Triage: Short-term Preservation Tactics for Found Media Objects in Cultural Heritage Collections

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Abstract

The vast majority of preservation literature refers to "long-term" preservation – that is, the efforts of a collector, institution or other interested party to preserve and maintain an object in its current state for as long as possible. However, "found objects", or media items that have not been accessioned and are serendipitously found in collections, have an initially uncertain history and may or may not be relevant to a collection. "Short-term" preservation aims to preserve and maintain an object economically yet as carefully as possible, allowing an institution to make a final decision regarding the fate of an object. These guidelines are specifically targeted at collections managers with little training in media preservation, and provide recommendations for immediate action regarding found objects as well as recommendations for short-term preservation.

Note: These guidelines are not intended to replace long-term preservation guidelines, nor are they meant to supplant any disaster plan or collections policy in place at any institution. While these guidelines are targeted toward museums, libraries and other cultural heritage institutions, they may be used by any interested collector of media objects.

Introduction

Media objects, such as audiotape, videotape, film and optical media, are in any number of different institutions throughout the world. While these objects are usually catalogued, a number of collections also contain these objects, uncatalogued and "found" while searching for something else. These objects may or may not be labeled, may or may not be usable and may or may not be related to the collection.

This paper will propose guidelines for immediate action to be taken by an institution, particularly with regard to a) objects in a state of decay; b) objects that are of potential value to the collection and the general public; c) objects of unknown content, type or provenance. These guidelines will also take cost into account, with the implicit understanding that "found" media objects are generally small in number and that spending large amounts of money for their initial care is not feasible in many cases. Larger quantities of media objects, especially friable (i.e. cylinders, acetate film) or hazardous (nitrate film) objects, may require more intensive measures for proper short-term care. It will cover almost all types of extant media, including magnetic tape, film, optical media, discs and rare media types such as cylinders, wire and tinfoil.

These guidelines act as temporary preservation measures, labeled here as "short-term" preservation, and all media items should be reviewed for further action at the earliest possible moment. These guidelines are also intended to "buy time" to research provenance, determine possible ownership of the materials (if ownership does not reside with the institution) and decide on further preservation or disposal of the object. Considering that playback of the materials is neither recommended nor in some cases possible (due to obsolescence of the media, decay, etc.), it is imperative that as much documentation as possible in the institution's archives be discovered.

The need for a document of this sort is quite apparent when reviewing the literature on media preservation. To date, there are few if any studies on "triage" media treatments, and the bulk of preservation literature is not concerned with surveying a number of different objects in a single document. While these guidelines will be targeted toward cultural heritage institutions, they may be applied to individual collections, commercial businesses and other interested parties as well. They are not intended as a guide for long-term preservation, nor are they meant to suggest that a "proper" method exists for all media; indeed, there remains some debate regarding best practices in the field of media preservation. Instead, these guidelines will provide a set of recommendations that curators can enact when encountering found media objects that will not compromise the integrity of the objects nor incur significant costs on behalf of the institution.

What is "Short-term" preservation?

The majority of preservation efforts are focused on "long-term" preservation – that is, the object in question and its content are intended to be maintained and made accessible for generations to come with current and future technologies. Long-term preservation is the ultimate goal for virtually all objects of historic, cultural or public significance.

Yet, when media objects are found, it is not always initially possible to know if an object is of significance, or if it is in a state where it can be preserved. For example, if a found media object is not relevant to a cultural institution's collection policies or mission, it may not be feasible for the institution to invest the time and money necessary for long-term preservation of an object. Also, found objects may be separated from their attendant objects or documentation and may not be easily identified upon first glance. Objects found in a severe state of decay may not be preservable themselves, although in some cases its information can be preserved.

"Short-term" preservation refers to a series of steps that a curator, registrar or keeper of collections can perform to identify media, isolate it from other media if

issues such as mold or vinegar syndrome are present, and allow time until a firm decision for long-term preservation or disposition can be made. The measures outlined here are not intended for long-term preservation, nor are they meant to replace the need for long-term preservation strategy. Rather, they are intended as triage for media objects, recommended actions that should be undertaken immediately to ensure the best possible survival of the media itself. The goal of short-term preservation is to maintain an object in the best possible condition for up to 12-16 weeks, long enough for most museums to decide whether or not to accession the found media object. Short-term preservation is intended to be economical and designed to use supplies already at hand, minimizing investment. While these are not best practice guidelines for permanent storage, they are adequate for the minimal amount of time defined above.

