



STORAGE OF CELLULOSE ACETATE COLLECTIONS:

A Preliminary Survey of Issues and Options

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1 Executive Summary

Cellulose acetate is a transparent plastic material that has been used as a carrier for photographic negatives, motion picture film, microfilm, microfiche and sound recordings. Cellulose acetate is susceptible to deterioration over time through a process termed the 'vinegar syndrome', which initially involves the release of acetic acid. Low temperature/low relative humidity storage and removal of any generated acetic acid are known to slow this degradation.

Lowering the temperature lowers the rate of chemical deterioration reactions. Cold storage (-18 °C) is recommended for permanent storage of materials that are already deteriorated. However, cool storage (0 °C – 16 °C) will also significantly slow the chemical reaction.

Care should be taken to avoid fluctuations in both temperature and relative humidity of storage conditions. Materials in cold storage may need up to a week to equilibrate to ambient conditions to prevent the possibility of damage during warm-up.

Since deacetylation of cellulose acetate requires the presence of water, the reaction can be slowed by limiting the amount of moisture present in the film base. However, acetate film is known to become brittle below 20 %RH so storage at relative humidities of 20 % - 50 % is recommended.

The use of enclosures can be important in controlling the microenvironment of cellulose acetate film. The type of enclosures used will differ depending on whether the storage environment is humidity controlled.

Removal of acetic acid produced by the deterioration of cellulose acetate will reduce its catalytic effect and slow further deterioration.

Facilities that can be used to store large collections of cellulose acetate materials include humidity controlled cool and cold storage vaults. Options for smaller collections include domestic frost-free refrigerators and freezers. Protection from high humidity levels is essential even in cold storage.

Geographical location has an influence on the storage environment where temperature and/or humidity are not controlled. Air conditioning without humidity control can increase the internal relative humidity to levels higher than those outside on hot days.

Systematic monitoring of collections is an essential element in managing cellulose acetate collections.

Copying methods such as duplication and digitisation are often used as preservation strategies in association with the provision of cool or cold storage. Factors such as the format of the material, whether or not originals are to be retained, and whether duplicate or digital copies are required for access purposes, have an important bearing on the preservation management strategy adopted.

Information about existing cold stores in Australia is provided in Appendix 1 of this report. It is intended that this information will be useful in facilitating cooperative cold storage arrangements.

In implementing any storage strategy, OH&S guidelines need to be followed.

2 Introduction

2.1 *What is cellulose acetate?*

Cellulose acetate is a transparent plastic material that has been widely used (and continues to be used today) as a base for photographic and motion picture film, microfilm, aerial film and transparent overlays, and for sound recordings. Originally marketed as 'safety film' and believed to be of archival quality, it is now known that cellulose acetate material can undergo significant deterioration within 30-40 years if stored at or near room temperature (Bigourdan & Reilly, 2000, p.14).

This deterioration, which initially involves the release of acetic acid, has been termed the 'vinegar syndrome'. The latter stages of degradation are accompanied by shrinkage, channelling and buckling with crystals and bubbles appearing on the surface of the film, and ultimately embrittlement and loss of information. (For further details about the degradation of cellulose acetate, see the 'Assessment Guidelines' available at <http://www.nla.gov/preserve/AssGuidelines2.doc>).

This paper aims to summarise some of the important issues emerging from the recent literature discussing preservation and storage of cellulose acetate based film. It also provides information about cool storage facilities in Australia. It is hoped that this information will assist institutions considering options for the storage of their cellulose acetate collections. For more in-depth discussion of the relevant issues the reader should consult the cited literature.

2.2 *Risks to cellulose acetate collections*

Apart from the vinegar syndrome, a range of other risks to cellulose acetate collections may exist. These include other forms of chemical deterioration, such as colour dye fade, physical damage, fungal growth, or loss of important information about the materials themselves arising from poor collection control. If information about what is actually present in the collection is not available, it is difficult to make educated storage decisions that support preservation of the collection.

2.3 *Colour film*

Colour film has its own storage requirements which reflect the instability of many of the colour dyes used in colour photographic emulsions. This document does not attempt to deal with storage of colour photographic materials, except to point out that cellulose acetate materials may be colour.

