STANDARDS AND INFORMATION DOCUMENTS

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AES recommended practice for audio preservation and restoration - Storage of polyester-based magnetic tape

AUDIO ENGINEERING SOCIETY, INC.
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AES recommended practice for audio preservation and restoration — Storage and handling — Storage of polyester-base magnetic tape

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Abstract

This standard provides recommendations concerning the storage conditions, storage facilities, enclosures, and inspection for recorded polyester-base magnetic tapes in roll form. It covers analog and digital tape and includes tape made for audio, video, instrumentation, and computer use.

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Foreword

[This foreword is not a part of *AES recommended practice for audio preservation and restoration — Storage and handling — Storage of polyester-base magnetic tape,* AES22-1997.]

This standard is concerned with the storage of magnetic tape on polyester base in roll form and covers analog and digital tape. It includes tape made for audio, video, instrumentation, and computer use.

This standard was prepared by a joint technical commission of the Audio Engineering Society Standards Committee SC-03 Subcommittee on Audio Preservation and Restoration and the American National Standards Committee Subcommittee IT9-5 on Stability of Electronic Imaging Materials. At the time of completion of the draft of this standard, the commission had the following members: Peter Z. Adelstein (IT9-5 Chairman), George Boston, Jim Burke, Alan Calmes, Tom Cavanagh, Delos A. Eilers, Jean-Marc Fontaine, Gerald Gibson (SC-03 Chair), John Gignac, Stephen P. Johnson, Takashi Kirakawa, Fredrick Kolb, Jr., Fred Layn, John Mattarazzo, Daniel Matukewicz, Charles W. Mayn, Bill Murray, David Peelle, Fernando Podio, Daniel Queen (AESSC Secretary), A. Tulsi Ram (IT9-5 Secretary), Dietrich Schuller, Ted Sheldon, Michael Stamp, Susan Stinson, William Storm (SC-03 Chair Emeritus), Carl Talkington, Ron Uhlig, John Van Bogart, Don Veri, Bob Waelbroeck, Johanna Wellheiser, James Wheeler, Jim Wong, and Joe Wrobel. The commission was co-chaired by Storm and Adelstein.

Gerald Gibson
Chair, AESSC SC-03 Subcommittee on Audio Preservation and Restoration
1995-09-20

AES recommended practice for audio preservation and restoration — Storage and handling — Storage of polyester-base magnetic tape

0 Introduction

Magnetic tape is an important medium in the capturing of information and has had widespread use in audio, video, and computer applications over the past 60 years. Preservation of this information is becoming of increasing concern to society, particularly as the recorded information becomes older and frequently of greater value to libraries, archives, museums, government agencies, and commercial organizations. Magnetic tape is also widely used by individual consumers to preserve records of personal or entertainment value.

The stability of magnetic tape is dependent upon that of the complete magnetic system. This includes stability of the tape itself, the equipment on which it is run, and, in some systems, the necessary software. It is recognized that tape records will eventually have to be copied or transferred to another material when the system that produced them becomes obsolete. Nevertheless, it is advantageous to prolong the tape life so it does not become the controlling factor. Although there have been many studies of tape stability, to date there does not exist a standard specification against which tape life can be evaluated. Likewise, standards are not available on the life expectancy of hardware and the problems associated with hardware wearing out or becoming obsolete. Therefore the best approach for tape users is to store magnetic tape under conditions that will extend its life and to handle tape so that it will not be subjected to stress and undergo physical breakdown during use. This standard addresses the concerns of storage.

A major component of magnetic tape is the plastic base. Early audio magnetic tape was manufactured on a variety of base materials, including paper and various esters of vinyl and cellulose. After extended storage, or storage under adverse conditions, some cellulose triacetate base decomposes and produces acetic acid (see annex A). However, in more recent years, since about 1960, magnetic material has been coated onto polyester base, which has excellent long-term stability.

The second component of magnetic tape is the oxide (or metal particle) and binder layer that determines the magnetic characteristics. A magnetic characteristic of importance in the aging behavior of tape is the development of print-through on analog tape. However, both research and use have clearly demonstrated that the critical concerns are primarily the change in physical properties, not the loss of magnetic characteristics. Upon use and upon aging, there may be changes in the friction properties, abrasivity, binder–base adhesion, and binder cohesion that render the tape inoperable. Many of these changes occur as a result of binder degradation. Unfortunately the user has no practical means to determine the stability of the composite tape and must rely on the studies of the manufacturer.