A Word on Vinegar Syndrome

Any acetate-based object is subject to a degradation known as vinegar syndrome. Vinegar syndrome is a progressive, irreversible condition in which the acetate reverts to acetic acid (vinegar) by means of hydrolysis (absorbing water from the atmosphere). Tapes and films which display vinegar syndrome present a noxious, vinegar-like odor, with possible shriveling and wrinkling of the object as degradation increases. As vinegar syndrome is contagious, objects displaying vinegar syndrome should be isolated from other objects and stored in a cool, dry place, preferably dark and with controlled low humidity. Acetate film was used exclusively for amateur films until polyester became the preferred standard in the 1960's; it was also the backing of choice for 35 mm film from 1951 through the 1960's, and occasionally into the 1980s as polyester replaced it. For magnetic tape, it was used for both audio- and videotape in the 1950's and partly into the 1960's.

Types of Media

Depending on the size and type of institution, or even its location and donor base, various types of media may be found, in any number of formats, enclosures and states of preservation. It is important to discern these media types from one another, as each has their own requirements for preservation. Also, if long-term preservation or data migration/reformatting is desired, the type of media may enhance or limit options for restoration.

Traditional climate control thresholds[1] for many art objects such as paintings, works on paper and pottery are not applicable to media objects. They are far more sensitive to fluctuations in temperature and humidity than most items and though of recent make should be considered fragile. Cold storage with controlled humidity in the range of 30-40% is ideal for tape, film and cylinders. Although room temperature is acceptable for optical media, low humidity is essential for best results.

Unlike a number of museum objects, "benign neglect" for media objects is not recommended, even for short periods of time. Decay for many media objects is swift and, in the presence of vinegar syndrome and nitrate decay, contagious and potentially hazardous. Because a number of media objects contain organic ingredients they are susceptible to mold. Humidity and temperature fluctuations can also cause media to swell and contract, which places stress on film and tape and can lead to hydrolysis in magnetic tape or degradation issues in other forms of media such as optical media and acetate discs. If enough damage has occurred, retrieving the information may be impossible.

Also, all media objects are vulnerable to ultraviolet light, fluctuations in temperature and humidity and physical damage. However, many if not most media objects have suffered from poor storage through part or all of their history, and so immediate action is required when these objects are discovered in a collection. It is impossible to tell what kind of light or temperature exposure an object has experienced in the past.

Magnetic media refers to magnetic tape, which was produced from the 1930's to the present, although modern manufacturers of magnetic tape are scarce. Until recently, magnetic tape was considered the preferred reformatting medium[2] for its high fidelity. It is notorious for "sticky shed", a condition in which magnetic particles come free from the plastic/polyester tape base. Sticky shed can result in loss of tape information, damage to tape or equipment if played without being properly cleaned and, in cases of acetate tape base, vinegar syndrome. Magnetic tape can be found in both audio and video formats, and for purposes of this paper both will be considered under the same category.

Film refers to cellulose nitrate, cellulose acetate or polyester-based image materials, with or without optical or magnetic sound, for both still and motion images. While much attention has been paid to cellulose nitrate and cellulose acetate, for those not intimately involved in film preservation this guide will offer the minimum recommendations for short-term preservation of both these and

[1] Defined as 70°F and 50% humidity, see Schultz, William, "CAL Scientists Revise Guidelines for Museum Climate Control", *The Torch*, Smithsonian Institute Office of Public Affairs, Vol. 17, No. 1, January 1995, pg. 23

[2] Brylawski, Samuel. *Preservation of Digitally Recorded Sound*. Library of Congress, http://www.clir.org/pubs/reports/pub106/sound.html, accessed 10/7/2008

polyester-based media. Be aware of the potentially explosive instability of nitrate film, "vinegar syndrome", in which acetate breaks down into acetic acid, and the rapid decay cycle of all film media. For a description of vinegar syndrome, please see the inset on page 8.

