) For 8-mm analog video recording. Later used in first generation 8-mm data recorders and 4-mm DAT/DDS equipment.

(2) For DVC camcorders and data recording.

(3) A nano-scale crystalline seedbed (NCS) layer under the recording layer for very short wavelength applications.

A.3 Metal oxide materials

Common name	Chemical composition	Year introduced	Coercivity range
Magnetite	Fe3O4	1981/1990 (1)	250-750
Gamma ferric iron (2) Oxide	GammaFe2O3	1947	250-750
Cobalt gamma (3)	CoGammaFe203	1975	600-1000
Chromium oxide	CrO2	1975	200-600
Barium ferrite	BaO-Fe2O3	— (4)	500-1600

NOTES

(1) Magnetite was used in the first commercially produced magnetic tape. It was soon withdrawn because of excessive print-through and replaced by gamma Fe2O3. It was reintroduced in the 1990s with much improved characteristics as a lower cost replacement for cobalt gamma tape. The cost of cobalt had increased in the later 1980s.

(2) Also referred to as low Hc oxide.

(3) Also referred to as high Hc oxide.

(4) Barium ferrite media has never been in large-scale commercial production.

Annex B (informative)
Magnetic recorder/reproducer error sources

There are three major sources of noise in a recorder/reproducer system. They are (1) the medium, (2) the reproducer head, and (3) the signal electronics. Media noise accounts for 60-80% of the total system noise in current magnetic data recording systems.

B.1 Single bit errors are frequently of short duration (1,2, or 3 bits) errors. Their sources include electronic systems noise (media-, head - and amplifier noise) and self-healing micro head clogging. Such errors are generally correctable by the Error Detection And Correction (EDAC) first stage operation.

B.1.2 There are two types of burst errors, i.e. hard errors where data is not recorded or recorded incorrectly, and soft errors when an anomaly has occurred during playback. Such errors may last up to 10,000 consecutive bits and as often as several times per second. Their sources include media surface defects; head-to-media separation by dirt and dust particles, smoke residue, oil film, etc.; head gap clogging; head mistracking due to mechanical system misalignments or media deformation. Such errors are corrected by the EDAC capability designed to encounter errors encountered under normal operation.

B.2 Media end-of-life

Media degradation is an important end-of-life factor for media and its content and is indicated by the number of uncorrected errors in a group of tapes from a given manufacturer tested, after 8 or more tries out of 10 playbacks (80%). The end-of-life (EOL) is considered to be 80% of the elapsed time between the recording date (or date of receipt) and the date the group of tapes failed by the criteria indicated above.

Annex C (informative)

C.1 Supplemental information on tape failure, operating and storage conditions

Three environmental factors influence the physical stability of the base film. They are: (a) temperature, (b) relative humidity, (c) tape tension.

C.2 Failure mechanisms

Failure mechanisms that impact the lifecycle of magnetic tape recording systems vary with their various and constantly evolving enabling technologies. These mechanisms should be taken into account by developing and implementing timely content migration strategies for extended-term storage and use. Thus excessive restoration costs or worse, the loss of content integrity or even loss of signal will be avoided. Given the variety of failure mechanisms and the nature of the different legacy tape technologies, even when observing the conditions indicated, not all tape media can be considered immune from premature degradation. Error-rate or dropout benchmarking when the recording is new and monitoring it during use and storage against previously established maximum levels, enables content integrity and its timely transfer to be assured.