2.4 *Occupational Health & Safety*

Occupational health and safety guidelines should be carefully followed when working in an environment where acid vapours from deteriorated film may be present. These acetic acid vapours, if present in sufficient concentrations¹, can pose a health risk.

¹ For acetic acid the Time Weighted Average Exposure (TWA) is 10 parts per million (ppm) or 25 milligrams per cubic metre of air (mg m³). TWA is defined as the time-weighted average airborne concentration of a particular substance when calculated over a normal 8-hour work day, for a five-day working week.
(source: <http://www.nohsc.gov.au/OHSInformation/Databases/PracticalGuidanceMaterial/a/001011.htm>)

“Exposure to acid vapours can cause eye irritation including conjunctivitis, blepharitis, and keratitis, tearing (lacrimation), irritation of the nose, throat and lungs; pharyngeal edema; skin sensitisation; hyperkeratosis (growth of hard skin layers) and dental erosion” (Nishimura, 1995, p.378)

Gloves made of natural rubber, neoprene or vinyl are recommended when handling deteriorated materials, and the wearing of contact lenses should be avoided. If substantial amounts of deteriorated material need to be handled, it is be advisable to use a fume hood, limit exposure time and/or ensure excellent ventilation (Nishimura, 1995, p.378).

It is often the case that cellulose nitrate negatives are mixed in with cellulose acetate negatives. These are of significant OH & S concern. For more information on how to identify and distinguish film base materials, see the ‘Assessment Guidelines’ available on this website.

3 Storage of cellulose acetate collections

The life span of cellulose acetate film is determined by a number of factors. Some of these are intrinsic factors, such as the quality of the cellulose acetate base (i.e. the presence or absence of residual solvents or acids), the storage history, and the quality of the photographic processing the item underwent. These factors cannot be controlled ‘after the event’.

The storage environment is the major external factor that affects the life span of cellulose acetate materials. It is widely accepted that cool to cold low humidity storage, in combination with duplication or copying programs, will be required to manage cellulose acetate collections. The following section considers how adjusting storage conditions may assist in the preservation of cellulose acetate collections.

3.1 Temperature

Lowering the temperature has the effect of slowing down any chemical reactions that may take place inside the film, thus increasing the life span of the film.

The most recent extended term storage recommendations for processed safety photographic films² are quoted by Adelstein (1999, p. 16):

Image	Base	Max. temp	Relative humidity range
B&W silver gelatin	Triacetate	2°C	20-50%
		5°C	20-40%
		7°C	20-30%
B&W silver gelatin thermally processed silver vesicular silver dye bleach	Polyester	21°C	20-50%
Colour (Chromogenic) Diazo	Triacetate	-10°C	20-50%
	Polyester	-3°C	20-40%
		2°C	20-30%

² Photography – Processed safety photographic films – Storage practices. ISO 5466. International Organisation for Standardization, Case Postale 56, CH-1211, Geneva 20, Switzerland.

However, Adelstein points out that

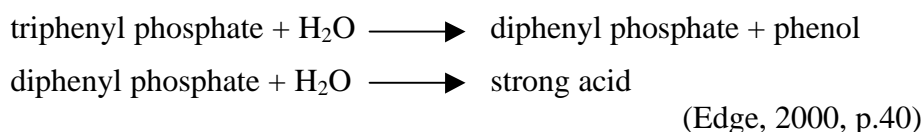
“ ... this table only applies to films that are currently manufactured. Older films may have already undergone some acetate or colour degradation ... Consequently, more stringent conditions should be used for such materials” (Adelstein, 1999, p.16-17).

Research indicates that as storage temperatures are lowered, the life expectancy of film increases. A decrease in the temperature from 10 °C to -12 °C increases the life expectancy of the film by a factor of 100 (Adelstein, 1992, p351-352). Therefore, the lower the temperature, the greater the benefit. However, maintaining a cold store at low temperatures is expensive.

Australian institutions are currently using cool storage for cellulose acetate collections at temperatures ranging from 2 °C to 16 °C. More details about cool stores in Australia are available in Appendix 1.