Optical media refers to CDs, DVDs, magneto-optical drives (the only prevalent type in the US is the MiniDisc) and recordable CD-Rs and DVD-Rs. All of these media types consist of a thin layer of foil sandwiched between two discs of polycarbonate/plastic upon which information is "burned" via a laser. The burn layer on CD-Rs and DVD-Rs is made of dye. This format is unstable for long-term preservation, being susceptible to light damage, physical damage such as corrosion and scratches, moisture and wear and tear. These media formats, however, are good choices for transporting preservation masters due to their low price, high storage capacity, light weight and current ubiquity. Any preservation master on this medium should be transferred to a more permanent storage medium as soon as possible due to the fairly short lifespan of optical media. CD-Rs and DVD-Rs may also be used as access copies, for the time being or until a newer format pushes them into obsolescence; please keep in mind that the life span for recordable media is also quite short.

Discs, commonly known as records, refers to vinyl, plastic, shellac or other composite materials shaped in the form of a disc. These are used strictly for audio recordings. While sound quality is generally not that of an optical or magnetic tape, they are the basis for a number of popular and genre-based music collections. Disc recordings in general should be considered unique until proven otherwise. They are mostly impervious to moisture, although mold, dirt, temperature and light can affect the quality and condition of the record. Shellac discs are fragile and will break when dropped; acetate and some instantaneous records are prone to vinegar syndrome, peeling or breakage.

Esoteric and Obsolete formats refer to cylinders (wax, cellulose or other material), foil (exceedingly rare) and wire recordings, in which playback equipment is no longer manufactured and preserving the materials may be a significant challenge. Foil recordings in particular are rare and may not be instantly recognizable as artifacts, whereas cylinder and wire recordings are found and occasionally culturally significant enough to warrant full restoration[3]. These recordings are often unique and should be treated with care. Wax cylinders should never be touched on their outer surfaces; instead two fingers should be placed inside the cylinder and no other part of it should be touched. Wax is prone to mold. Keep wire recordings away from magnetic fields such as speakers. All esoteric media should be kept away from moisture.

[3] Two recent examples come to mind. In 2006, a recording once thought lost of George W. Johnson's "Carving the Duck" was located in a Canadian collection of wax cylinders. Johnson was the first African-American recording star, and perhaps the first African-American ever to record. In 2009, a wire recording of Buddy Holly's first-ever recorded effort, a cover of Hank Snow's "I Gambled My Heart" from 1949, was released to the public for the first time in 2009.

Initial actions

♦Upon finding the object, it is imperative that a provenance for the object be established, as best as possible. Any attendant information, such as labels, cases and loose papers in the cases or attached to the object should remain with the object, and all attempts should be made to find additional identifying information. Provenance may be difficult to determine, yet it may be the most crucial part in making a final decision for long-term preservation. Found media objects should be handled in a well-ventilated environment in the event that mold, pests or other noxious substances are discovered along with the media object.

♦Next, it is important to identify the type of media, again to the best degree possible. In some cases (discs), the media type is easily identifiable, while others look remarkably similar to each other. Although it can be difficult to sort out videotape formats in particular, curators should know that these are not interchangeable objects; a Betacam tape, for example, will not play on a UMatic machine, and vice versa. The Appendix will outline various types of videotape media and offer insight as to how to identify each type.

♦The condition of the object should be noted. Items with mold in particular must be isolated in a sealed plastic bag and kept away from other media objects. Because mold can also be toxic to humans, it is imperative that curators wash their hands after making contact with mold-contaminated objects. Also note objects showing signs of vinegar syndrome (see below for a description), and isolate them from other media objects.

♦Devising a date for the object can be useful for tracking down ownership and establishing provenance, and may help narrow down the number of files a curator needs to search in order to find related material. For example, magnetic tape, while first invented in the 1930's, was not widely available in the US until after World War II. Also, the oldest magnetic tape was often found on acetate, which looks distinctly different from newer tape made of polyester. If an acetate magnetic tape was found, then the object in question would likely date from 1930-1960, and curators could weed out a number of objects that do not fall within those parameters.

