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SMPTE RECOMMENDED PRACTICE

RP 190-1996

Care and Preservation of Audio Magnetic Recordings

Introduction

Audio magnetic recordings of continuing interest and importance exist on a variety of media types, with earlier records in the analog mode while more recent records may be either analog or digital. This recommended practice examines the hazards that may limit the useful life of such recordings and recommends storage practices to optimize their future performance.

1 Scope

Stability and preservation of audio magnetic recordings require attention to and precautions against all three of the following hazards: chemical degradation, physical distortion, and magnetic corruption. Analog and digital recordings are on media with the same susceptibilities to chemical degradation and physical distortion. They do respond somewhat differently to magnetic corruption effects, and this will be discussed. Recommendations are offered for minimizing each of these risks.

Useful and acceptable reproduction from records so preserved further demands that in the anticipated reproduction process there be conformance to the essentials of good practice. These essentials are also reviewed.

1.1 Storage time scales

This recommended practice specifies the desirable storage conditions for audio magnetic recordings of continuing value, as they may remain in library or vault storage between periods of intermittent reproduction or duplication. Two categories of storage time are defined. The categories are in agreement with those defined by ANSI/NAPM IT9.11. [12]

1.1.1 Medium-term storage conditions: Storage conditions suitable for the preservation of recorded information for a minimum of ten years.

1.1.2 Extended-term storage conditions: Storage conditions suitable for the preservation of recorded information having permanent value.

2 Structure of magnetic media

In figure 1, the structural components that provide media integrity and performance are identified. While it is sometimes possible to combine the function of two components within a single physical entity, each of the functions is essential and must survive without failure.

For the media of interest in audio recording, both as a final audio release and as audio recorded or presented in conjunction with images, many compositions of these structural components are encountered. Figure 2 identifies most of those found in archives, along with those employed in the recordings on current media.

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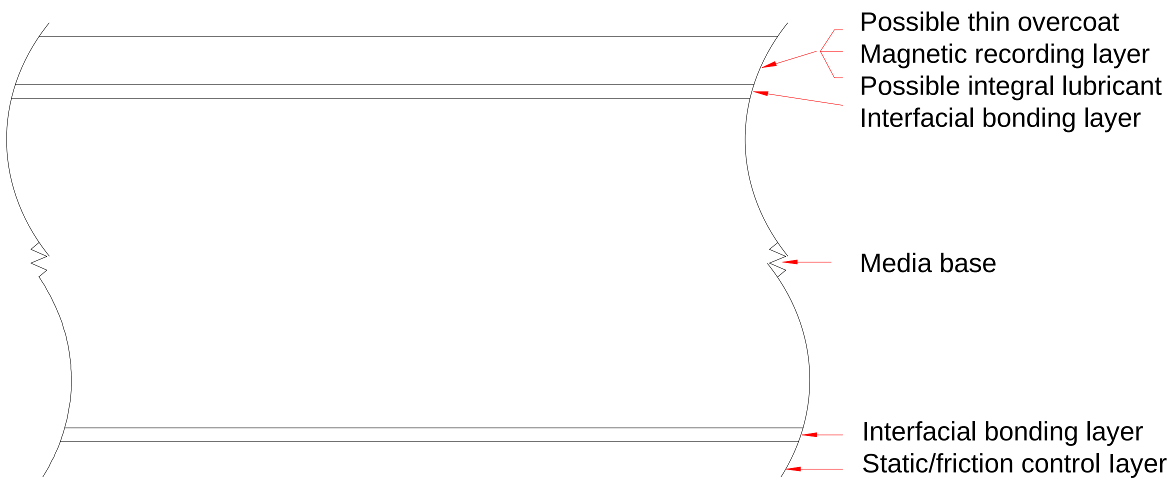

Figure 1 – Cross section of magnetic recording media (schematic)

Format	Nominal total thickness		Magnetic medium					
	Mils	Microns	Oxide, standard base	Oxide, medium base	Chrome, dioxide	Oxide, high bias	Metallix particle	Metallic film
Tape:								
Polyvinyl	2.5	63	*					
Acetate	1.4	36	*	*	*		*	
Acetate	2.0	51	*	*	*		*	
Polyester	1.3–1.5	33–38	*	*	*	*	*	
Polyester	1.9–2.2	48–56	*	*	*	*	*	
Audio cassettes:								
Polyester	0.4–0.6	10–15	*	*	*		*	*
Polyester	0.7–1.2	18–30	*	*	*		*	*
Full-coat magnetic film:								
Acetate	5.6	142	*	*				
Polyester	3.6–3.8	91–96	*	*				
Polyester	5.6–5.7	142–145	*	*				
Striped magnetic film:								
Acetate	5.6–6.3	142–160	*	*				
Polyester	5.4	137	*	*				
Striped composite prints:								
Acetate	6.8	173	*					
Polyester	5.9	150	*					

