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ANSI/NAPM IT9.23-1996

American National Standard

for Imaging Materials –

Polyester Base Magnetic Tape – Storage

ANSI American National Standards Institute
11 West 42nd Street
New York, New York
10036

ANSI/NAPM IT9.23-1996

American National Standard
for Imaging Materials –

Polyester Base Magnetic Tape – Storage

Secretariat

National Association of Photographic Manufacturers, Inc.

Approved September 6, 1996

American National Standards Institute, Inc.

American National Standard

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Contents

Foreword (This Foreword is not part of American National Standard ANSI/NAPM IT9.23-1996.)

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 contains five informative annexes, which are not considered part of this standard.

Suggestions for the improvement of this standard will be welcome. They should be sent to the National Association of Photographic Manufacturers, Inc., 550 Mamaroneck Avenue, Suite 307, Harrison, NY 10528-1612.

This standard was processed and submitted to ANSI by NAPM Technical Committee IT9 on the Physical Properties and Permanence of Imaging Materials. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the IT9 Committee had the following members:

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Introduction

Magnetic tape is an important material 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 retrievability of the information on 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 upon the necessary software. It is recognized that tape records will eventually have to be copied or transferred to another material when the system 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 an American National 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, various vinyl esters, and cellulose esters. After extended storage or storage under adverse conditions, the cellulose triacetate base decomposes and produces acetic acid (see annex A). However, since the 1960s, magnetic tape has been coated onto polyester base, which has excellent long-term stability.

The second component of magnetic tape is the oxide (or metal particle) -binder layer that determines the magnetic characteristics. A magnetic characteristic of importance in the aging behavior of tape is the development of print-through of analog tape. However, both research and use have clearly demonstrated that the critical concerns are primarily changes in physical properties, not the loss of magnetic characteristics. Upon use and aging, there may be changes in the friction properties, abrasivity, binder-base adhesion, and binder cohesion that render the tape unusable. Many of these changes occur as a result of binder degradation. Unfortunately, the user has no practical means of determining 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,[1)] it can slow down additional deterioration. 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 convenience, and the cost of building and maintaining a storage facility.

[1)] Some degraded tape can be rendered temporarily playable by a variety of specialized procedures.

American National Standard
for Imaging Materials –

Polyester Base Magnetic Tape – Storage

1 Scope

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.

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

Deviations from these recommendations, whether before or after its recording, may result in shortened life expectancy.[2)]

2 Normative references

The following references contain provisions which constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards and publications are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards and publication listed below.

ANSI/NAPM TR1-1995, *Image materials – Humidity measurements*[3)]

ANSI/NFPA 75-1995, *Electronic computer/data processing equipment*

ANSI/NFPA 90A-1996, *Installation of air conditioning and ventilating systems*

ANSI/NFPA 232-1995, *Protection of records*

ANSI/UL 72-1990, *Standard for safety for tests for fire resistance of record protection equipment*

ASHRAE, *Equipment.*1988 [4)]

ASHRAE, *Handbook of fundamentals.*1988[4)]

ASHRAE, *Systems.*1987[4)]

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2) For example, adverse conditions during shipment, handling, or usage.

3) This is a technical report and not an American National Standard.

4) Available from the American Society of Heating, Refrigeration and Air Conditioning Engineers, 1791 Tullie Circle, NE, Atlanta, GA 30329.

3 Definitions

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

3.1 aperture: The opening in the flange that is used to facilitate threading of magnetic tape on the hub and inspection of the wind (also referred to as *window*).

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

3.2.1 cellulose acetate base: A base for recording materials composed mainly of cellulose-esters of acetic acid.

3.2.2 polyester base: A 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: A housing for a roll of recording material, such as photographic film or magnetic tape, attached to a single hub or reel. See also *cassette*.

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

3.5 container: A box, can, or carton used for storage and shipping of recording materials. (The box into which a reel, cassette, cartridge, or shell is placed is a container. Reels, cassettes, cartridges, or shells are not containers.)

3.6 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*.

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, and steam developed by insulation of safes or caused by the extinguishing of fires and collapsing structures.

3.9 flange: A fixed or removable circular disc that is connected to the hub to make a reel. The purpose of the flange is to protect the roll of recording material. See also *reel*.

3.10 heads out: The 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: The cylindrical object at the center of a reel, around which the recording material is wound.