3.2 *Relative Humidity*

Relative humidity, or moisture, is a very important factor when considering storing cellulose acetate film. Deacetylation of cellulose acetate requires the presence of water. Water also combines with at least one degradation product of plasticiser deterioration (diphenyl phosphate) to form a strong acid:



As the polymer degrades, its affinity for water increases and degradation accelerates. As the pH of the base decreases, the pH of the gelatin emulsion decreases also. As the pH falls, the gelatin swells and may absorb more moisture at any given relative humidity (Sheppard, 1927, p.708; Rose, 1977, p.64). Gelatin is very susceptible to physical damage and mould growth under conditions of high relative humidity. However, the gelatin emulsion requires the relative humidity to stay above a minimum level of about 20%, otherwise it is subject to excessive and irreversible drying and subsequent embrittlement. There is also a danger that the emulsion will shrink and delaminate from the base.

Relative humidity is an important factor even at very low temperatures. If film is stored in high relative humidities it will slowly equilibrate to that high humidity irrespective of the temperature. (Wilhelm, 1993, p.701). As the moisture content of the film increases, the temperature at which the gelatin will become sticky lowers, with the possibility that at humidities of 70-75 %RH the gelatin will become sticky at room temperature. At these high humidities it is also likely that the gelatin will be susceptible to physical damage and mould growth (McCormick-Goodhart, 1995, p.68).

“It has been suggested that at temperatures below freezing, the moisture content of the film and the relative humidity of the storage environment may not matter. In fact, there could be serious problems. If a film were stored at 0° F (-18° C) with an ambient relative humidity of 95%, the film would eventually reach equilibrium with the 95% RH air. The moisture content of the film would then be essentially the same as if it were stored at room temperature at 95% RH. Upon removal from the freezer, the film would stick together, swell, and likely support fungus growth. ... Films and prints must always be protected from excessive humidity, regardless of the temperature” (Wilhelm, 1993, p.701).

Geographical location may also be important since local climate affects the internal conditions in buildings which do not have temperature and humidity control systems. Many institutions have air-conditioning systems to moderate outside temperatures. However, unless relative humidity is also controlled, internal relative humidities during the summer months could be higher than outside levels. As the warm outside air is cooled, the relative humidity of the air rises. This is because cool air holds less moisture than warm air.

For example during January in Sydney, the mean minimum relative humidity may be 62 % and the mean maximum daily temperature may be 26 °C. If air at 26 °C and 62 %RH is cooled to 21°C, the relative humidity rises to just over 80 %. During January in Melbourne, the mean minimum relative humidity may be 50 % and the mean maximum daily temperature may be 25 °C. If air at 25 °C and 50 %RH is cooled to 21 °C, the relative humidity would rise to about 63 %. Additional dehumidification of the air is needed to bring the internal relative humidity within acceptable storage limits.

In practice, the relative humidity inside a building is influenced by a number of other factors as well as outdoor temperature and relative humidity.

“The final indoor relative humidity depends on a complex set of factors including the outdoor temperature and relative humidity, ventilation rates, building insulation, internal heat load ..., moisture added to the air by people and other sources, solar heat load, type of air conditioner and many others ... It is not uncommon, however, for the indoor relative humidity in an airconditioned building to actually be *higher* than the outdoor relative humidity” (Wilhelm, 1993, p.549)

Horvath found that collections which had been exposed to excessive relative humidities at some point in the past were much more likely to exhibit signs of deterioration than collections which had not been exposed to humidity stress.

“Many of the collections faced with serious degradation were produced and/or stored in geographic areas with a high average relative humidity or the specific storage history of individual collections has included some degree of temperature and humidity trauma at some point in their lifetime before arriving at an institution ” (Horvath, 1987, p. 50)

Temperature and humidity averages for Australia can be found at the Bureau of Meteorology website at <http://www.bom.gov.au/>.

A psychrometric chart³ is commonly used to predict how relative humidity will rise or fall as temperature changes.

The risk that relative humidities may rise dramatically when air is cooled is also the reason why cold storage facilities should be designed to fail safely. If dehumidification equipment fails, the cooling system should automatically shut down. Otherwise, as the air cools, the contents of the storage area may become saturated with water. (Wilhelm, 1993, p. 711-712)

Fail-safe automatic shutdown systems are further discussed in Henry Wilhelm's "The Permanence and Care of Colour Photographs", Ch. 20, p.711-12.