C.3 Binder material evolution

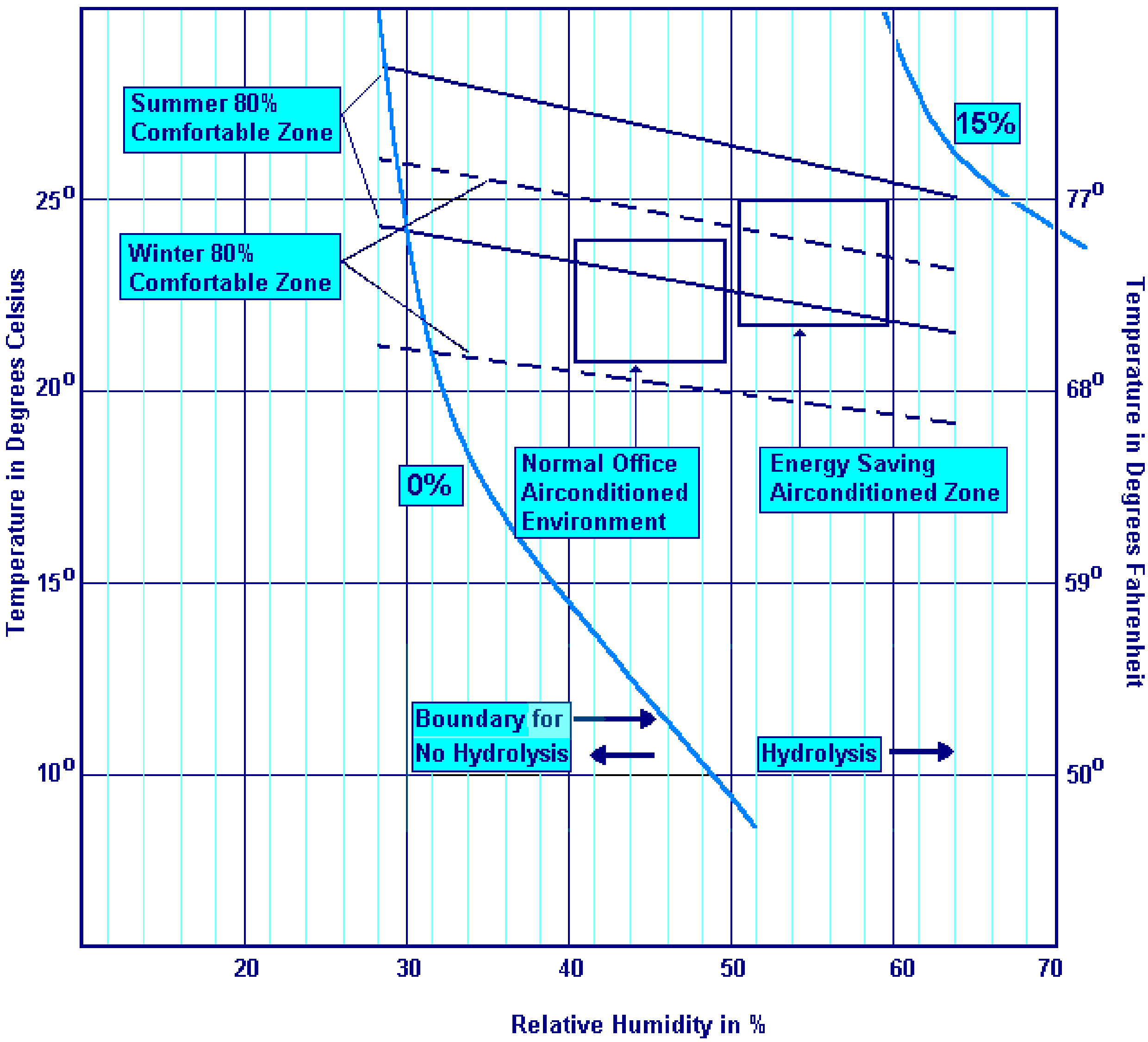
Physical degradation of the polyester-polyurethane binder material, such as was used for gamma ferric oxide coated magnetic recordings, is considered to be a weak link in legacy magnetic tape life expectancy. It was introduced through the early 1970s and was widely used for video, audio and data recording. Hydrolysis could induce binder breakdown and would sometimes cause playback to fail, when tape storage conditions had fallen outside the recommended temperature and relative humidity levels. Such tapes suffered excessive dropout levels and even separation of the coating from the base film in the form of powder and debris, while in most cases the magnetic coating maintained its integrity, unless acids as by-products of hydrolysis, had oxidized the magnetic particles and degraded their magnetic properties. The inferior polyester-polyurethane binder material was replaced by polyvinyl chloride-polyurethane during the late 1970s. Current magnetic media binder systems are composed of polyvinyl chloride derivatives and cross-linked polyurethane (PU). To prevent acid-catalyzed hydrolysis of the polyurethane, when it reacts with water vapor, epoxide is added to these binders. They are less likely to degrade through hydrolysis and their tensile strength is also greater under all conditions. Manufacturers which have done accelerated tests of this most recent binder material at 95% RH until the binder lost 50% of its original tensile strength, indicate a projected potential binder life expectancy of 200 years at 20 degrees C.