Figure 2 – Diversity of analog audio magnetic records
(Application and storage procedures need to be tailored to the format)

3 Summation of storage recommendations

	Medium-term	Extended-term
Equilibrium temperature °C	23 max	20 max
Equilibrium relative humidity %	20-45	20-30
Alternate 1: Temp	—	15 max
Alternate 1: R.H.	—	20-40
Alternate 2: Temp		10 max
Alternate 2: R.H.		20-50
Physical status:		
Winding	Co-planar	Co-planar
Enclosure	Protective	Protective
Orientation	Vertical	Vertical
External magnetic field:		
dc: *0e*	50 max	50 max
ac: *0e*	10 max	10 max

4 Derivation of recommended storage conditions

Temperature and humidity atmospheric conditions for magnetic media storage are summarized and tabulated in clause 3. The values have been derived from the extensive practical experience with photographic films, as recommended by ANSI/NAPM IT9.11 [12] for the minimization of various chemical degradations in monochrome photographic films. Most of the same polymers and modifiers are the major components of magnetic media. Therefore, the environmental recommendations for the minimization of chemical degradation during the storage of audio magnetic records have been derived from ANSI/NAPM IT9.11, modified only slightly by applying specific experience with magnetic records. [13]

4.1 Application of the recommendations of clause 3

4.1.1 Cycling of temperature and/or humidity increases the severity of the storage conditions and should be minimized.

4.1.2 Control of air-entrained and gaseous impurities as recommended by ANSI/NAPM IT9.11 for photographic films is equally applicable to magnetic media and, therefore, recommended.

Gaseous impurities: sulfur compounds, acidic vapors, ozone, peroxides, nitrogen oxides, ammonia, etc., are observed to accelerate chemical degradation.

Dust and air-entrained solid particles contribute to dirt and debris, and occasionally may be reactive.

4.1.3 Audio magnetic recordings may exist in cassette form, with the media already enclosed by the shell of the cassette. Media in roll form should be placed in a protective enclosure, selected from one of the following compositions: coated steel, aluminum, polyester plastic, polyethylene or polypropylene plastic, or acid-free paperboard, meeting ANSI IT9.2. [20]

4.1.4 It is preferable for magnetic media to be stored with the rolls in vertical orientation. If the media is not on a substantial reel, or within a cassette, the rolls should be supported by their hubs to eliminate asymmetric pressures on the rolls.

4.2 Moisture content and temperature of the media

All of the studies on chemical stability confirm that it is the precise moisture content and temperature of the actual media that controls, not the moisture content and temperature of the surrounding environment.

4.2.1 It must be recognized that a compact roll of tape or film can achieve temperature equilibrium with its environment rather quickly, but can achieve moisture equilibrium only by molecular diffusion of moisture into or out of the face of the roll, all the way to the midplane of the tape or film, which can be agonizingly slow. [19]

4.2.2 Media storage should be in a protective enclosure or in a cassette. Such enclosed recordings will require even more time to achieve a different equilibrium relative humidity.

4.2.3 Actual media moisture content: During the generation and prior history of the audio magnetic recordings, there may have been significant exposure to higher humidities and some equilibrium expedited by multiple transporting, as in a reproducer. Recognizing the very slow rates of moisture equilibration in media rolls not in active use, 4.2.1 predicts that any magnetic media which may enter a storage vault of lower humidity than the equivalent relative humidity of the media itself may take many months or even longer to equilibrate to vault conditions. Consequently, the effort at achieving low vault humidities may be less effective in preserving such media. [19]

4.2.4 Actual media temperature: Magnetic media which may enter a storage vault maintained at reduced temperature, however, will be very quickly cooled to environmental temperatures [19], thus effectively retarding hydrolytic decomposition.

4.2.5 Optimum extended-term storage: Inasmuch as the rate effects of temperature and of equilibrium relative humidity (i.e., actual moisture content of the media itself) upon chemical degradation are cooperative, it is still desirable when maximum useful life of the recordings is important to attempt reconditioning of the media before storage, and to store at the lower range of recommended relative humidities.

5 Removal of media from low-temperature storage

5.1 To minimize the formation of moisture condensation on the media or its enclosures, material removed from the low temperatures of extended-term storage should be "equilibrated" for at least 24 hours at medium-term conditions. The maximum temperature and humidity gradient during transition should not exceed 10°C/hr or 10% RH/hr. This gradient refers to the maximum temperature and humidity change to which the media (not the reel, cassette, or container) is subjected. The media should remain in its container during acclimatization to help control relative humidity and temperature gradient extremes.

The same preconditioning period should be applied to media received for storage, that is presumed to have been exposed to low temperatures during transportation, etc.