3.3 *Fluctuations in environmental conditions*

Film materials have low thermal mass and equilibrate relatively quickly to changes in temperature. However, moisture equilibration is much slower, especially at low temperatures. Cyclical variations in temperature and relative humidity, which are typical for both refrigerators and freezers, are not a problem as long as the cycling is moderate and fairly rapid – the material's equilibrium moisture content will not change quickly enough to be affected, but will remain more or less stable at the average.

Enclosures further retard moisture equilibration, and therefore help to maintain a stable environment. Long-term variations, such as seasonal fluctuations in an uncontrolled relative humidity environment, are more serious because they will cause fluctuations in the equilibrium moisture content of the material. They should be avoided as much as possible. Sealed enclosures may be used to protect the materials from these changes (This is a general recommendation for hygroscopic materials, see Bigourdan & Reilly, 1997, p.7).

3.4 *Enclosures*

Choice of enclosure materials is an important aspect of providing storage which will improve the life expectancy of cellulose acetate film.

"Open or permeable enclosures may offer a small benefit to film that has already started to degrade, but they can only be used when the macroenvironment is optimized." (Bigourdan & Reilly, 1997 p. i)

This is because they permit evaporation and diffusion of acetic acid, thereby slowing deterioration.

If macroclimatic humidity control is not available, enclosures, in combination with adsorbents, such as silica gel or zeolites, can be used to create beneficial microclimates, to buffer and protect materials from fluctuations in temperature and relative humidity, and from condensation during warm-up, and/or to segregate deteriorated material.

Enclosures should be composed of inert materials that will not release chemicals that may affect the photographic materials. A 'photographic activity test'⁴ has been

³ An on-line psychrometric chart can be found at http://www.chemicalogic.com/download/psychrometric_chart_metric.pdf

⁴ Photography – Processed photographic materials – Photographic activity test for enclosure materials. DIS 14523. International Organisation for Standardization, Case Postale 56, CH-1211, Geneva 20, Switzerland; or *American National Standard for Imaging Media--Photographic Activity Test*, ANSI Standard IT9.16-1993. New York: American National Standards Institute, 1993. 1430 Broadway, New York, New York 10018.

devised which can be used to evaluate materials under consideration (Adelstein, 1999, p.17).

To protect film from excessive moisture, it should be sealed inside a vapour-proof enclosure. Two methods which have been used to achieve this are the FICA system and the CMI system. The FICA system uses enclosures that have a very low permeability to moisture vapour, consisting of fused layers of polyethylene, aluminium, plastic, and sometimes paper. The enclosures are heat-sealed, and a moisture preconditioning procedure is generally recommended. Disadvantages listed by McCormick-Goodhart are that the packages are not reuseable, it is difficult to monitor the condition of the material because the packaging is opaque, and preconditioning the material increases time out of storage.⁵

The CMI system was developed by McCormick-Goodhart to improve on the FICA design. He uses two 'zip-lock' low-density polyethylene (LDPE) bags, one inside the other, with a moisture buffer between the two (eliminating the need for pre-conditioning). A cobaltous chloride humidity indicator, which is visible though the outer PE bag, indicates when humidity levels are getting high (McCormick-Goodhart, 1999, p.20). He estimates that the cardboard buffer will need to be replaced every 15-20 years inside a freezer environment.⁶

3.5 Adsorbents: Zeolites and silica gel

There are three major factors that accelerate the degradation of cellulose acetate film: temperature and humidity, which have both been discussed, and the amount of acid present. Initially, free acid is generated slowly, the rate of reaction being governed primarily by temperature and moisture. However, as the film degrades, the amount of acid present becomes a more important factor in the reaction. The film will eventually reach its autocatalytic point, where the reaction will continue by feeding on itself, producing more and more acid (Reilly, 1993). This autocatalytic reaction can still be slowed if the temperature or moisture of the film are reduced. The reaction can also be slowed if the amount of free acid around the film is reduced.

Zeolites have been reported to have the advantage of trapping both acid vapours and moisture. Silica gel may also exhibit similar acid trapping properties (Bigourdan et al, 1998, p. 156 & 161) as well as its well know ability to adsorb moisture. The adsorbants trap the acid by holding the water that is bonded to the acetic acid. This, combined with the adsorbition of moisture in the sealed enclosure and the film itself, slow the autocatalytic reaction.