♦Lastly, the object should be stored in acid-free archival-quality containers appropriate to its type. Although not recommended for long-term preservation, commercial refrigerators and freezers can be invaluable for short-term preservation. For film, freezing the object is essential; refrigeration will work for magnetic tape, photographs and optical media. Before placing any object in the refrigerator or freezer, it should be placed in a sealed, acid-free plastic bag with

all air removed. Because moisture from the air can be captured in a sealed plastic bag and then migrate to the media, the items should be bagged in a climate controlled room with humidity no greater than 50%.

Below is a table of storage recommendations for each type of media for short-term preservation. In some but not all cases (discs, optical media) they may be appropriate for long-term preservation as well. These ensure that the media will survive long enough for an institution to decide whether or not to preserve an object indefinitely.

Media	Storage
Magnetic tape (all types)	Store in refrigerator in tightly sealed bags. Place objects in bags in a humidity controlled environment, ideally between 30-45% humidity to prevent mold growth on objects. The ideal temperature range is between 38°-45°F. Lower temperatures may contribute to deterioration of the lubricant in the binder; higher humidity levels may contribute to hydrolysis. Do not use a wine refrigerator, as the humidity is too high.
Film and photographic negatives (all types)	Store in freezer, preferably a frost-free freezer, in tightly sealed plastic bags. Remove films from canisters and place in acid-free archival containers before placing in bags. For negatives: Place in acid-free preservation quality sleeve before bagging. If object is in a state of decay: add molecular sieve packages to the containers; make sure they do not touch the object. Humidity should remain at 20-40% for optimal conditions; 45-50% is acceptable for short term conditions if the humidity remains steady; in this case temperatures should be no higher than 50°F
Optical media (all types)	Place objects in jewel cases (if not found in this state) and keep away from light, heat and moisture. Unless objects are badly degraded, keep objects in a climate controlled room of 68°F, 20-50% relative humidity. Degraded items may be kept in the

	refrigerator under similar conditions as magnetic tape; be aware that seriously degraded optical discs may not be salvageable.
Discs	Vinyl and shellac discs: Keep away from light, heat and moisture in a climate controlled room no greater than 68°F, 20-50% relative humidity. Replace all paper sleeves with polyethylene acid-free sleeves. Store upright in a rack, preferably a powder-coated metal rack specifically tor records. Shellac discs are fragile and shatter when dropped even from a short height. Instantaneous and acetate discs: These items can be fragile and are usually unique. Treat as for film.
Cylinders	Keep at 65-70°F and 45-50% humidity. Temperatures and humidity should remain stable, and keep in mind that cold cylinders may shatter if warmed too quickly (including the touch of a hand).
Wire	Keep away from moisture, place in a climate controlled environment no greater than 70°F. Low humidity is desirable; if this is not achievable, place in refrigerator and treat as for magnetic tape.
Tinfoil	Little to no literature exists on the preservation of tinfoil recordings. Place tinfoil in acid-free paper or polyethylene enclosure and keep flat. Maintain a constant temperature of no greater than 70°F and humidity no greater than 50%[4]

[4] This information was reported by tinfoil phonograph collector Rene Rondeau as the conditions in which he found a tinfoil recording at the Henry Ford Museum in Dearborn, MI (private correspondence, 6/10/2010). I am awaiting confirmation of his description.

Institutional considerations for long-term preservation

The accession of media objects varies only marginally from non-media objects, in that they require more intensive long-term care. Unlike paper and canvas based works (and many organic materials such as bone, shells and rock), media objects require cold storage for their entire lifecycles, and subjection to frequent fluctuations in temperature and/or humidity can lead to their destruction. Standard museum climate controlled environments, while stable in terms of fluctuation, do not provide the cold storage needed to ensure long-term survival of the object.

Inherent in media preservation is the ultimate demise of the media object despite the best efforts of current and future preservationists. No media object is permanent, and its survival prospects for long-term preservation are largely dependent on its storage conditions in the past. Unless good provenance can be established to determine what those conditions were, it is impossible to say what the decay cycle for most media will be without extensive (usually destructive) testing of the object in most cases[5].