Regardless of the inherent stability of the binder layer, it is known that good storage conditions will extend the life of all tapes. While a good storage environment cannot reverse any degradation that has already occurred, it can slow down additional deterioration.

NOTE Some degraded tape can be rendered temporarily playable by a variety of specialized procedures.

Two storage conditions are described in this document. Medium-term storage conditions are recommended for tape with an expected useful life of ten years while extended-term storage conditions are intended for tape that contains recorded information of long-term value. The conditions given in this storage recommendation represent a compromise between maximizing the tape life, considerations of conve-nience, and the cost of building and of maintaining a storage facility.

1 Scope

1.1 This standard provides recommendations concerning the storage conditions, storage facilities, enclosures, and inspection for recorded polyester-base magnetic tapes in roll form. It covers analog and digital tape and includes tape made for audio, video, instrumentation, and computer use.

1.2 This standard applies to extended-term and medium-term storage of magnetic tape as defined in clause 3.

1.3 This standard applies to magnetic tape records intended as master tapes, which should not be in frequent use. This standard does not apply to "work" or "use" copies (see annex B).

1.4 Deviations from these recommendations, whether before or after a tape is recorded, may result in shortened LE.

NOTE Although outside the scope of this standard, adverse conditions during shipment, handling or usage will also result in decreased LE.

2 Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the indicated standards.

[Under consideration]

3 Definitions

For the purpose of this standard, the following definitions apply:

3.1
aperture
window
opening in the flange that is used to facilitate threading of the tape on the hub and inspection of the wind

3.2
base
support in a recording material on which the magnetic layer (and, if necessary, the backing layer) is coated

3.2.1
cellulose acetate base
base for recording materials composed mainly of cellulose esters of acetic acid, such as cellulose triacetate

3.2.2
polyester base
base for recording materials composed mainly of a polymer of ethylene glycol and terephthalic acid (also referred to as polyethylene terephthalate), or a polymer of ethylene glycol and 2,6-naphthalene dicarboxylic acid (also referred to as polyethylene naphthalate)

3.3
cartridge
housing for a roll of recording material, such as photographic film or magnetic tape, attached to a single hub or reel
[see also 3.4]

3.4
cassette
housing for a roll of recording material, such as photographic film or magnetic tape, the two ends of which are attached to two hubs or reels

3.5
container
box, can, or carton used for storage and shipping of recording materials

NOTE The box into which a reel, cassette, cartridge, or shell is placed is a container. Reels, cassettes, cartridges, and shells are not containers.

3.6
dew point
a) surface temperature at which moisture begins to condense on a surface
b) temperature corresponding to saturation for a given absolute humidity
[see also 3.22]

NOTE The more humid the air, the higher is the dew-point temperature.

3.7
extended-term storage conditions
storage conditions suitable for the preservation of recorded information having permanent value

3.8
fire-protective storage
facilities designed to protect records against excessive temperatures, water and other fire-fighting agents, steam developed by the insulation of safes or caused by the extinguishing of fires, and collapsing structures

3.9
flange
fixed or movable circular disk that is connected to the hub to make a reel
[see also 3.21]

NOTE The purpose of the flange is to protect the roll of recording material.

3.10
heads out
configuration of magnetic tape stored on its reel or in its cassette, such that the tape is positioned to play from the beginning of the recorded information

3.11
hub
cylindrical object at the center of a reel, around which the recording material is wound

3.12
leader
flexible plastic or paper strip that can be spliced to either end of a roll of recording material

3.13
leafing
multiple popped strands in a magnetic-tape wind
[see also 3.19 and 3.29]

3.14
life expectancy
LE
length of time that information is predicted to be retrievable in a system under extended-term storage conditions

3.15
loose pack
undesirable pack condition in a roll of recording material such that the outer portion of the roll can be moved and tightened by pulling on the end

3.16
magnetic field strength
measure of a magnetic field at a point in space

3.17
medium
media (plural)
material on which information is recorded

3.18
medium-term storage conditions
storage conditions suitable for the preservation of recorded information for a minimum of ten years

3.19
popped strand
lateral displacement of a single strand or wrap of magnetic tape extending beyond the plane of the tape pack
[see also 3.13 and 3.29]

3.20
print-through
unwanted transfer of a magnetic field and its signal from one tape lap to another within a roll of magnetic tape

3.21
reel
spool
hub or core with flanges (protective sides) onto which recording material is wound