3.12 leader: A 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 *popped strand* and *stepped pack*.

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

3.15 loose pack: An 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 intensity: The level of magnetic field at a point in space.

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

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 *stepped pack* and *leafing.*

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

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

3.22 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.)

3.23 shell: The cassette/cartridge housing for magnetic tape.

3.24 slot: A space or slit in the hub or reel surface.

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

3.26 splicing tape: A paper or plastic strip coated with a thermal or pressure sensitive adhesive, used in splicing.

3.27 spoking: Deformations in a roll pack that appear radially outward and disrupt the circular nature of the wind.

3.28 staging: The 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 *leafing* and *popped strand.*

3.30 storage environment: The conditions for storing materials, i.e., temperature, relative humidity, cleanliness of facilities, and atmospheric pollutants.

3.31 storage housing: A physical structure supporting materials and their enclosures. It may consist of drawers, racks, shelves, or cabinets.

3.32 system: The material, hardware, software, and documentation necessary for recording and/or retrieving information.

3.33 tape pack: A length of magnetic tape wound on a reel or hub.

3.34 tails out: The 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.

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

4 Environmental conditions

4.1 Humidity and temperature limits

4.1.1 Medium-term storage environment

The average relative humidity of a medium-term storage environment shall not exceed 50% RH and shall not be lower than 20% RH. The maximum temperature for extended periods shall not exceed 25°C (77°F) (see table 1). The peak temperature for short time periods shall not exceed 32°C (90°F). Tape should not be stored below 8°C (46°F) due to a potential problem with lubricant separation from the binder.

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

4.1.2 Extended-term storage environment

The rate of chemical reactions, such as the degradation of tape base and the polymer binder layer, is lowered with decreasing temperature and decreasing relative humidity. Consequently, life expectancy is increased as storage temperature and/or storage humidity is lowered within the range of recommended storage. A lower storage temperature can compensate for a higher humidity to provide the same life expectancy (see annex C) and a wider relative humidity range can be tolerated. For this reason, several relative humidity-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 relative humidity 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-hour period. It should be recognized that while tape reaches temperature equilibrium quickly, it takes a long time for a tape pack to attain moisture equilibration (see annex D).

For any facility, it is impossible to specify what the best relative humidity and temperature of storage should be, since 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 relative humidity 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. The fundamentals of air conditioning are given in the three ASHRAE publications listed in clause 2. 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 humidity measurements (see ANSI/NAPM TR1).

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 relative humidity 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.

Table 1 – Maximum temperature and relative humidity range for storage

Medium-term storage			Extended-term storage		
Maximum temperature (see notes 3 and 5)		**Relative humidity range** (%) (see notes 1 and 2)	**Maximum temperature** (see notes 3 and 5)		**Relative humidity range** (%) (see notes 1 and 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-hour period.

3 Cycling shall not exceed ±2°C (±4°F) over a 24-hour period.

4 Cycling shall not exceed ±5% RH over a 24-hour period.

5 Storage of tape below 8°C (46°F) may cause lubricant separation from the tape binder. The manufacturer should be consulted to determine if this is a potential problem.

4.2 Gaseous impurities

Best practical 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

Within a storage area, the peak intensity of external DC fields shall not exceed 50 Oersteds (4 kA/meter) and the peak intensity of external AC fields shall not exceed 10 Oersteds (800 A/meter). External magnetic fields are most frequently observed near motors and transformers (i.e., commercial building elevator installations). Most of such installations are localized and the field intensity falls off rapidly with separation. A few feet separation from the source will usually provide sufficient protection. External fields of a more unanticipated nature are produced by some headphones, speakers, microphones, magnetic cabinet latches, or magnetized tools.

See 7.2 for a discussion of print-through.

5 Materials

The materials used for hubs, flanges, reels, cassettes, cartridges, containers, and storage housing 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 nonmagnetic. 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 Hubs

Hubs shall be cylindrical and composed of materials that are resistant to distortion. Hubs without slots, irregularities, or deformations on the surface in contact with the tape are preferred. They shall be of such a construction so as to minimize deformation or damage of 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. It is recommended that flanges shall be removable and replaceable.

6.2 Cassettes and cartridges

6.2.1 Cassette and cartridge shells

Cassette and cartridge shells and their components shall be impact resistant. They shall be of such construction so as not to damage the tape and shall be able to be disassembled and reassembled.