Short-term preservation guidelines are meant to act as a bridge between an initial period in which an institution decides whether or not to accession an object, and the period of accession or disposal. Each institution should follow its own guidelines regarding accession and disposal. If at all possible, because media items can be rare, items that will not be accessioned into another institution's permanent collection should be placed with a fellow institution. If an appropriate institution cannot be found, the institution may choose to dispose of it in accordance with its internal policy. A good faith effort to place unwanted media objects should be stressed.

Before accessioning a media object, four questions should be asked:

1. Is it within the institution's mission to preserve media works?
2. Can the institution raise funds for digitization and continued maintenance of the original object?
3. Is the object related to the collection?
4. Are there any donor-based stipulations that affect the retention of the object?

Of these questions, the second is the most crucial. Preservation best practice dictates that all media objects be digitized to ensure access and long-term

[5] A significant exception is acetate film, in which a simple test can be performed to determine the acidity of the film and how close it is to developing vinegar syndrome. A-D Test Strips formulated for this purpose may be purchased from the Image Permanence Institute, http://www.imagepermanenceimstitute.org

preservation of the information due to the prevalence of media obsolescence with regards to media formats and in the event that the original object decays beyond usability. While digital formats are subject to obsolescence in similar fashion as the original media object, it is far less destructive and generally less expensive to convert a digital preservation-quality file than to re-digitize an original. Digital copies also permit an access copy – or multiple copies in different formats - to be made from the preservation copy.

In no way does this mean that an original, once digitized, may be discarded. Because technology continues to improve at a rapid rate, future digitization projects may improve on previous efforts, and digitizing an original provides the most accurate results. Also, while audio preservation is mostly standardized and much of the information can be accurately captured, this is not necessarily true for video preservation. The standards for video preservation are not yet agreed upon, and improvements in digital video capture are improving at a sufficient rate to warrant future investigation.

Challenges to media preservation

Media is machine-driven. It is wholly reliant on machinery in order to express itself, and without external labeling, attached paperwork or some level of documentation, it is impossible to identify what the object contains without playing it. In many cases, however, the machinery required may be hopelessly outdated, impossible to acquire or, if immediately available, beyond repair. While this does not hinder the preservation of the media, it severely limits opportunities to access the media or to discern what information is present. This may become a factor in deciding whether or not to keep an object in a collection, or to find a location better suited to its long-term preservation.

According to Bigourdan, the "overall lack of awareness of preservation issues (is) the biggest problem to be overcome[6]" with regard to media preservation. While he is speaking specifically about magnetic tape archives, his statement could be easily applied to a number of cultural institutions and museums. The American Association of Museums offers a single page of recommendations to curators who are in possession of media objects[7], and while the advice proffered is generally sound, it is hardly enough for curators to rely upon, especially for institutions unfamiliar with handling media. While much is written on media preservation, the information available occasionally conflicts with previous

[6] Bigourdan, Jean-Louis, Reilly, James M., Santoro, Karen and Salesin, Gene. The Preservation of Magnetic Tape Collections: A Perspective. Image Permanence Institute, December 22, 2006, pg. 15

[7] American Association of Museums, "Discs, Tapes and Cylinders". http://aam-us.org/museumresources/ic/cs/pc/bytype/discs.cfm?cs_LoginTime-144542, accessed June 2, 2010. This page is password locked, although the resources listed on the page are easily accessible via other means.

writings and curators need answers they can rely upon for even the most basic care.

Like all objects to be preserved, curators, registrars and keepers of collections must be aware of the effects of temperature and humidity on media objects. Both must be monitored closely as each has its own destructive effects on media objects. In general, the lower the temperature, the better, but humidity is somewhat more fickle. Conditions that are too dry can lead to cracking and peeling of gelatin layers and sticky shed or blocking on magnetic tape. Too much humidity, however, and autocatalytic reactions such as vinegar syndrome can be accelerated. In general, relative humidity between 30-40% is ideal, with some media (film) permitting as low as 20% or as high as 50% (magnetic tape) without significant damage.

Conclusion

Found media objects possess their own unique preservation challenges, and maintaining such objects can strain an institution. Unfortunately, there is no quick way to ascertain the level of decay for most media types. It remains important to preserve the original in as pristine a state as possible for as long as possible, even though the physical life of media is fairly short and finite. For preservation of the data, however, there is hope. Technological advances in capturing data from media objects have allowed for the fullest possible preservation of sound and video to date, yet there is reason to believe that future technologies will prove even better.