3.22
relative humidity
RH
ratio, expressed as a percentage, of the vapor pressure of water vapor in moist air to the saturation vapor pressure with respect to water or ice at the same temperature

3.23
shell
cassette or cartridge housing for magnetic tape

3.24
slot
space or slit in the hub or reel surface

3.25
splice
union of two pieces of recording material to form a single piece

3.26
splicing tape
strip of plastic coated with a thermal or pressure-sensitive adhesive used in splicing

3.27
spoking
wind condition where there are deformations in a roll pack that appear radially outward and disrupt the circular nature of the wind

3.28
staging
process of conditioning material from one set of temperature–moisture conditions to another

3.29
stepped pack
multiple adjacent strands of magnetic tape extending beyond the level of a tape pack
[see also 3.13 and 3.29]

3.30
storage environment
conditions for storing materials, that is, temperature, RH, cleanliness of facilities, and atmosphere

3.31
storage housing
physical structure supporting materials and their enclosures

NOTE It can consist of drawers, racks, shelves, or cabinets.

3.32
system
material, hardware, software, and documentation necessary for recording or retrieving information, or both

3.33
tails out
configuration of magnetic tape stored on its reel or in its cassette, such that the tape must be fully rewound in order to correctly play from the beginning of the recorded information

3.34
tape pack
length of magnetic tape wound on a reel or hub

3.35
wind

a) physical appearance and tension of the magnetic tape pack
b) process of transferring a roll of recording material from one spool or reel to another

3.36
winding direction, coating inside
winding of tape on to the reel or spool with the magnetic coating facing the winding core

3.37
winding direction, coating outside
winding of tape on to the reel or spool with the tape-back coating or base facing the winding core

4 Environmental conditions

4.1 Humidity and temperature limits

4.1.1 Medium-term storage environment

4.1.1.1 The average RH of a medium-term storage environment shall not exceed 50 % and shall not be lower than 20 %. Ideally, the maximum temperature for extended periods should not exceed 25 °C (77 °F) (see Table 1). The peak temperature for short time periods shall not exceed 32 °C. Tape should not be stored below 8 °C (46 °F) because of a potential problem with lubricant separation from the binder.

Table 1 Maximum temperature and RH range for storage

Medium-term storage			Extended-term storage		
Maximum temperature		RH range (%) (see notes 1,2)	Maximum temperature (see note 3)		RH range (%) (see notes 1,4)
(°C)	(°F)		(°C)	(°F)	
23	73	20 – 50	20	68	20 – 30
			15	59	20 – 40
			10	50	20 – 50

NOTES
1 The moisture content of the tape to be stored shall not be greater than tape in moisture equilibrium with these relative humidities.
2 Cycling shall not exceed ± 10 % RH over a 24-h period.
3 Cycling shall not exceed ± 2 °C over a 24-h period.
4 Cycling shall not exceed ± 5 % RH over a 24-h period.
5 Storage of tape below 8 °C (46 °F) may cause lubrication separation from the tape binder. The manufacturer should be consulted to determine if separation can occur.

4.1.1.2 Cycling of temperature shall not be greater than ± 2 °C (± 4°F) over a 24-h period. Cycling of RH shall not be greater than ± 10 % over a 24-h period. Protection may be increased by storing tape at a low temperature and a low RH.

4.1.2 Extended-term storage environment

The rate of chemical reactions such as the degradation of the tape base and the polymer binder layer is lowered with decreasing temperature and decreasing RH. Consequently, LE is increased with the lowering of storage temperature or storage humidity, or both. Moreover, a lower storage temperature can compensate for a higher humidity to provide the same LE (see annex C), and a wider RH range can be tolerated. For this reason, several RH–temperature combinations can be used for an extended-term storage environment as specified in Table 1. The maximum temperature shall not exceed 25 °C (77 °F) and storage of tape below 8 °C (46 °F) is not recommended. When low-temperature storage is used, attention must be given during warm-up to avoid moisture condensation (see 7.1). Cycling of RH in the storage environment shall be no greater than ± 5 % and cycling of temperature shall not be greater than ± 2 °C (± 4 °F) over a 24-h period. It should be recognized that while tape reaches temperature equilibrium quickly, it takes a long time for tape in a shell to attain moisture equilibrium (see annex D).