6.2.2 Hubs

Hubs shall be cylindrical and shall be of the largest possible diameter. Hubs shall be constructed to minimize pack irregularity caused by the attachment of the tape/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 shall 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 containers are stored in their 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

Reels, cassettes, cartridges, and containers shall provide a means for labeling that allows identification of the recorded information contained within. The labeling shall be non-acid, non-debris, and non-oxidant producing and shall be attached to or affixed in such a manner that it will remain for the life expectancy of the media. The number and size of labels shall be kept to a minimum to reduce the possibility of adhesive migration. Bulk information shall be on the container label. Labels shall be small enough to avoid adhesive contamination of the tape and shall not overlap the tape.

The original manufacturer's product identification shall be maintained with the tape. The magnetic tape or leader tape shall not be marked, labeled, embossed, or identified.

6.5 Supplementary materials

Supplementary inserts shall not be stored in the tape container.

7 Preparation

All preparation of tape for storage shall be done in areas having an environment of approximately 20°C and 50 ±10% RH. 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 the storage facility, or when being removed from an extended-term storage area, to an access or production area. These materials shall be allowed to warm up to a temperature above the dew point at medium-term storage conditions for the equilibrium times given in annex D. Tape packs shall be kept in appropriate containers during acclimatization. Tapes shall not be rewound when they are cold.

A tape pack may require moisture acclimatization to ensure that it will play properly. When tape is in equilibrium with a low-temperature or low-humidity environment, it will have reduced dimensions and may not play properly. High-density helical scan tape may be susceptible to mistracking problems due to inadequate moisture acclimatization. This can be corrected by allowing the tape to reach partial humidity equilibrium (see annex D) or by rewinding the tape several times on a machine.

7.2 Wind, pack

Prior to storage, the 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 a too loose and a too tight pack shall be avoided. A pack that is too loose can cause slippage or cinching of the tape on the hub and subsequent damage to the tape. A wind that is too tight can cause stretching and deformation of the tape, especially if the temperature and humidity variations are significant. Tapes in cassettes or cartridges shall be wound so that all the tape is on one hub. Tape pack shall not have leafing, stepped pack, spoking, or any other pack abnormality.

Tape rolls that are wound at room temperature and/or humidity, then stored at a lower temperature and/or humidity can 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 phenomenon 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 levels. With time, the strong magnetic signals will "print" copies of themselves on the weakly magnetized adjacent laps. It can be significant to the user if the "echo 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 since 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 is not possible for many tape formats (e.g., magnetic tape in cassettes all have splices). In such cases, the use of manufacturer-produced splices is recommended.

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 splicing tape 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 storage housing shall conform to the requirements of clause 5. Drawers, racks, and shelves shall be designed in such a way that reels and/or cassettes in their containers can be placed in their appropriate vertical position, supported by the hub. They shall be designed and utilized in such a manner that no container supports another container. Shelving shall be strong enough to support the shape and weight of the containers without deformation of the container 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 and burning plastic onto lower shelves in case of fire.

Magnetic tape 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 phonographic records or cellulose acetate tapes (see annex A) 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 class 100,000 clean room requirements (see ANSI/NFPA 90A) and be under constant environmental control in accordance with the specifications of clause 4. Air pressure in the storage area shall be maintained at a positive pressure relative to adjacent hallways and rooms. Dust- and/or debris-generating devices or materials shall not be allowed in the storage room (e.g., carpet, draperies, unsealed insulation, fibrous wall coverings, and furnishings etc.). Storage rooms shall not be used for activities other than storage (see ANSI/NFPA 75).

In order to minimize UV damage to labeling and packaging materials, rooms shall not be lit 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, i.e., floods, leaks, sprinklers, etc.. 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 periodically cleaned. A goal shall be removal of dust without blowing fine particles around 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 includes all common household cleaners. A minimum amount of water shall be used with a clean mop to clean floors. All traces of water shall be removed immediately by a clean dry-mop.

10 Fire protection storage

During heating for 4 hours at 150°C (300°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 (see ANSI/NFPA 232) 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 standards and regulations may be used (such as class 150 record containers as described in ANSI/UL 72). They shall not exceed an interior temperature of 65°C (150°F) and an interior relative humidity of 85% when given a fire exposure test from 1 to 4 hours depending on the classification of the record container.

