

Recommended Conservation Practices for Archival Audiovisual Materials Held in General Special Collections

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March 2001

This document proposes conservation practices for archival audiovisual materials held in general or primarily paper-based special collections. The sections give an overview of the most frequently-encountered audiovisual formats (film, video, magnetic audio, mechanical audio, and optical media), preservation and conservation issues relating to these formats, and recommended conservation practices to assist these materials' longevity.

I.

FILM

Film formats included in general special collections can include Regular 8mm, Super-8mm, 9.5mm, 16mm, and 35mm gauges. Acquisitions can include films with magnetic sound stripes; original reversal; magnetic soundtrack (fullcoat); workprint outtakes and trims; and prints with optical tracks. Films can be stored on cores, daylight spools, reels, or loosely lying in cans; and stored in metal cans, in plastic and fiber shipping containers, or in original cardboard boxes.

Chronological film benchmarks:

1895-1951:

35mm film on nitrate stock (after 1951, on triacetate; from 1980s, also on polyester)

1922-1950s:

9.5mm (an early amateur format; can be identified by the sprocket hole in the center of the frame line)

1923-present:

16mm film (on diacetate in 1920s-30s; triacetate 1940s-present; polyester 1980s-present)

1936-1970s:

Regular 8mm

1970s-1990s:

Super-8 (1973: magnetic sound stripe on film introduced)

Ideally, film should be transferred to film, and to the same gauge as the original. However, 8mm and other small gauge formats are frequently "blown-up" to 16mm.

Transfer priorities should be:

deteriorating film, whether from vinegar syndrome or nitrate deterioration, or that is warped,
shrunken, brittle
moldy film with unique/important content
color-faded film

Deterioration

Damage from use

Film can be damaged from use by either humans or machines. Originals should never be used; only access copies should be used by staff and researchers. Examples of damage from use include:

Scratches. These can be treated in re-printing by printing through a wet gate; through chemical treatment; or by digitally removing the scratches and re-printing. Some think that “treating” scratches also traps off-gasses that contribute to “vinegar syndrome” (see “Natural deterioration process” below).

Sprocket and edge damage. Repair with tape on a sprocket-repair machine.

Tape and cement splices. Old tape turns yellow and can leave a permanent mark on the film; cement splices turn brittle and can also stain. The old tape should be removed and the film re-spliced, but cement splices require losing a frame on either side of the splice.

Natural deterioration process

Motion picture film has been produced since 1895. In proper storage conditions, it can last hundreds of years. However, in normal temperature and humidity environments, film suffers from several kinds of deterioration, depending on the film base.

Vinegar syndrome

Acetate-based film is susceptible to “vinegar syndrome,” a process in which moisture in the air interacts with the acetate base in the film, creating acetic acid. Over time, the film begins to warp, shrink, and the emulsion pulls off. The film emits a vinegar odor, hence the name of the “syndrome.” Deteriorating diacetate stock will smell like mothballs.

Acetate film originals should not be discarded, even if a film is thought to be extremely warped or deteriorated (an exception is nitrate deterioration, which is a more complex issue with laws regulating its disposal). Warped or shrunken films can be re-shot on optical printers. In addition, future advances in film restoration could produce better copies from the original film.

Films affected with vinegar syndrome should be segregated from “healthy” films since the off-gassing could migrate to the healthy films and accelerate their deterioration. To determine the acidity level of films, use A-D strips available through the Image Permanence Institute or archival supply catalogs. There is some disagreement over whether VS films should be segregated in a separate area with good ventilation so the gasses can dissipate, or whether individual cans should be tightly sealed and placed together in a larger sealed container. However, both arguments agree that the VS films should be stored in a different room than the healthy films, if at all possible.

In general, 16mm film from the 1920s through 1930s will be on diacetate. From the 1940s to the present, 16mm is on triacetate, with polyester also available from the 1980s. 8mm film is on triacetate, with the exception of Fuji Super-8 which is on polyester.

Polyester-based film, which will be found in some Super-8 film and more recent 16mm and 35mm prints, is not subject to vinegar syndrome. Its potential natural deterioration process has not yet been identified.

Polyester film can be distinguished from acetate film by holding a roll of film up to a light with the film backlit. If the film seems opaque, it is polyester. If you can “see through it” (translucent), the film is acetate. Also, if you try to tear a piece of polyester, it will not tear; acetate will easily break off.