For any facility, it is impossible to specify what the best RH and temperature of storage should be. It depends upon the value of the material, the past storage history, the length of time the tape is to be kept, the size of the vault, the cost of various options, and the climate conditions where the facility is located. Lower temperatures with the specified RH range may be difficult to achieve with normal-humidity air-conditioning equipment and may require a specialized installation.

Properly controlled air conditioning may be necessary for maintaining humidity and temperature within the limits specified. See annex D for references describing air-conditioning fundamentals. Automatic control systems are recommended, and they shall be checked frequently enough to determine that the temperature and

humidity limits specified in Table 1 are not being exceeded. A reliable hygrometer can be used for this purpose. Where air conditioning is not practical, high humidities may be lowered by electrical refrigeration-type dehumidifiers controlled with a hygrostat. Inert desiccants, such as chemically pure silica gel, may be used, provided the dehumidifier is equipped with filters capable of removing dust particles down to 0.3 μm in size and is controlled to maintain the RH prescribed in Table 1. Dehumidification may be required in storage areas such as basements and caves that have inherently low temperatures but frequently exceed the upper humidity limit.

The recommended humidity and temperature conditions can be maintained either within individual storage housings or within storage rooms containing such housings.

4.2 Gaseous impurities

Best available technologies shall be used to ensure minimization of gaseous impurities such as ammonia, chlorine, sulfides, peroxides, ozone, oxides of nitrogen, smoke, and acidic gases.

4.3 Magnetic fields

The peak strength of external d.c. magnetic fields shall not exceed 4 kA/m (50 Oe) and the peak strength of external a.c. magnetic fields shall not exceed 800 A/m (10 Oe). External magnetic fields are most frequently observed near motors and transformers (that is, commercial building elevator installations). Most of such installations are localized and the field strength falls off rapidly with separation. A separation of 1 m to 2 m from the source will usually provide sufficient protection. External fields of a more unanticipated nature may be produced by some headphones, loudspeakers, microphones, magnetic cabinet latches, and magnetized tools.

NOTE See 7.2 for a discussion of print-through.

5 Materials

The materials used for hubs, flanges, reels, cassettes, cartridges, containers, and storage housings shall be chemically stable and non-debris-producing and shall meet the requirements of clause 10. They shall be free from warpage and distortion. Metals shall be non-magnetic. Plastics are suitable for flanges, hubs, cassettes, and cartridges but they must be sufficiently strong so they do not distort or break under use conditions. Plastics are not recommended for open reels.

6 Enclosures

6.1 Reels

6.1.1 Reel hubs

Hubs, whether flanged or not, shall be cylindrical and composed of materials that are resistant to distortion. Hubs shall not contain slots or deformations on the surface in contact with the tape. Their form of construction shall not deform or damage the tape. Hubs shall be of as large a diameter as is practical, since larger diameter hubs yield better resistance to inner tape-pack distortions.

6.1.2 Flanges

Flanges with smaller apertures are recommended in preference to flanges with larger apertures. Flanges shall not be padded and shall be removable and replaceable.

6.2 Cassette and cartridge shells

Cassette and cartridge shells and their components shall be impact resistant. Their form of construction shall not damage the tape and shall allow disassembly and reassembly.

6.2.1 Cassette and cartridge hubs

Hubs shall be cylindrical and shall be of the largest possible diameter. Hubs shall be constructed in such a way as to minimize pack irregularity caused by the attachment of the tape or leader tape to the hub. Hubs shall lock in such a way that the tape pack is held in place without loosening when the cassette is not in the machine. Those shells that do not provide such locking devices must be stored in containers that provide locking mechanisms.

6.3 Containers

Containers shall be resistant to impact, moisture, and dust intrusion. Containers made of paper or cardboard are not recommended.

Containers shall be designed so that the flanges are not load bearing when the container is stored in its proper vertical position. Containers shall not be able to be deformed in the defined storage conditions. The container lid shall be capable of being latched, attached, or locked to prevent accidental opening.

6.4 Labeling

6.4.1 Reels, cassettes, cartridges, and containers shall provide a means for labeling which allows identification of the recorded information contained within. The labeling shall produce no acid, debris, or oxidants and shall be attached to or affixed in such a manner that it will remain for the LE of the medium. The number of labels shall be kept to a minimum to reduce the possibility of adhesive migration. Bulk information shall be on the container label. Labels must be small to avoid adhesive contamination of the tape and shall not overlap the tape.