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

11 Identification, inspection, and cleaning

11.1 Identification

Documentation such as dates, manufacturer's identification, control-number information, location, and title shall be maintained.

11.2 Inspection

Representative samples of tape shall be inspected at 5-year intervals. If deviations from recommended temperature and relative humidity 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. Dyeless gloves that do not shed (most commonly found as clean, thin, 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

During inspection, if there is any evidence of dirt or debris on the 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 for over 45 years and was also used for magnetic tape for a much more limited time period in the 1950's and 1960's. While it has been a very satisfactory base, it degrades with time. This degradation increases at higher temperatures and at elevated humidities. It is initially characterized by the release of acetic acid, with subsequent embrittlement, distortion, plasticizer exudation, and shrinkage. This is the characteristic problem 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 a recent publication [1].[5)] In general, lower storage temperatures and relative humidities are 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 life expectancy of 100 years for cellulose-triacetate base, which is longer than the expected life of the tape binder [2]. The life expectancy of polyester base used in today's materials is many times greater than 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.

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5) References are given in annex E.

Annex B
(informative)

Distinction between master tapes and work copies

The distinction between tapes intended for storage and those intended for use has not always been clear. The value of use or work copies 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, master tapes should be prepared and stored according to the recommendations of this standard. They may occasionally be used to make copies. However, their use should be infrequent.

Annex C
(informative)

Temperature–relative humidity relationship

Degradation of magnetic tape is caused by chemical reactions, whose rates are lowered with decreasing temperature and decreasing relative humidity [3–7]. Consequently, the useful life of tape can be increased by lowering the storage temperature and/or storage humidity. Moreover, a lower storage temperature can compensate for a higher humidity to obtain the same life expectancy. This is illustrated in figure C.1 for the degradation of the polyurethane tape binder [7]. Similar behavior exists for the degradation of polyester base and the oxidation of metal particulate tape [8]. These relationships permit several temperature-relative humidity combinations to be acceptable for extended-term storage conditions as specified in table 1 (see 4.1.2). This gives the storage vault designer a range of options.