C.4 Protective coating for metal particle (MP) tape

First generation metal particle (MP) coating technology has evolved from a product that lacked adequate protection against metal oxidation and suffered corrosion from airborne pollutants that caused gradual degradation of its magnetization after being subjected to high temperatures and high humidity levels for a couple of years. Subsequent products made since the mid-1980s, feature encapsulation of the metal particles with a protective coating. Dual coat MP media has now become the mainstay of high-density tape recording.

C.5 Corrosion resistance for metal evaporated (ME) coatings

First generation metal evaporated (ME) featured a mixture of cobalt and nickel as the recording medium. The cobalt used was corrosion-prone, and nickel was used to slow it down. It also suffered occasional problems with the magnetic layer peeling off the base film when the tape was repeatedly moved around a small diameter pin or roller at high speed. Current ME coatings no longer use nickel to retard corrosion, but an extremely thin over-coating of carbon, often referred to as diamond-like-carbon (DLC) covered with a lubricant. Advanced multi-layered ME (AME) tape technology now available, contains a cobalt oxide thin film layer applied to the base film, followed by a normal thickness of cobalt deposition.



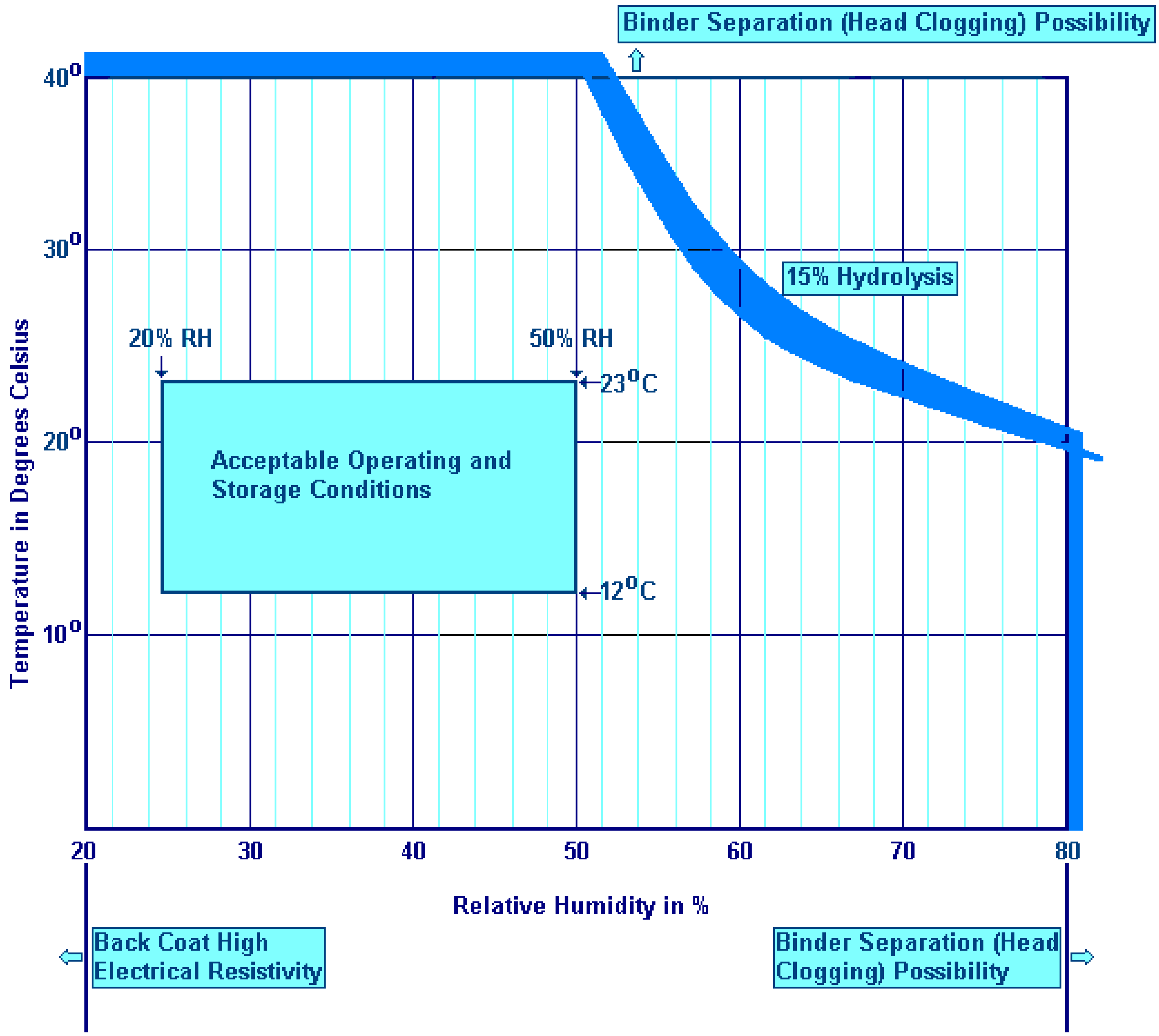
Low hydrolysis activity region for current tape technologies