Nitrate deterioration

Nitrate-based film should not be stored on-site. It is highly flammable, and should be stored at specially-designed nitrate vaults. There are some commercial storage facilities equipped to store nitrate film. Nitrate stock was used only in 35mm film, and was discontinued in 1951.

Color fading

Technicolor and Kodachrome color do not fade as quickly as other Kodak color stocks. Film prints on Eastmancolor from the late 1960s through mid-1970s are notorious for fading quickly to red or magenta. To slow down the color fading process, color films should be stored as cold as possible (see below under "Conservation").

Ferrotyping. The silver salts in black and white film can age and become shiny.

Shrinkage. If the film shrinks, it cannot be passed through a normal printer and will need to be step-printed. AMIA members can borrow a shrinkage gauge through the AMIA office.

Brittleness. If the film becomes brittle, it cannot be bent or projected.

Watermarks. Water splotches can be caused either by water damage or by chemicals during processing or cleaning.

Mold. In high humidity, mold will grow on film. It must be cleaned off, either in-house with the proper equipment and fume hood, or at a film lab. If left to grow, the mold will eat into the film emulsion.

Staining. Rust from old metal cans can form iron oxide deposits on film.

B.

Conservation

Film's natural deterioration process cannot be stopped, but it can be retarded by following these conservation steps:

Macro storage environment: Store the films in a cold and dry environment. Original color films should be stored at the coldest possible temperature to reduce color fading.

0° F for color films is preferred, but if not realistic, 30° F with 25-35% RH is sufficient. Black and white originals can be stored at 25-50° F with 25-35% RH.

Micro storage environment:

Store films on cores, not on reels. The exception is with Super-8 films, which should be stored on plastic reels.

Store in inert plastic polypropylene cans.

Remove all paper from inside cans (paper will increase the acid level in the micro environment, and accelerate vinegar syndrome).

Do not store magnetic fullcoat in the same can with its corresponding workprint or reversal. Magnetic stock deteriorates more quickly than film emulsion, and if stored with the film it will accelerate vinegar syndrome.

If possible, place molecular sieves in the plastic cans (available through FPC/Kodak in Los Angeles). The sieves soak up the acetic gasses emitted by deteriorating film.

Do not "photoguard" originals, as the sealant is thought to trap the offgassing, in effect making the film stew in its acetic gasses and accelerating deterioration.

Ends should be taped down.

Storage position: Films should be stored "flat" like pancakes, with no more than 6 cans stacked on top of each other. Only stack same-size cans (e.g., don't put a 400 ft. can beneath a 1600 ft. can).

II.

VIDEO

Video formats held in general special collections can include: 2" Quad videoreels, 1/2" open reels, 3/4" U-matic, Betacam, VHS, 8mm.

A.

Deterioration

Longevity

Being a magnetic medium, videotape has a short lifespan. Signals on the tape can start disappearing in as

few as 2 years for VHS and consumer grade tapes, and 5 years for professional grade tapes. Lifespan ranges depend on quality of the tapestock, quality of the recording, and storage conditions. Longevity estimates are:

8mm video:

2-10 years

VHS :

5-10 years

U-matic:

20 years

Betacam:

25-40 years

1/2" open reel:

20-30 years

2" Quad:

35-50 years

Because of the short lifespan of videotape, transferring (or "refreshing") video materials is the only way to preserve the video's content for the future. Some sources recommend making new copies every 5 years. Conservation practices can help slow down the videotape's deterioration, but older and at-risk tapes should be transferred as soon as possible.

Transfer priorities should be:

1/2" open-reel videotape (most likely dates from between 1965-1975)

3/4" U-matic videocassettes dating from 1973-1983.

Original VHS tapes that have valuable content and are older than 10 years.

2" Quad videoreels (this is an obsolete format; was in use 1956-1981)

2) Damage from use

Videotape's longevity can also be shortened by damage from use. As with all archival audiovisual materials, originals should never be used; only access copies should be used by staff and researchers. Examples of damage from use include:

Edge damage caused by improper winding so a poor tape pack results. The tape's control track (a signal that tells the VTR to pull the tape through the machine) is on the edge of the tape. If the control track is damaged, the tape will not play.

Creased tape (cinching) can also occur from an improper tape pack.

Drop outs can be caused by dirt or other debris coming in contact with the tape as it crosses the VTR head. The debris can become embedded on the tape.