Active ventilation (Section 8) is another way of reducing the amount of acid available for the catalytic reaction.

⁵ According to an earlier paper by McCormick-Goodhart, sealing material in vapour-proof packaging at moderate relative humidities before placing it in a freezer is an effective method of ensuring that the relative humidity inside the package will not be too high:

"... for humidity controlled vaults which operate at -18°C, a 30 to 35% RH environment does not actually extract any more moisture from photo materials previously conditioned to 45 to 50% RH at room temperature. Thus, the micro-climate of a package sealed under moderate humidity conditions at room temperature and then stored at subzero temperature is essentially equal to the macroclimate found in a traditional humidity controlled cold vault operating at -18°C and 30%RH"(McCormick-Goodhart, 1995, p.68).

⁶ CMI packages are available commercially from Metal Edge, Inc.; further details are available at: http://www.wilhelm-research.com/Cold_Storage/cold_storage.html.

4 Equilibration Procedures

When storing objects at low temperatures, care must be taken that damage from condensation does not occur. Condensation will form when the temperature of the object is lower than the dew point⁷ of the environment.

There are two ways of preventing this condensation forming and damaging the object. Either ensure that the temperature of the object is above the dew point of the surrounding room, or surround the object with moisture-resistant packaging so that the moisture is kept away from the film (Bigourdan & Reilly, 1997).

Tim Padfield of the Danish National Museum recommends that care should be taken not to decrease or increase the temperature too rapidly, regardless of whether the package is sealed⁸. Padfield advises that the material be sealed inside a polyethylene freezer bag, and then placed inside a picnic cooler, before being placed in a refrigerator or freezer. Likewise, for retrieval the materials should be allowed to equilibrate slowly to ambient conditions. Again, a picnic cooler or esky would be suitable. Additionally, a refrigerator or cold store could be used as an intermediate storage environment during equilibration.

Generally for cool stores above 0 °C overnight is sufficient for equilibration.

5 Access

Access evidently becomes more complicated when materials are stored at low or subzero temperatures. Equilibration procedures may take time. Many institutions are digitising valuable collection items to facilitate access, which not only protects originals from handling, but also makes it possible to make the items widely accessible via networks.

6 Monitoring

Regular monitoring of collections is an integral part of the management of collections of cellulose acetate.

“the major tool for proper preservation management of negative collections is frequent and systematic monitoring” (Horvath, 1987, p. 61).

In many collections of negatives of a similar age which have been kept under similar conditions it has been found that only some will exhibit signs of deterioration, while others will appear unaffected. Regular monitoring is necessary to ensure that deteriorated film is located and segregated from material in good condition (to prevent contamination), and to ensure the survival of the deteriorated material (if desired) by placing it in a storage environment appropriate to its condition – for example by placing it in a freezer.

7 Facilities/Storage Options

7.1 Humidity controlled cold storage vaults

Many institutions with very large collections in the United States have chosen to store their valuable photographic material in large scale humidity controlled cold storage

⁷ Dew point: The temperature at which the air is 100% saturated.

⁸ Personal communication with the author.

vaults. The advantage of having a humidity controlled environment is that the material requires no special packaging, which reduces costs in terms of materials and handling, especially where very large collections are concerned.

There are a number of humidity controlled cold-stores used by a variety of institutions in Australia (see Appendix 1). These may house valuable polyester or acetate masters, among other materials. Because of the volatile acids released by degrading cellulose acetate, many cold store managers have concerns about accepting cellulose acetate, and particularly degraded cellulose acetate, into their vaults. Although controlled results are not available, the ability of acetic acid vapours to initiate and/or accelerate the deterioration of other nearby materials is well known. However, whether this is likely to be a problem if the materials are not in direct contact with each other, and the storage area is well ventilated, is not known with any certainty.

7.2 Domestic frost-free freezers

According to McCormick-Goodhart,

“... a careful economic assessment of the extra material and labour costs associated with packaging methods will show that it is cost-effective for small to medium size collections up to and including those which would normally occupy a storage area of 100m². With this size of photographic collection, the material and labour costs associated with packaging and reuse are more than offset by the lower operating cost of a conventional freezer when compared to the operating cost of the custom dehumidified vault design ...” (McCormick-Goodhart, 1999, p.22).