C.6 Shrinkage and stretch of polyethylene terephthalate (PET) base film

Polyethylene terephthalate (PET) has a weakened physical strength at elevated temperatures and tends to shrink or stretch more than polyethylene naphthalate (PEN) base film. Magnetic property degradation has generally been absent in metal oxide coated materials.

C.7 Back coating hydrolysis

In general, the back coating does not impact media life expectancy. But PVC, which is the common binder material, produces a very small amount of chloric acid when hydrolysis occurs. As the back coat is in intimate contact with the next tape layer in a tightly packed reel, it is known to produce carbonic acid in reaction with chloric acid. This reaction occurs only rarely and under extreme conditions and should be of no concern.



Minimum allowable operating and storage conditions

C.8 Playback technology obsolescence

Recording and playback system obsolescence begins with the discontinuation of manufacturing support and sales for a system, usually when a superior product has been established in the marketplace. This event determines and limits the remaining time left for content dependent on the technology, to be migrated in order to be preserved.

Annex D (informative)
Periodical inspections

It is recommended to re-spool the tape at regular intervals at least once per year, and preferably twice per year. It should be run forward to the tape end and then rewound to the beginning. Spooling should occur at the normal record/playback speed, and on a well maintained and accurately aligned tape transport deck. Properly executed re-spooling is highly desirable and extends media life by releasing inner tape tension, as well as moisture accidentally trapped within the tape pack.

The level of quality (error rate) of each tape, especially of signals on the tape wound closest to the spool, should be benchmarked for later maintenance reference. When tape is archived in an automated digital asset storage system, scheduled re-spooling and error rate checking can be achieved automatically, during otherwise inactive hours. Otherwise, every videotape in an archive should be physically inspected at least every 3 to 5 years for characteristics such as tape playback performance, debris, contaminants, container gasket deterioration, or other problems. This can be carried out by inspection of one-third to one-fifth of the archive each year.

If the playback equipment is obsolete, or when this operation is to be done manually, or the volume of tape involved is prohibitive, this approach may not be practical. Therefore shorter tape lifecycles should be expected, with an associated greater migration frequency. To limit tape stresses, maintain tighter tolerances for storage temperatures and relative humidity fluctuation.

Records should be maintained of legacy and source recordings, containing proper date control-number information, location, title, first recording pass date, recording machine number, the manufacturer ID code, and other required information.

Annex E (informative)
Air pollution tests

E.1 Oddy sensitivity test

Certain gaseous impurities commonly found in the atmosphere should be filtered out of the extended-term storage environment in order to minimize the deterioration of the magnetic recording media and the paper labels and other documentation stored with the media.

To determine whether pollutants present might be damaging to the material being stored over extended-term periods of time, the Oddy test commonly used in museums, may be applied to establish whether any new or legacy magnetic recording material being evaluated is resistant to predominant pollutants in the air.

Clean samples of the tape(s) to be tested for the ability of their recording layer to resist environmental corrosion by certain volatiles are sealed using inert materials, in a conical volumetric class A flask with a capacity of 250 ml, that contains a source of humidity and the storage material to be tested. The flask should have ground glass necks and stoppers, which should not be greased, and poly-tetra-fluro-ethylene (PTFE) sleeves should be used to prevent sticking. The flask should be thoroughly cleaned and dried before use, and the test pieces should be handled with tweezers.