6.4.2 The original manufacturer's product information shall be retained with the tape.

6.4.3 The magnetic tape or leader tape shall not be marked, labeled, embossed, or identified.

7 Preparation

All preparation of tape for storage shall be done in areas having a temperature of approximately 20 °C (68 °F) and a RH of (50 ± 10) %. All tapes shall be stored on reels, cartridges, or cassettes, and in appropriate containers.

7.1 Acclimatization

A tape pack shall be acclimatized for temperature to prevent moisture condensation when it is transferred from a cold environment outside a storage facility, or when being removed from an extended-term storage area to an access or production area. It shall be allowed to warm to a temperature above the dew point at medium-term storage conditions for equilibrium times such as those shown in annex D. Materials shall be kept in appropriate containers during acclimatization. Tapes shall not be rewound when they are cold.

> NOTE A tape pack may require moisture acclimatization to ensure that it will play properly. When tape is in equilibrium with a low-temperature or a low-humidity environment, it will have reduced dimensions and may not play properly. High-density helical-scan tape may be susceptible to mistracking problems because of inadequate moisture acclimatization. This susceptibility can be

corrected by allowing the tape to reach partial RH equilibrium (see annex D) or by rewinding the tape several times on a machine in the storage-condition environment.

7.2 Wind, pack

Prior to storage, tape should be played continuously end to end, or continuously wound at a tension that approximates the play tension, to ensure a smooth and even-tensioned pack. Both too loose and too tight a pack must be avoided. Too loose a pack can cause slippage or cinching of the tape on the hub and subsequent damage to the tape. Too tight a wind can cause stretching and deformation of the tape, especially if temperature and humidity variations are significant.

Tapes in cassettes or cartridges shall be wound so all the tape is on one hub. The tape pack shall have no leafing, stepped pack, spoking, or any other pack abnormality.

Tape rolls that are wound at one room temperature or RH, or both, and are then stored at a lower temperature or RH or both, may have a looser wind. Additional care in handling may be required to avoid slippage, popped strands, and other pack-related problems.

Print-through is a problem of analog audio recording tape. It occurs when a strongly recorded (magnetized) section of tape is embedded in a tape wind pack next to laps with low recorded magnetization. With time, the strong magnetic signals will imprint copies of themselves on the weakly magnetized adjacent laps. It can be significant to a user if the echo-like effect is audible enough to detract from the quality of the recording.

When recordings are stored heads out, the print-through information precedes the recorded information and is most disconcerting. When recordings are stored tails out, the print-through may become less obvious because an echo is less objectionable than a pre-echo. Storage of analog audio tape tails out has the additional advantage of requiring a rewind, which decreases the print-through level.

7.3 Splices

The optimum choice for tape storage is the absence of all splices. However, this condition is not possible for many tape formats. (For example, magnetic tapes in cassettes all have splices.) In such cases, splices produced by the manufacturer should be used.

When the tape contains non-manufacturer-produced splices, storage of a back-up copy is recommended. Otherwise all splices shall be examined and replaced whenever any indication of splice deterioration is evident. Only tape recommended for splicing shall be used. Any paper-based leader tape spliced in the tape pack shall be replaced with polyester-based leader or recording tape.

8 Storage housing

The material used for a storage housing shall conform to the requirements of clause 5.

Drawers, racks, and shelves shall be designed in such a way that reels or cassettes in their containers can be placed in their appropriate vertical positions and therefore be supported by their hubs. They shall be designed and utilized in such a manner that no container supports another container. Shelving shall be strong enough to support the shapes and weights of the containers without deformation of the containers or the shelving itself. Shelves should allow for adequate air flow so that the conditioned environment can be maintained throughout the storage area. To avoid catastrophic damage, shelves should not be placed too close to heat sources, water pipes, and sprinkler heads. The shelves should possess a lip to minimize dripping of melted plastic and burning plastic onto lower shelves in case of fire.

Magnetic tapes may have possible interactions with other recording materials that are showing signs of degradation. They shall not be stored in the same storage housing as vinyl records or cellulose acetate tapes that have any indications of deterioration.

9 Storage rooms

Storage rooms shall be designed to be able to bear the load of the fully loaded shelving. They shall be clean areas, satisfying at least clean room requirements such as ANSI class 100,000 (see annex F for ANSI/NFPA 90A-1993) and be under constant environmental control per clause 4. Air pressure in the storage area shall be maintained at a positive pressure relative to adjacent hallways and rooms. Dust and debris-generating devices or materials shall not be allowed in the storage room (for example, carpet, draperies, unsealed insulation, fibrous wall coverings, furnishings, and so on). Storage rooms shall not be used for activities other than storage (see annex F for NFPA 75-1989).