Short-term preservation need not be expensive, but it must be executed properly in order to sustain the object for as long a duration as possible. Few guidelines currently exist for any type of inexpensive short-term preservation. These guidelines will not replace any long-term preservation standard in place, but act as a quick single resource for cultural institutional professionals with little training in media preservation.

Appendix A: Description and Preservation of Media Types

In all cases, media objects should be carefully maintained until a final decision as to its fate is determined. If an item is to be accessioned, long-term preservation actions should be instituted immediately. Museums should consult their own accession/deaccession guidelines for dispersal of undesired media objects. If the item is to be accessioned, then preservation and access copies of the media must be made in order to prevent damage to the original and provide the general public with a copy acceptable for most purposes. In almost all situations this can only be done by a trained professional due to the friability and specialized nature of the media.

This section covers some long-term preservation strategies as well. They are intended for the beginning media preservationist or the nonspecialist, and will provide only general recommendations. For a more technical grounding in media preservation, or for specific issues not covered in this text, please consult the sources in the Bibliography.

In all cases, both preservation and access copies of any medium should be made. Preservation copies should be digitized to the highest quality now available in order to capture the largest amount of data. For audio, the current standard is 96KHz, 24-bit Broadcast Wave files for preservation masters and 44.1 KHz, 16-bit Wave/Broadcast Wave files for access copies. MP3 web-accessible copies may also be made. For video, while standards are not entirely agreed upon, 14-bit uncompressed JPEG 2000 files provide the highest quality available today. MPEG-2 files may be made for access copies.

A playback machine appropriate to the media in question with replacement parts should also be accessioned with all media objects, if possible. Obsolescence is as much of an issue for media preservation as decay, with most formats now extinct.

Magnetic Tape: Formats

Cassette tapes

This term will be used exclusively for the compact cassette tape first released to the public by Philips in 1963. This medium was incredibly well distributed[8], and

[8] Cassette tapes were quickly accepted by consumers, with 6.9 million cassette players sold in 1969 and 10.2 million sold in 1972. Cassette tape sales grew commensurate with declines in reel-to-reel tape sales. See Hoffman, Frank (2005), *Encyclopedia of Recorded Sound*, pg. 307.

was used both for commercial recordings and home recording projects. The tape is ¼" magnetic tape, in one of three metal-oxide configurations, labeled Type I, II or IV. Almost all content on this medium was audio-based, but early computing devices would sometimes utilize cassette tape for large programs. Playback of a computer program on a standard cassette machine will not result in damage to the tape or the program. Although cassette players are fairly prevalent at present (2010), they are in danger of obsolescence in the near future.

Videocassette recordings

Many different videocassette formats were released between 1955 and the present, all vying for different markets and none compatible with one another. It is extremely important to identify the type of videocassette for preservation purposes, as there remain few operable machines today and fewer preservationists in this field. Videocassettes range in size from tiny 8mm camcorder tapes intended for consumer markets to large Betacam and UMatic formats used in broadcast studios. While many of these videocassettes look alike, they are not interchangeable. Almost all consist of an outer plastic shell with a transparent window over one or both spools, a plastic flap with springs allowing machines to access the tape and a small spot which if uncovered would prevent accidental erasure of the tape's content. The tape is pulled within the machine via two plastic hubs with spokes. To identify various types of videotapes, sites such as the Video Format Identification Guide[9] may be quite helpful.

Reel-to-reel tape

Both audio-and videotape is available on reels; it is the oldest tape format. Reel tapes may be backed with acetate, which is translucent when held up to light, or polyester, which is opaque[10]. Polyester is less subject to the type of catastrophic breakdown that acetate-backed tapes experience, but should nevertheless be treated with care. Magnetic reel tape comes in sizes from ¼" to 2", and while smaller gauges tend to be audio recordings and larger ones tend to be video recordings, this should not be assumed. Audiotape tends to be stored on plastic reels, while videotape is usually found on metal reels. Also, audiotape is generally thinner and consequently usually weighs less than videotape (and can be prone to stretching). Audiotape is usually stored in cardboard boxes, while videotape is often found in plastic cases. Again, these are generalizations, and objects can be shifted from their original boxes.