Tape break

Stretched tape occurs when a tape is left in pause for more than 5 seconds

Demagnetization

3) Natural deterioration process

Videotape will also deteriorate over time. Examples of natural deterioration include:

Print-through. This is the magnetization of one layer of tape by another, so the audio track pre-echoes or "ghosts." This occurs when a tape is stored for a long period of time.

"Sticky shed syndrome." Moisture in the air contacts the tape, causing the binder to start shedding.

Oxide containing the recorded material is lost, and the residue can collect on a VTR's head and cause

the player to stop running.
Mold can occur in high humidity environments.

B.

Conservation

Video's short lifespan can be extended by following these conservation steps:

Macro storage environment: Store the videos in a cold and dry environment, but not as cold or dry as film. Magnetic media should not be stored below 46° F; temperatures below that will cause the lubrication to separate from the binder. Environment recommendations for long-term storage have these ranges: 50-60° F with 30-40% RH.

Do not store magnetic material close to strong magnetic sources (motors, transformers, electrical fixtures, loudspeakers, vacuum cleaners, floor buffers).

Micro storage environment:

Store in enclosed inert plastic polypropylene cans.

Remove all paper from inside containers. Do not store tapes in cardboard VHS containers.

Before storing, wind to the end of the tape, and then rewind to the beginning. It might take several tries before achieving a good, flat tape pack with no tape edges sticking up from the pack. Do not store tape in a cued wind; this leaves the tape exposed for possible hydrolysis contact.

Storage position: Videotapes should be stored standing up, like books. They can be stood either on their spines (long end), or on their edges. Storing videos upright helps to maintain a good tape pack.

III.

AUDIO (MAGNETIC)

Magnetic audiotape formats commonly found in general special collections include: 1/4" audiotapes, audiocassettes, and DAT.

Deterioration

1) Longevity

Like video, audiotape also has a short lifespan and suffers from the same use and natural deterioration problems that affect all magnetic media. Audio material needs to be transferred to another medium as soon as possible.

Lifespan ranges depend on the quality of the tapestock, the quality of the recording, and storage conditions. It is universally recognized that Ampex audiotape made in the late 1970s through early 1980s (~ 1977-1983) is especially at risk for sticky shed syndrome.

Fresh 1/4" audiotape can last 40-50 years, stored in a proper environment.

Approximate audiotape lifespans:

1/4" paper or acetate-backed audiotape:

If dates from 1940s-50s, likely to be in poor condition by 2000.

1/4" polyester-backed audiotape:

35-50 years
audiocassettes:

5-15 years
microcassettes:

2-10 years

Transfer priorities should be:

Paper and acetate-based 1/4" audioreels
Any recordings made between 1977-1983 on Ampex 1/4" audiotape
Unique audiocassettes made before 1990

2) Damage from use

Audiotape has the same potential for damage from use as videotape. Originals should never be used; only access copies should be used by staff and researchers. Examples of damage from use include:

Edge damage caused by improper winding so a poor tape pack results.

Creased tape (cinching) can also occur from an improper tape pack.

Drop outs can be caused by dirt or other debris coming in contact with the tape as it crosses the ATR head. The debris can become embedded on the tape.

Tape break

Stretched tape occurs when a tape is left in pause for more than 5 seconds

Demagnetization

3) Natural deterioration process

1/4" audiotape manufactured between the 1940s and 1960s could have paper or acetate backing rather than polyester (polyester was using beginning in the 1960s). Some audiotapes from those decades could have vinegar syndrome if they have acetate backing. Those with paper backing also are at risk for deteriorating due to the acid content in the backing.

Like film, polyester tape can be distinguished from acetate-backed tape by holding a reel up to a light with the reel backlit. If the tape seems opaque, it is polyester. If you can "see through it" (translucent), the tape has acetate backing. Also, if you try to tear a piece of polyester, it will be difficult to tear; acetate-backed tape will easily break off.

Audiotape has the same natural deterioration possibilities as video (see above for descriptions):

Print-through

"Sticky shed syndrome"

Mold

"Vinegar syndrome." This will affect acetate-backed audiotape. The tape will become warped, and the oxide will shed.

B.

Conservation

Audiotape's short lifespan can be extended by following these conservation steps:

Macro storage environment: Store the audiotapes in a cold and dry environment, but not as cold or dry as film. Magnetic media should not be stored below 46° F; temperatures below that will cause the lubrication to separate from the binder. Environment recommendations for long-term storage have these ranges: 50-60°

F with 30-40% RH.