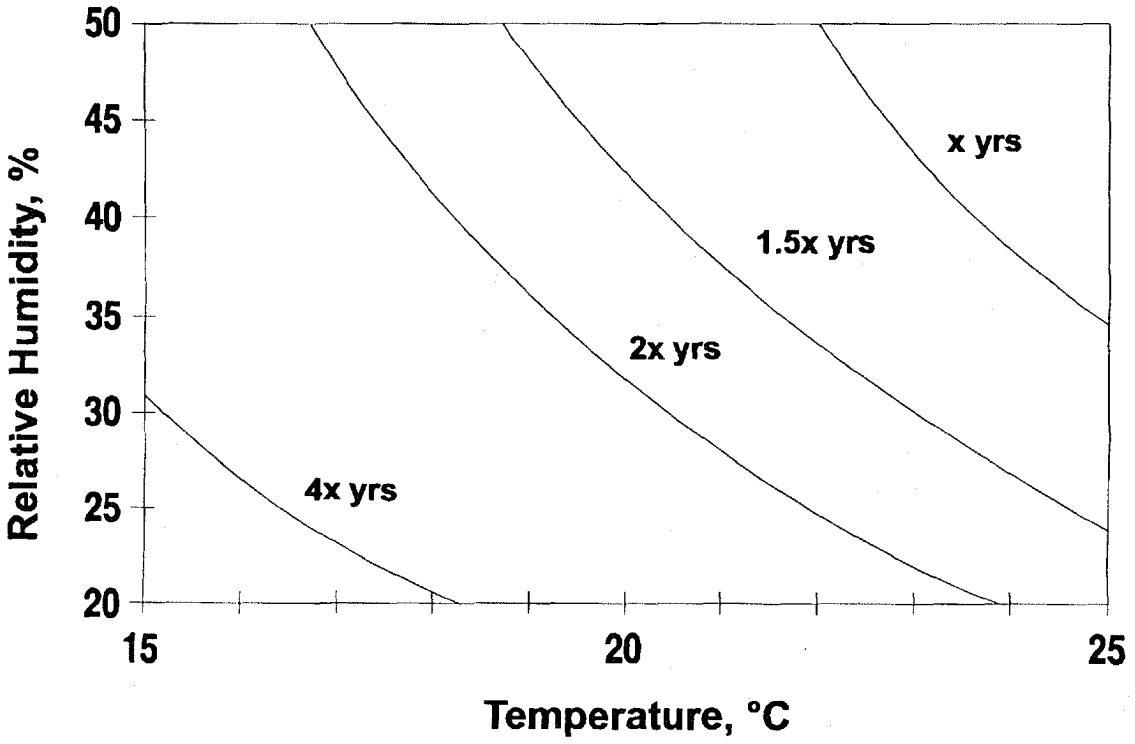

Figure C.1 – Temperature-relative humidity relationship for hydrolysis of magnetic tape binder

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/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 either temperature and humidity. The total length of the wound tape will become slightly smaller with either decreasing temperature or humidity. This can result in a minor change in pitch or frequency of an audio recording if played prior to acclimatization. A temporary change in the track angle of a helical scan recording can also occur after low temperature/low humidity storage. This 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 hygroscopic equilibrium. The times were calculated using models for heat and moisture diffusion in tape packs [9]. Storage conditions were assumed to be 15°C (60°F) and 30% RH below playback conditions.

Table D.1 – Approximate acclimatization times of magnetic tape

Tape width (inches)	**Temperature acclimatization time**[1] (hours)	**Relative humidity acclimatization time**[2] (days)
1/4	0.5	1
1/2	0.5	4
3/4	1	8
1	1	14
2	4	50

[1] To warm the tape to within 5°C (10°F).

[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 width of a tape pack [9]. This results from the fact that heat and moisture principally diffuse into the pack from the edges of the tape. A 3/4-inch wide reel of tape (e.g., a U-Matic cassette) will require more than twice the time to equilibrate to a new environment than a 1/2-inch wide tape (e.g., a VHS cassette). An enclosing tape cassette offers only minor resistance to moisture intrusion, so the rate of moisture acclimatization of a bare tape reel and a tape cassette are similar [9].

The acclimatization process can be accelerated by exposing more of the tape surface to the environment. One of the easiest ways to do this is to fast forward and then rewind the tape on a recorder or other transport. 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 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. 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, and a tape reel or cassette stored in a cardboard/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 those used for motion picture film, will require a significantly longer time to equilibrate to the new environment. If the storage container is airtight, 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)

Bibliography

[1] Reilly, J.M., *IPI storage guide for acetate film,* Rochester, NY: Image Permanence Institute, Rochester Institute of Technology; 1993[6)]

[2] Van Bogart, J., Magnetic tape storage and handling, A guide for libraries and archives, Washington, DC: National Media Lab, The Commission on Preservation and Access, June 1995.[7)]

[3] Cuddihy, E.F., Aging of magnetic recording tape, *IEEE Transactions on Magnetics* 16 (4): 558–568; 1980 July.

[4] Bertram, H.N., and Cuddihy, E.F., Kinetics of the humid aging of magnetic recording tape, *IEEE Transactions on Magnetics* 18 (5); 993–999; 1982 September.

[5] Brown, D.W., Lowry, R.E., and Smith, L.E., Equilibrium acid concentrations in hydrolyzed polyesters and polyester-polyurethane elastomers, *Journal of Applied Polymer Science* 28, 3779–3792; 1983.

[6] Smith, L.E., Factors governing the long-term stability of polyester-based recording media, *Restaurator* 12, 201–218; 1991.

[7] Van Bogart, J., National Media Lab, private communication.

[8] Okazaki, Y., Hara, K., Kawashima, T., Sato, A., and Hirano, T., Estimating the archival life of metal particulate tape, *IEEE Transactions on Magnetics* 28, (5); 2365–2367; 1992 September.

[9] Vos, M., Ashton, G., Van Bogart, J., and Ensminger, R., Heat and moisture diffusion in magnetic tape packs, *IEEE Transactions on Magnetics* 30 (2), 237–242; 1994 March.

[10] ANSI/NFPA 232A-1995, *Fire protection for archives and records centers*

[11] ANSI/NFPA 910-1991, *Protection of library collections*

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6) Available from the Image Permanence Institute, Rochester Institute of Technology, 70 Lomb Memorial Drive, Rochester, NY 14623-5604.

7) Available from The Commission on Preservation and Access, 1400 16th Street, NW, Washington, DC 20036-2217.