Film and photograph negatives

Film bases include cellulose nitrate, cellulose acetate (also known as "safety" film") and polyester (also known by the trade name Mylar). Cellulose nitrate is

[9] The Video Format Identification Guide may be found at http://videopreservation.conservation-us.org/vid_id/index.html

[10] Paper magnetic reel tape exists, but it is exceedingly rare and quite fragile.

famous for being unstable; however, it should be noted that nitrate may be more pristine in appearance than newer acetate films.

Nitrate should be stored away from other films and, if possible, other institutional holdings. Even temperatures as low as 106°F can cause nitrate to explode. Nitrate fires are extremely dangerous and can only be put out by smothering, usually with chemicals. Nitrate was first manufactured in 1889 and was available until 1951. Its use was restricted mostly to motion picture film after the 1920s.

Acetate films are not explosive, but vinegar syndrome is a constant threat. Acetate makes up the bulk of most film collections[11] and because of its long and extensive production it may turn up as a found object in a number of different types of collections. Acetate was used in amateur films are early as the 1920s, in photographic film in the 1930s and motion picture film in the 1950s. Until the 1990s acetate was still used extensively for motion pictures.

Polyester film was first manufactured in 1955, and began supplanting acetate film beginning in the 1960s. While polyester itself has proven to be stable, the color dyes in polyester film tend to fade in as little as twenty years. Almost all film on the market today is polyester film, but at this point the future of film in general is a matter of debate as digital technologies supplant it.

For long-term preservation, frozen storage is recommended for all types of film regardless of the level of decay.

Optical media

Compact disc technology was invented in 1982 by Philips, and has since become the medium of choice for a number of applications. DVD (for digital video disc, or more recently digital versatile disc) technology was first placed on the market in the late 1990s. Both CDs and DVDs are made of two polycarbonate layers, between which is a foil layer which carries the data. CD-Rs, CD-RWs and DVD-Rs include an additional dye layer which allows or blocks laser light to the metal layer. The polycarbonate facing on optical discs is quite porous and can absorb humidity; it is always best to keep them in a cool, dry place. Frozen storage is not recommended for optical discs. Optical discs are also prone to “disc rot” in which the metal layer has oxidized, making information irretrievable.

The life of a CD or DVD is relatively short; while independent studies are rare, an NIST study showed that DVD-R discs can survive for up to 30 years of stored at

[11] Bigourdan, Jean-Louis. “From the Nitrate Experience to New Film Preservation Strategies. *This Film Is Dangerous*, R. Smither, ed., C. A. Surowiec, assoc. ed., Paris: International Federation of Film Archives (FIAF), 2002, pg. 57

77°F and 50% humidity. In general, it is expected that all forms of optical media can survive for 20-100 years before data is irretrievable.

Because of the short life expectancy of the medium, it is recommended that all content on the disc, regardless of the disc's condition, be transferred to a preservation-quality hard drive RAID series. Data should be routinely checked and reformatted as necessary to ensure continued access to the data and to ensure the integrity of the bits. If the disc itself is expected to be played, a suitable player with replacement parts should be accessioned into the collection as well. Playback machines are widespread at this time, and currently most computers will also read these discs as well. As history has shown, this will not always be the case.

If the item is to be accessioned, mark the object with a medium tip non-solvent felt-tip marker, preferably in the clear area closest to the center hole. Solvent-based markers can degrade the foil layer, destroying information on the disc. Fine tip markers, pens, pencils and other fine styli can cause physical damage to the disc.

Disc recordings

Disc technology matured alongside cylinder technology and the first discs were placed on the market shortly after the first cylinders, in 1894. While Edison championed cylinders, discs were preferred by the general public, and eventually won out by 1925, the beginning of electric recording. Discs are made of a variety of materials, including rubber, acetate, lacquer, shellac and polyvinyl chloride ("vinyl"). These discs may be lateral or vertical cut, and mono or stereo. Most discs including modern 33 RPM records are lateral cut, in which the groove walls are side to side with a shallow trench. Vertical cut discs, also known as "hill and dale", recorded the signal in an up-an-down fashion much like cylinders. They are not interchangeable. Until after World War II, there was little standardization in terms of the speed of a record, although 78 RPM was frequently cited as a constant speed.