In order to minimize ultraviolet (UV) damage to labeling and packaging materials, rooms shall not be lighted other than when being actively accessed. Walls and enclosures of environmentally controlled spaces shall be designed to prevent condensation of moisture on interior surfaces. Provisions shall be made to prevent damage from water, that is, floods, leaks, sprinklers, and so on. Floors shall be provided with drains or other means of water removal. Storage rooms should be located above basement levels and above any expected flood levels where possible.

Storage rooms should be cleaned periodically. A goal shall be removal of dust without blowing fine particles around the space and removal of dirt without the use of acids or oxidants. Dust removal shall be done by a vacuum system that has an exhaust pipe that carries the dust completely out of the storage room. Non-chemically-treated, clean, and static-free wipes shall be used to remove dirt and dust from shelves and from the outside surfaces of containers. Chemical cleaning solutions shall not be used to clean floors or any other surfaces within the storage facility. This restriction includes all common household cleaners. A minimum amount of water shall be used with a clean mop to clean floors. All traces of water must be removed immediately by a clean dry mop.

10 Fire protection storage

During heating for 4 h at 150 °C (302 °F) in the package that is to be stored, enclosure materials for fire-resistant storage shall not ignite or release more reactive fumes than the tape itself does. The materials used in hubs, flanges, reels, cassettes, or cartridges shall be neither more flammable nor more decomposable than the tape itself.

For protection against fire and associated hazards, the tape package shall be placed in either fire-resistive vaults or insulated record containers. If fire-resistive vaults are used, they shall be constructed in accordance with recommendations contained in appropriate standards and regulations (such as ANSI/NFPA 232-1991; see annex F) with particular care for protection from steam. Masonry or concrete walls may release steam from internally bonded water when heated in a fire. A vapor barrier is recommended for such vaults, or else sealed containers should be used.

When the quantity of tape is not too great, insulated record containers conforming to appropriate national or international standards and regulations may be used (such as the class 150 record containers described in ANSI/UL72-1990; see annex F). They shall not exceed an interior temperature of 65 °C (149 °F) and an interior RH of 85 % when given a fire exposure test from 1 h to 4 h, depending on the classification of the record container.

For the best protection from fires of the information, duplicate copies of tape records shall be placed in other storage areas.

11 Identification, inspection, and cleaning

11.1 Identification

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

11.2 Inspection

Representative samples of tape shall be inspected at five-year intervals. If deviations from recommended temperature and RH ranges have occurred, inspection shall be made at more frequent intervals. A sampling plan established in advance shall be used, and a different lot shall be inspected each time. Deterioration of either tape or enclosures shall be noted. Tape shall be examined for playback performance, spoking, loose wind, stepped pack, physical distortion, debris, and container and label deterioration. Tape shall only be handled or touched using gloves. Dye-free gloves that do not shed, most commonly found as thin, clean, clean-room-specified fabric gloves, shall be used.

If tape has been stored at a temperature below the dew point of the atmosphere where inspection is to take place, the tape in its enclosure shall first be allowed to warm up, before opening, to a temperature within a few degrees of that of the inspection room. The time required for warm-up increases with the volume of the material and the temperature difference.

11.3 Cleaning

If during inspection there is any evidence of dirt or debris on tape or in the container or shell, appropriate cleaning shall be done prior to putting it back into storage. Tissue-wipe cleaning is recommended. Solvent cleaning shall not be used. Scraping and burnishing shall only be done under carefully controlled conditions.

Annex A

(informative)

Stability of cellulose triacetate base

Cellulose triacetate has been used as a base for photographic film from 1935 to 1985 and was also used for magnetic tape for a much more limited time period from about 1950 through 1965. While it has been a very satisfactory base, it does degrade with time. This degradation increases at higher humidity and at elevated temperature. It is initially characterized by the release of acetic acid, with subsequent embrittlement, distortion, plasticizer exudation, and shrinkage. This characteristic problem is known as the vinegar syndrome. It has been observed after storage at moderate temperature and humidity conditions with both photographic film and magnetic tape. Guidelines for the proper storage of this base are given in annex E, reference 1. In general, a lower storage temperature and RH combination is recommended to increase the time to onset of the vinegar syndrome. Tapes having the vinegar syndrome should be stored separately to prevent the contamination of other archive materials by acetic acid. After the onset of the vinegar syndrome, acetate films degrade at an accelerated rate. Tapes that have been stable for fifty years may degrade to the point of being unplayable in just a few years. Any valuable tape showing vinegar syndrome should be transcribed as soon as possible. The environmental recommendations given in this standard should ensure a LE of 100 years for cellulose triacetate base, which is longer than the expected life of the tape binder (see annex E, reference 2). The LE of polyester base used in today's materials is many times greater than that of cellulose triacetate. Polyester base should last at least 500 years if stored under reasonable conditions, which is considerably longer than the life of the binder.