For small collections, Henry Wilhelm⁹ advises the use of domestic frost-free freezers. However, domestic frost-free freezer units usually maintain humidity levels between 50% - 70%, which are too high for storage of cellulose acetate. The material therefore needs to be sealed to protect it from the high humidity levels. A system similar to the CMI package (section 3.4) may be useful.

7.3 Domestic frost-free refrigerators

In his book “The Permanence and Care of Colour Photographs”, Henry Wilhelm advocated the use of frost-free refrigerators for the storage of photographic film. Since that time, there have been concerns that the relative humidity inside a frost-free refrigerator is not suitable for the gelatin emulsion. Therefore it is suggested that if using frost-free refrigerators, the objects be enclosed in sealed enclosures with some form of buffering material. Again, a system similar to the CMI package (section 3.4) may be useful.

8 Active Ventilation

Because the efficacy of acid scavengers is limited by the slow diffusion of acetic acid vapours, ScreenSound Australia has been experimenting with methods of ventilating film cans. It was found that simply punching some holes in the enclosure is ineffective in lowering acid concentrations inside a film can. They have therefore been investigating more active approaches to ventilation. They have determined that the

⁹ Henry Wilhelm (1993) “The Permanence and Care of Colour Photographs: Traditional and Digital Colour Prints, Colour Negatives, Slides, and Motion Pictures”. Iowa: Preservation Publishing Company

best way of ventilating a film can is to have the air flow in the vault pass through two holes in the film can which are directly opposite each other. The positive air pressure from one side to the other helps ventilate the film can. Further experiments varying the design of the film can and shape of ventilation holes are under way.¹⁰

Dr Ngo Hieu Chi of the Vietnam Film Institute has developed a treatment method whereby films affected by Vinegar Syndrome are unrolled and exposed to a ventilator for 36 hours. The amount of acetic acid in the film is reduced by 90-95%, and the life expectancy of the film is increased by about 3 years (with subsequent storage at 14°C and 40%RH). This allows more time for duplication before the film becomes unuseable (Ngo Hieu Chi, 1998, Annex Q).

Evaporation of the acetic acid reduces the rate of deterioration of the film, however, it also leads to accelerated shrinkage. According to Dr Ngo, this method is most effective if the acid content of the film is still relatively low – between 0.7% - 6% of the total film weight, or 50-400 mg per meter of film for 35mm film. In this case, shrinkage is restricted to about 1.5% –2.5%, and the film remains useable (Ngo, 1998). If the film is severely deteriorated, evaporation of the acetic acid results in shrinkage of over 3%, and the film becomes unusable.

9 Copying and cold storage

Copying methods such as duplication and digitisation are an important element in any cellulose acetate preservation plan. Copying is an effective strategy for preserving the information contained on an item. In some cases, it is the information only that will need to be preserved. In these cases, copying alone is sufficient as a preservation strategy. In many cases, however, institutions will want to preserve originals after copying. In these cases, copying may be an effective strategy for providing access to the information. Fragile or deteriorated originals can then be stored at low or very low temperatures without the need for handling.

“Generally the preservation of acetate film collections will require an approach that combines the systematic duplication of acetate film materials onto polyester based film with the cool/cold storage of original film materials to extend the useable life. Often for small collections it will be most economical to duplicate the collections, while large acetate film collections will require a combined approach of cool/cold storage and a long term plan for preservation” (Puglia,1995, p.50)

¹⁰ For further details, contact Mick Newnham at ScreenSound Australia

McCormick-Goodhart advocates cold storage as being more economical:

“Despite the seemingly high construction and operating costs, the preservation benefit derived from the custom cold vault is enormous. A thorough economic comparison with copying or duplication strategies will reveal that copies actually cost more, suffer loss in quality, and fail to preserve the images in their original format.” (McCormick-Goodhart, 1999, p.20)

Henry Wilhelm makes a similar point:

“With large quantities of materials, it is much less expensive to preserve the original films than to make duplicates; in addition, cold storage allows preservation of the original artefact, and the subtle – or sometimes major – image quality losses that *always* occur when making duplicates are avoided” (Wilhelm, 1993, p. 692)

In order to determine the most cost effective strategy for any given collection, a cost-benefit analysis of cool storage as opposed to duplication should be carried out.