While vinyl and shellac records are chemically stable, mold and dirt remain problematic, as does direct sunlight and heat. Acetate and instantaneous discs are more problematic and are highly susceptible to temperature and humidity, and must be monitored carefully. All records should be cleaned and placed in acid-free sleeves before storing. Acetate and instantaneous discs should be kept in cold storage. The earliest records were made of vulcanized rubber, which is affected by light, heat and humidity. These three factors cause sulfur to transform into sulfuric acid, which eventually degrades the record.

Shellac records are heavy and fragile. If the record breaks, collect all of its pieces and store under the same conditions as other records. It is believed that future technologies will provide appropriate treatment allowing for the sound

information to be preserved. All records suffer from deterioration if frequently played.

Esoteric and Obsolete Media

Cylinder recordings

Cylinders are made of either soft brown wax for the earliest recordings (ca. 1886-ca. 1900) or a cellulose nitrate blend containing lampblack (for black cylinders) or a blue color base (for Blue Amberol cylinders). Most contain a plaster core, although other materials were used. Cylinders were manufactured through 1925, although the majority of cylinders were produced through 1915[12]. All are subject to mold and breakage, and should be handled carefully, touching only the inside of the cylinder. For long term preservation all cylinders should be kept in cold storage and warmed gradually to room temperature before use.

If the object is to be accessioned, labeling should be applied to the inside core of the object only. Because players for cylinder recordings are scarce, these recordings should be digitized for preservation and access. Keep in mind that repeated playing of a cylinder will result in its deterioration, and frequent playback of cylinders is discouraged.

Wire recording

The first wire recorder was invented between 1898 and 1900 by Dutch inventor Valdemar Poulsen. Known as the Telagraphone, it used what is believed to be standard piano wire and worked similar in principle to modern magnetic recording. Recording units were produced through the early 1950's and used for dictation (particularly over telephone wires, for which it was initially invented) and military purposes. A commercial market for cheaper household wire recorders peaked in the late 1940's, but the medium was no longer supported by the late 1950's.

Most wire made for the consumer market is stainless steel, which though resistant is not entirely impervious to rust or oxidation. Older wire such as that made for professional use before 1946 is usually very prone to rust. Players are difficult to acquire, and media should be digitized for preservation and access. Because wire recordings are magnetic, keep all objects away from strong magnets such as speakers to avoid demagnetization and loss of data. Keep away from high humidity or humidity fluctuations. Unlike magnetic tape, wire is not subject to hydrolysis or blocking.

[12] Cylinders for dictation were manufactured and used until ca. 1950. They could be shaved and reused a number of times.

Foil recordings

Tinfoil phonographs represent the first commercially available devices for recording and playing sound. The foil itself is made either of pure tin or tin-coated lead[13], neither of which is widely available today. The recordings look like long strips of foil with indented lines pressed into them vertically. Information on preservation of tinfoil recordings is scarce, and best practices may still be in development.

The condition of the foil may vary depending on storage conditions, manufacturer and damage to the foil over the subsequent years. Methods are currently being developed for playing back tinfoil audiorecordings without using a tinfoil phonograph, but the technology is still in its infancy[14]. Like disc recordings, repeated playback of the original media may result in irreparable damage and loss of information. Tinfoil phonographs are still occasionally used for demonstration in science museums, and therefore dating these recordings can be tricky without good provenance.

At this time, physical preservation may be the only nondestructive measure that a preservationist can undertake, at least until digitization methods improve. Similar to fragile paper, recordings should be stored unfolded, sandwiched between two pieces of acid-free board and stored in an acid-free folder. Maintaining low humidity and constant temperature is essential, but thresholds for this medium have not yet been determined.

[13] There may be silver foil recordings available, but tests to determine whether or not any known foil recordings are made of silver have not yet been performed. See Rene Rondeau (2001), *Tinfoil Phonographs*, pg. 130

[14] Personal correspondence with Rene Rondeau, 6/10/10.

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