5.2 Physical effects of low-temperature storage

Rolls that have been stored at low temperatures will be found somewhat looser than when first introduced from the dimensional changes noted in 8.4. Additional care in handling may be required.

6 Chemical stability

Stability of the organic carrier-matrix bearing the magnetic particles must hold the composite in its as-recorded structure to maintain the reproducibility of the record.

ANSI/NAPM IT9.11 provides guidance for storage conditions that minimize the chemical degradation of photographic films. Although specific audio magnetic records may incorporate additional chemical compounds not normally found in processed photographic films, it is perhaps fortunate that the chemical stabilities of the major components are controlled by the same environmental factors.

6.1 Polymeric hydrolysis

A major chemical degradation mechanism for each of the organic compounds present, both in photographic films and in magnetic recording media, is hydrolysis — paced by the moisture content and temperature of the medium, and possibly also catalyzed by some industrial pollutants. This moisture content tends over time toward an equilibrium with operational and storage atmospheres.[1] [1, 2, 7, 16, 17]

6.2 Magnetic particle chemical stability

The inorganic magnetic materials in the media may include oxides of extended thermodynamic stability, or metallic elements potentially subject to oxidation — which is frequently facilitated by increased moisture content and/or increased temperature. [11, 14,15, 18]

[1] The actual moisture content of the media, either photographic or magnetic, increases with increasing partial pressure of water in the atmosphere (the absolute humidity), and decreases with increasing temperature of the medium. For most materials of interest over temperature ranges near "room temperature," this relationship — by pure chance — correlates approximately with relative humidity of the atmosphere. Thus, ANSI/NAPM IT9.11 and related guides recommend equilibrium relative humidity ranges.

7 Construction of environmentally controlled storage vaults

The design, construction, and maintenance of storage vaults required to be maintained at a lower relative humidity than their environment is expensive and technically challenging. Maintenance of storage vaults at a lower temperature than their environment, however, is much easier and less expensive.

This balance was reviewed during the reaffirmation of ANSI/NAPM IT9.11, resulting in the identification, reproduced in clause 3, of three operating conditions for extended-term storage, experimentally shown to be equally effective in controlling the rate of hydrolytic decompositions. [12]

8 Physical distortion

Reproduction of magnetic recordings (as well as the original recording process itself) requires consistent, intimate contact of the magnetic head with the media surface. Physical distortions interfere with achieving this requirement, and thus degrade the reproduction.

8.1 Plastic flow

The deformation thresholds for plastic materials such as magnetic recording media are greatly dependent upon time. The yield point stress, beyond which nonelastic and irrecoverable deformation occurs, will be nearly as high as the break stress for suddenly applied shock loads, and may be nearly zero for stresses maintained over a period of years. The relative importance of potentially deforming stresses, therefore, depends upon both the magnitude of each stress and the time over which it continues to act.

8.2 Quality of roll winding

Since the prior use of the recording may have resulted in an irregularly-wound roll, perhaps with protruding convolutions, or with tension changes from programmed interruptions in the transport of the medium, a full-length rewind is desirable to provide a uniform roll before storage.

8.3 Tail-out storage

Magnetic records are preferentially wound tail-out for storage, and should be rewound to head-out orientation immediately before use.

8.3.1 Rewinding in itself is somewhat beneficial in relieving physical stresses, and in countering some of the magnetic corruption.

8.4 Dimensional changes

The plastic materials in magnetic recording media show a measurable dimensional increase with the absorption of moisture, as well as with the increase in temperature. For most of the formats, the thickness direction has the highest coefficient and shows the greatest change. Temperature changes equilibrate relatively rapidly and, thus, result in relatively uniform changes in inter-layer pressure. The slow equilibrium of moisture, however, produces sustained dimensional differentials, as by the subjecting of a tightly-wound roll to a relative humidity gradient such that the exposed edges of the medium condition rapidly while the midplane may require weeks or months — thus inducing plastic flow and its resultant physical distortion.

8.5 Shrinkage

Magnetic media may suffer some shrinkage over time from loss of volatile components and/or release of manufacturing-induced strains. This is normally of insignificant magnitude, if it is not accompanied by other physical distortions.

8.5.1 For the magnetic films, perforated for compatibility with motion-picture systems, shrinkage will change the perforation pitch. Unless accommodation is made in the reproducing transport, the level of flutter may be increased.

9 Magnetic corruption

Magnetic recording is a reversible process, and the magnetic pattern representing information in a record remains capable of alteration by subsequent exposure to an appropriate magnetic field. Thus, recordings stored for later reproduction must be kept in areas free of excessive extraneous magnetic fields.

9.1 Magnetic particle populations

An indication of the nature of possible changes is given by the statistical properties of the individual particle population or of the metallic film domain population. The characteristic curve of magnetic induction vs applied field (the hysteresis curve) is composed of sloping and curving lines, indicating a distribution of particles over a range of coercivities within the population. (A population of identical particles, each of identical coercivity, would give a rectangular hysteresis curve.) Thus, some particles can have their magnetization sense changed under a field significantly smaller than that required for producing a quality recording on the total population for that medium.