Annex B
(informative)

Distinction between master tapes and work copies

The distinction between tape records that are intended for storage and those intended for use has not always been clear. Use or work copies are the predominant records found in libraries or record centers. Their value lies in their being available for ready reference. However, as a result of this use, they are subjected to dirt, abrasion, fingerprints, contamination with foreign materials, and exposure to excessive temperature. Such use copies may become moisture conditioned to the conditions of the working area, which may be quite different from the storage area where they are filed in the library. Use copies of magnetic tape are not suitable for long-term preservation.

Where there is a need for extended storage of tape records, master copies should be prepared, and they should be stored according to the recommendations of this standard. Master copies of records may occasionally be used to make copies. However, their use should be infrequent.

Annex C
(informative)

Relationship between temperature and RH

Degradation of magnetic tape is caused by chemical reactions, whose rates are lowered with decreasing temperature and decreasing RH (see annex E, references 3, 4, 5, 6, and 7). Consequently, the useful life of tape can be increased by lowering the storage temperature or storage humidity, or both. Moreover, a lower storage temperature can compensate for a higher humidity to obtain the same LE. This compensation is illustrated in Figure C.1 for the degradation of the polyurethane tape binder (see annex E, reference 7). Similar behavior exists for the degradation of polyester base and the oxidation of metal particulate tape (see annex E, reference 8). These relationships permit several temperature–RH combinations to be acceptable for extended-term storage conditions as specified in Table 1, giving the storage-vault designer a range of options.

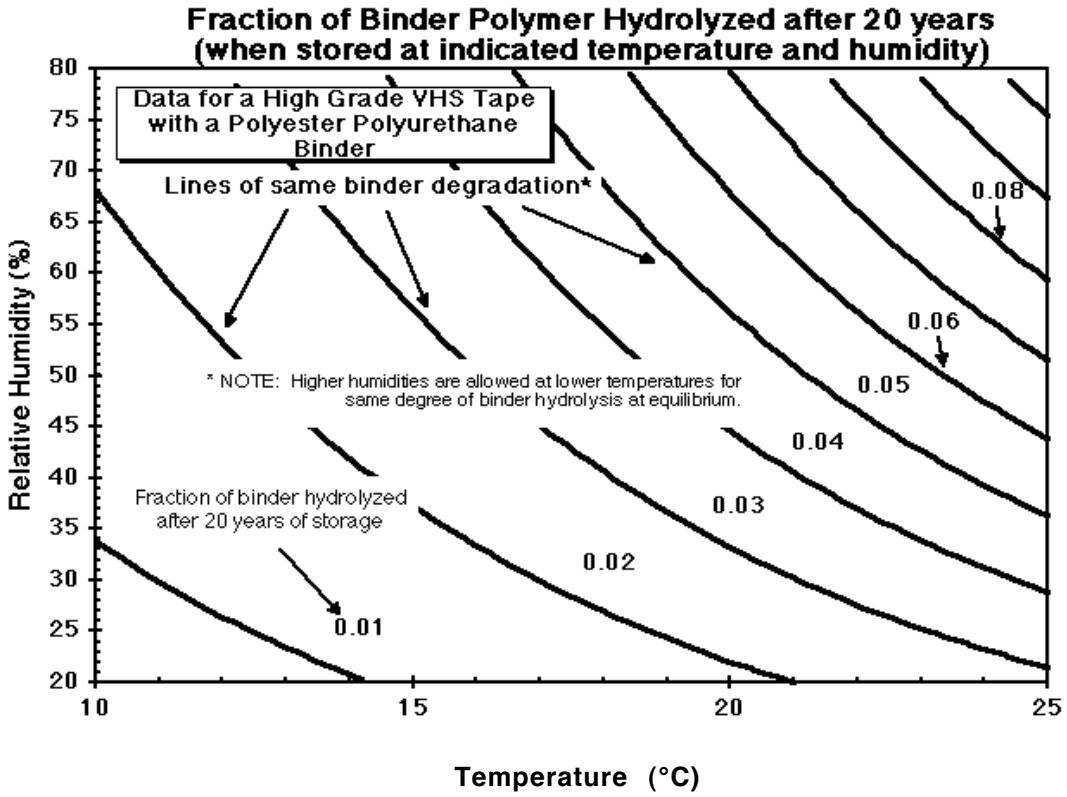

Figure C.1 — Temperature–RH relationship for hydrolysis of magnetic tape binder

Annex D

(informative)