Do not store magnetic material close to strong magnetic sources (motors, transformers, electrical fixtures, loudspeakers, vacuum cleaners, floor buffers).

Micro storage environment:

Store in enclosed inert plastic polypropylene cans. Do not store tapes in cardboard containers.

Remove all paper from inside containers.

Store 1/4" audioreels on NAB metal hubs.

Tape down ends.

Before storing, wind to the end of the tape, and then rewind to the beginning. It might take several tries before achieving a good, flat tape pack with no tape edges sticking up from the pack.

Storage position: Audiotapes should be stored standing up, like books. Storing audiotapes upright helps to maintain a good tape pack.

AUDIO (MECHANICAL; e.g. LPs)

Common mechanical audio materials found in general special collections can include sound discs (acetate, vinyl, and aluminum). Obsolete formats could include dictaphone belts and wax cylinders.

Deterioration

1) Longevity

Rough chronological history of sound recording discs:

1890s-1950s:

shellac (with organic fillers)

1950s-present:

vinyl

instantaneous recordings 1930s- :

acetate. The disc's base could be made of aluminum, or glass during WWII. Some acetate discs had a cardboard base; this was especially true for the "home recording" market. The base was coated with nitrocellulose lacquer plasticized with castor oil.

2) Damage from use

In general, audio discs are a hardy medium, with discs recorded at the beginning of the 1900s playable today. Some sources say vinyl recordings should last 100 years if correctly stored. As with all archival materials, only copies should be used by researchers and staff, not the originals.

Special care should be taken with aluminum discs. These are very soft, and if they are played with hard needles, the grooves could be destroyed. Only audio restorers and engineers experienced in working with aluminum discs should transfer them.

Sound discs should be handled by their edge and label areas; do not touch the surface. Wax cylinders should be at room temperature before touching, and do not touch the grooves.

Examples of audio discs being damaged from use include:

Scratches. These can't be treated, but "pops" can be removed digitally in re-recording.

Broken/shattered discs. To re-record, some archivists suggest placing the broken pieces on top of a solid disc sitting on a turntable, adjusting the height of the tonearm, and re-recording.

Chipped edges. Apply a very small amount of petroleum jelly to the chipped area, and cover with a small piece of masking tape, being careful to not cover any grooves. Transfer the disc, and remove the tape after transfer.

Worn-down grooves. Adjust the height of the tonearm and stylus size until a satisfactory recording is achieved.

3) Natural deterioration process

Some of the natural deterioration processes that can affect sound discs are:

Plasticizer residue and mold. Deteriorating acetate discs exude a greasy white powder made of byproducts of deteriorating plasticizer. This residue, as well as mold, can be removed with Kodak Lens Cleaner following the steps outlined by Chris Paton in the *ARSC Journal* (vol. 28:1, Spring 1997), and transfer immediately.

Shellac discs become brittle over time, which causes a fine powder to be shed from the disc after every play.

Delamination occurs when acetate on an aluminum or glass base separates from the base. The castor oil plasticizer evaporates over time, so the lacquer shrinks, causing the coating to crack and peel off.

Shellac discs can also shrink due to condensation interacting with the organic fillers.

□

Mold especially affects shellac discs. The organic fillers can attract mold, even though the shellac itself does not. Remove the mold following the steps outlined by Chris Paton in the *ARSC Journal* (vol. 28:1, Spring 1997), and transfer immediately.

Vinyl discs are the most stable of sound recording discs, having an estimated 100 years lifespan. However, they are made of polyvinyl chloride (PVC) which degrades when stored in high temperatures and under ultraviolet lights.

B. Conservation

Macro storage environment. Store the discs at 50-60° F, with 30-40% RH. Keep discs away from ultraviolet light.

Micro storage environment. Store in acid-free archival sleeves and boxes.

Storage position. Store discs standing up in the archival boxes, making sure there is no room for discs to bend or lean. Broken discs should be stored flat, but do not stack more than two sleeves containing broken discs on top of each other. Use gloves when handling the discs. Cylinders should be stored standing on end like glasses.

V.

OPTICAL AND DIGITAL MEDIA

Format obsolescence is the main problem in preserving optical and digital media. Computers were invented in the 1940s. There has been a multitude of information storage methods since then, beginning with punch cards, Dectape, Univac, etc. As hardware becomes obsolete, so do program languages (and programmers).

Optical media has been used as a commercial format since the early 1980s. CD-ROMs have been in use since 1985; now there is CD-R and DVD, with other formats in development.