The samples are placed inside the flask with the air sample from the storage area or construction material being evaluated. The inclusion of water in the flask interior increases its relevance to real conditions. To prevent contact with the tape samples, use a small test tube containing moist cotton wool. The flask is then placed in a clean laboratory oven which is kept at a temperature of 60°C (140ºF) for one month. A 'blank' test must be run at the same time with air or construction material to be tested from the same environment or batch. The tape samples are then examined under magnification for signs of oxidation or corrosion compared to the blank control that has not been heated. This test is not meant to reproduce natural aging, but is intended to exaggerate and accelerate any reactions or problems that might occur in time. It is a fairly uncomplicated test that does not require laboratory instruments other than a laboratory oven and a few flasks, or large test tubes with ground glass stoppers and small test tubes for moist cotton wool.

If the test proves positive (showing signs of oxidation or corrosion) on any tape sample, repeat the test again. This time obtain an air sampling of the air inside the storage area, and another outside of it. These samples should at the same time be taken as when the air is introduced into the bottle, by an industrial hygienist or engineer. Have the air samples analyzed for common pollutants that are potentially corrosive, such as sulfur dioxide (SO2) nitrogen dioxide (NO2), ozone (O3), acetic acid (CH3COOH), and formaldehyde (HCHO), (hydrogen) peroxide , hydrogen sulfide (H2S), ammonia (NH3), paint fumes, acrylics, polyvinyl acetate [-CH2CH (OOCCH3)-], epoxies, synthetic rubber, etc.

Examine the second set of tape samples also under magnification for signs of oxidation or corrosion as compared to a blank control that has not been heated. If the tests prove to be double positive, submit the results along with a copy of the air analysis report to the tape manufacturer. Be aware that the symptoms of flaws occurring after the test, may be the result of the severe 60°C. testing environment. It can cause tape shrinkage and affect the tape surface. In fact, the test may also be useful as a predictor of tape binder robustness under adverse or prolonged storage of some legacy tape formulations.

(W.A. Oddy, "An unsuspected danger in display", Museums Journal, 1973, 73 (1): 27-28. Also: Carolyn Rose, Catharine Hawks, Hugh Genoways, editors, "Storage of Natural History Collections: A Preventive Conservation Approach." 1995, Society for the Preservation of Natural History Collections).

E.2 Reactivity monitoring coupon test

Another, non-destructive approach is the use of a Reactivity Monitoring Coupon Test. This test uses coupons of polished silver and copper that are placed on the wall of a tape vault for a defined exposure duration to normal prevailing environmental conditions. Reactivity Monitoring Coupons and services that analyze and report reactivity results after a prescribed exposure period are available commercially. The test is used to assure that the air in archives is tape-friendly. Reactivity Monitoring Coupons are used to evaluate existing conditions or to verify that the implemented air filtering control measures and systems are indeed effective.

Annex F (informative)
Definition of magnetic field strength needed to specify the magnetic field required to erase a magnetic recording

Definition of some magnetic properties:

Magnetic flux: Field lines building the magnetic field
Symbol: **Φ** (Phi)
Unit in SI (mks): **Wb** (Weber)
1 Wb = 1 Vs

Unit in cgs: M (Maxwell)
1 Wb = 10^8 M

Magnetic induction: Density of magnetic flux per area unit
Symbol: **B**
Unit in SI (mks): **Ts** (Tesla);
1 Ts = 1 Vs/m^2

Unit in cgs: G (Gauss)
1Ts = 10^4 G

Magnetic field strength: The magnetic field necessary to generate a certain magnetic induction at a certain environment.
Symbol: **H**
Unit in SI (mks): **A/m** (Amperes per meter). For practical reasons in magnetic tape technology the unit **kA/m** is mainly used for magnetic field strength.
The relation between the magnetic field strength and the induction is

H= B/μ[a)]
Unit in cgs: Oe (Oersted)
1kA/m = 4πOe

The magnetic field strength able to reduce the induction of a piece of material, formerly magnetised into saturation, to zero is called
coercivity, **coercive field strength** or **coercive force**.
Symbol: $\mathbf{H_C}$

[a)] Here it should be necessary to introduce the **magnetic permeability**
Symbol: **μ**
Unit in SI (mks): Vs/Am
The magnetic permeability consists of
μ_0 the magnetic permeability of the (ideal) vacuum (practiacally normal air) is
$\mathbf{\mu_0 = 4\pi 10^{-7}}$ **Vs/Am** and
$\mathbf{\mu_r}$ **a relative dimensionless factor** indicating by how much larger the magnetic permeability of a given material (environment) is in relation to $\mu_{0.}$ So
$\mathbf{\mu=\mu_0\ \mu_r}$

Annex G (informative)
Bibliography

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