Temperature and humidity acclimatization

Tapes that are removed from extended-term storage conditions may not be immediately ready for playback. Acclimatization to the environment of the recording and playback facility may be necessary to ensure that the tapes play without distortion, mistracking, or excessive errors. In general, acclimatization is more important for helical-scan formats, digital recordings, and recordings with a narrow track width. It is less important for longitudinal formats and analog recordings.

Dimensional changes will occur in a wound tape pack as a result of changes in both temperature and humidity. The total length of the wound tape will become smaller with both decreasing temperature and decreasing humidity. This length change can result in a change in pitch or frequency of the recording if played prior to acclimatization. A temporary change in the track angle of a helical-scan recording can also occur after low-temperature or low-humidity storage, or both. This change can result in mistracking if played prior to acclimatization.

Table D.1 shows the amount of time that may be required for various tape types to acclimatize to a new environment. Magnetic tape reels and cassettes approach thermal equilibrium more rapidly than they approach hygroscopic equilibrium. The times were calculated using models for heat and moisture diffusion in tape packs (see annex E, reference 9). Storage conditions were assumed to be 15 °C and 30 % RH below playback conditions.

Table D.1 — Approximate acclimatization times of magnetic tape

Tape width, mm (in)	Temperature acclimatization[1] time, h	Relative humidity acclimatization[2] time, d
6.35 (1/4)	0.5	1
12.70 (1/2)	0.5	4
19 (3/4)	1	8
25.4 (1)	1	14
50.8 (2)	4	50

NOTES
1 To warm the tape to within 5 °C.
2 To humidify the tape to within 10 % RH.

As a minimum, tapes should be allowed to thermally equilibrate to the new environment prior to tape playback. It may not be necessary to wait the full amount of time indicated for humidity acclimatization if the tapes play back properly. If an excessive data error rate or mistracking is noted on playback, more time for humidity acclimatization may be necessary.

The rate at which a spooled tape approaches thermal and moisture equilibrium is roughly proportional to the square of the thickness of the tape pack (see annex E, reference 9). This proportionality results from the fact that heat and moisture principally diffuse into the pack from the edges of the tape. A reel of 19-mm (3/4-in) width tape (for example, a U-Matic cassette) will require more than twice the time to equilibrate to a new environment than a reel of 12.70-mm (1/2-in) wide tape (for example, a VHS cassette). An enclosing tape cassette offers only minor resistance to moisture intrusion, so the rates of moisture acclimatization of a bare tape reel and a tape cassette are similar (see annex E, reference 9).

The acclimatization process can be accelerated by exposing more of the tape surface to the environment. One of the easiest ways to achieve this exposure is to fast forward and then rewind the tape on a recorder. A few passes may be required. An exposed strip of tape will thermally equilibrate in a matter of seconds and reach equilibrium moisture content in a matter of minutes.

If the tape cassette is in a storage case during acclimatization, a longer period of time is required for the tape to reach thermal equilibrium. The amount of time required will depend upon the insulating properties and thickness of the storage case. As a rule of thumb, allow twice the time indicated in Table D.1 for thermal equilibrium if the tape is housed in a storage case.

The time required for moisture equilibration of a tape reel or cassette housed in a storage case or box will depend on the airtightness and moisture permeability of the storage case. Paper does not offer much resistance to moisture permeation, so a tape reel or cassette stored in a cardboard or paperboard box will equilibrate to the moisture content of the new environment almost as quickly as a bare reel or tape cassette. Most of the resistance to moisture change in a tape is within the tape pack itself. On the other hand, a tape enclosed in an airtight steel container, such as is used for motion-picture film, will require a significantly longer time to equilibrate to the new environment. If the storage container is air-tight, it is best to leave the lid on the storage case slightly ajar to readily allow the exchange of moisture between the tape pack or cassette and the ambient environment.

Annex E
(informative)

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Annex F

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