Physical properties and identification

Digital storage media

Digital storage media on magnetic tape has the same preservation problems as other magnetic media. Magnetic tape used for digital storage tends to be on metal particle rather than metal evaporated tape. A tape cartridge can contain 600 MB or 1.2 GB compressed.

Tape reel:

400 ft.

25 MB

800 ft.

50-60 MB

2400 ft.

120 MB

2) Optical media

There are three kinds of optical media: Read-only Memory (ROM); write-once; erasable. CDs can hold 650 MB of data; DVDs can hold 4.7 GB.

CD-ROMs and CD-R share some similar physical properties, but also have some differences due to CD-R's writing capabilities (see below). In general, CD-ROMs will have a "silver" color on the non-label side; CD-Rs will be green or green-golden.

CDs have three layers:

polycarbonate substrate (holds data in pits)

metallic reflective layer: reflects the laser beam light into a light-sensing detector

(in CD-ROMs, made of aluminum; in CD-R, made of gold)

protective lacquer coating (hardened polymer)

Laser technology basics: the light beam burns microscopic pits into a photosensitive disc surface. The information is read off the disc by a disc drive which reflects light off a disc surface. The "read head" interprets the pits and lands and the transitions between the pits and lands according to variations in reflected light. The disc drive converts these variations into corresponding digital data which is usable by a computer.

CD-R differences

On CD-Rs, no pits are produced on the polycarbonate disc. The disc has a groove (like analog LPs) to guide the laser beam in writing. Scratches and fingerprints on the CD-R before writing can scatter the beam of the writing laser.

CD-Rs have a unique manufacturer's serial number on the inner hub.

CD-Rs have a layer of light-sensitive green organic dye. Above the dye layer is a thin film of metallic gold. The gold layer reflects the reading beam back into the detector. When the laser beam “writes,” the dye becomes dark and blocks reflections. CD-Rs are especially susceptible to light, even casual light exposure. Light exposure can cause the dye to fade and the contrast between marks and lands can disappear.

B. Deterioration : Optical media

Manufacturers assert that their CD products should last up to 200 years in good storage conditions. However, independent studies are less optimistic, and warn that CD-R longevity depends on storage conditions and dye stability.

1) Damage from use

Scratches and dirt. The CD label side is the disc’s most sensitive side since the label is close to the metal. The laser can compensate for small scratches and dirt, unless the scratch is circular (the drive could follow it).

Ink and dyes. Label and pen inks can erode protective lacquer coating. If you must put identifying marks on the CD, write in a circle on the thin plastic inner hub where there is no metal. Don’t use ballpoint pen on label: sharp point will deform the substrate.

Shattering.

Improper cleaning. Only use a soft cloth with no solvents (Kodak recommends using Kodak lens tissue with Kodak lens cleaner). Clean straight across, not in a circular motion, from center hub out.

Handling. Don’t flex. Remove holding outer edges.

2) Natural deterioration processes

Oxidation of recording surface. High humidity is the most important factor. NIST recommends storing optical media at 62-68 F, 33-45% RH.

Pollutants. A test done by the National Center of Scientific Research in Paris studied the effect of sulfur dioxide and nitrogen dioxide on CD-Rs in temp/humidity environments in the human comfort zone. The Center, which released its results at the Joint Technical Symposium in January 2000, tested four kinds of products. Researchers found that pollutants affected “protective” lacquer coatings, causing premature oxidation and disappearance of the reflective layer.

Those CD-Rs made of phtalocyanine (Kodak) had BLER (block error rate) of 650 after 25 weeks (end of life occurs when BLER reaches 50). Those on cyanine (Sony) had an average BLER of 2.

3) Other

Format obsolescence. NIST recommends refreshing/migrating data every 10-20 years. It’s recommended to store data on servers as well as on discs; because of potential catastrophic failure, it’s important to have backups.

Poorly manufactured plastic and metal.

Poor quality recording.

C. Conservation : Optical media

Macro storage environment. NIST recommends storing optical media at 62-68 F, 33-45% RH. Kodak: no warmer than 77 F. Cooler temperatures, as low as 50 F, and a relative humidity range of 20-50% will ensure long life expectancy of the physical media itself. Keep away from dust, light, and rapid humidity changes.

Micro storage environment. Do not store in plastic sleeves, which can adhere to the disc. Store in a jewel case, or even better, an inert plastic container.