These particles of altered state will be responsible for a corrupted reproduction. The most obvious effect is an addition to the noise floor at a relatively low level.

9.2 Thermal energy effects

Randomized distribution of thermal energy among the particles over time, furthermore, can with some probability assist additional particles to change their magnetic sense — possibly even in response to the juxtapositioned fields of the recording itself.

9.3 Environmental effects on magnetic corruption

All mechanisms contributing to magnetic corruption increase in activity and significance with increasing temperature.

9.3.1 The temperature recommendations of clause 3 have been chosen for minimizing chemical degradation over several years storage. Elevated temperatures limited to several weeks or even days, however, can induce magnetic corruption and also should be avoided.

9.3.2 External magnetic fields provide an additional potential for magnetic corruption of the recordings.[2]

9.3.2.1 External dc fields with a magnitude no greater than 50 Oe (4 kA/m), acting upon audio magnetic records in storage, have generally shown no degrading effect upon analog or digital recordings.[3]

9.3.2.2 External ac fields have the capability of causing a larger number of particles to change magnetization sense and, therefore, the somewhat lower ac field level of 10 Oe (800 A/m) should be observed.

9.3.2.3 External fields not only increase the level of the noise floor, but also increase the print-through effect (see 9.4.1). An ac external field has been shown particularly effective in accelerating growth in the level of the printed signal.

9.3.3 External magnetic fields are most frequently observed near motors and transformers (i.e., commercial building elevator installations, for example). Most of such installations are localized and, therefore, the field intensity falls off rapidly with separation; a few feet separation from the source may provide protection. External fields of a more unanticipated nature may be produced by audio speakers, by cabinet latches, and by the ubiquitous magnetized screwdriver.

9.4 Analog audio recordings

Analog audio recordings strive for a signal-to-noise ratio of 60 dB to 80 dB and are, therefore, most sensitive to low-level corrupted information.

9.4.1 Print-through is a significant problem in the storage of analog audio magnetic recordings with the imprinting field that is acting upon the most susceptible particles coming from the adjacent layer of the recording itself. The "added noise" is thus not random, but recognizable music or dialog and, therefore, most distracting.

9.4.1.1 The "printing field" is asymmetric and the greatest effect is upon the next convolution closest to the magnetic recording surface.[4]

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[2] The earth's magnetic field is of the order of 1 Oe (80 A/m) and is below the level of concern.

[3] Magnetic flux meters reading in this range have recently become commercially available at prices an audio archive could consider. Most meters read in gauss (technically the field induced in the meter's sensor). This is numerically equal to the value in oersteds (technically the applied field) because of the design of the meter.

[4] The wavelengths in the original recording, transferred with greatest "efficiency" in the print-through phenomenon, are those equal to the thickness of the medium; i.e., to the spacing between magnetic convolutions in the roll.

9.4.1.2 Thus, when recordings are stored “head out,” the print-through image precedes the recorded image. It is most disconcerting in a music recording to hear musical notes during a rest before the conductor’s start.

9.4.1.3 When recordings are stored “tail out,” the print-through image may become inobvious as it is lost in the full volume of the recording and the nature of the ending.

9.5 Digital audio recordings

Digital audio recordings provide quality reproductions from magnetic signal-to-noise ratios of about 20 dB. However, the recording system has usually been designed to produce recordings whose signal-to-noise ratio is no greater than necessary — thereby taking advantage of higher information densities. Accordingly, the reputed insensitivity of digital recordings to magnetic corruption has some foundation, but since the systems usually work close to the limiting ratio, the margin for tolerable signal-to-noise decrease may not be as great as assumed.

10 Preparation for reproduction after storage

Reproduction of archived recordings should only be attempted after a thorough check of the reproducing transport.

10.1 The reproducing transport should be properly serviced and clean, particularly at all surfaces contacting the medium.

10.1.1 The mechanical alignment should be checked so that the medium is properly transported and guided, and physical distortions are not induced.

10.1.2 Prior to loading the recorded medium, the magnetic heads should be demagnetized.[5] The entire media path should be checked for residual magnetism and demagnetized as needed.

10.1.3 The reproducing transport should be checked with a suitable test and calibration recording to determine that it is performing according to the appropriate standard.

10.2 The archived recording should be observed during reproduction to verify that it is free from physical distortions and other potentially degrading characteristics.

10.3 If repeated usage of the archived recording is anticipated, a working copy should be prepared and used for the continuing operations.

11 Preservation of deteriorating recordings

Whenever an archived recording is found to show any signs of quality degradation, the best possible copy should be made immediately.

12 References

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