Both Puglia (1995) and Nishimura (1995) have provided guidelines for calculating the cost benefits of implementing different preservation strategies. It is important to note that in his calculations, Puglia assumes that polyester duplicates will not be placed in cold storage, and that they are likely to last 500 years. He also assumes that originals are not kept.

When copying, it is also important to factor in the costs of inspecting copies to ensure standards have been adhered to - which are often greater than the actual copying costs. Copying costs are also highly dependent on the format of the material to be copied.

Choice of copying strategies will necessarily depend on the use that will be made of the copy and the costs and risks associated with maintaining access to copies. For example, digitisation confers the ability to provide ready access and might be considered suitable for highly used items. However, methods of preserving access to digital materials are largely untried and might be considered unreliable.

10 Cold storage in Australia

Information about cool storage facilities in Australia is presented in Appendix 1. It is intended that the information provided will assist institutions in setting up cooperative storage arrangements with others.

The storage space required for different formats can be calculated using storage density data. In “Cost-Benefit Analysis for B/W Acetate: Cool/Cold Storage vs Duplication” (available online at <http://palimpsest.stanford.edu/byorg/abbey/an/an19/an19-4/an19-410html>) Puglia provides information on storage densities for the different formats:

Table 1: Storage densities of various formats

		Imperial	Metric
Still photos	4" x 5"	0.0009 cu. ft./neg	25.4 cu. cm./negative
	5" x 7"	0.003 cu. ft./neg	84.9 cu. cm./negative
	8" x 10"	0.003 cu. ft./neg	84.9 cu. cm./negative
Microfilm	16 mm, 100' roll	0.02 cu.ft./roll	566.4 cu. cm./roll
	35 mm	0.04 cu.ft./roll	1132.8 cu. cm./roll
Motion Pictures	16 mm, 1000' roll	0.07 cu.ft./roll	1982.4 cu. cm./roll
	35 mm, 1000' roll	0.14 cu.ft./roll	3964.8 cu. cm./roll
Aerial	5", 200' roll	0.06 cu.ft./roll	1692.2 cu. cm./roll
	5", 500' roll	0.16 cu.ft./roll	4531.2 cu. cm./roll
	9.5", 500' roll	0.33 cu.ft./roll	9345.6 cu. cm./roll
X-ray	14" x 17"	0.006 cu.ft./roll	169.9 cu. cm./roll

While data collected in the Cellulose Acetate Survey (2000)¹¹ does not allow us to determine if there is a shortage of cold storage space in Australia, we do know that:

- In libraries and archives, acetate competes with polyester, as well as other materials, for cold storage space. Collections on polyester are growing, and will continue to do so.
- Copying projects are unlikely to significantly decrease the total cold storage space required in Australia. This is because many institutions are wary of discarding original material, and want to keep it, 'just in case'. In view of the possibility of unforeseen problems in terms of image quality or deterioration of the copy being discovered years later, this may be prudent. Materials being retained because of their intrinsic value will also require cold storage space.
- Deteriorated acetate cannot be stored alongside other materials without being sealed, and packaging large amounts of material is costly.
- There are no large cold stores in Australia today which are cold enough to arrest further decay in materials which are already deteriorated.
- Low temperature (freezer) storage will substantially increase the stability of cellulose triacetate base.

¹¹ Available from <http://www.nla.gov.au/preserve/ca.html>

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12 Appendix 1 Where are the cool stores?

Not all cool or cold stores in Australia are listed. Please contact the relevant person for further information on each facility.

Institution	How many Cool Stores?	Temp/RH	Size Sqm and/or cum	Use space elsewhere?	Conditioning Room?	Filtration system?	Type of air conditioning system and dehumidifier	Person to contact re cold store
1 Australian Broadcasting Corporation (ABC)	1	7°C, 35% (will build new one in 2002, existing will be raised to 12°C after Feb 2001 for stock take)	100 sqm	NAA	yes	yes	Munters dehumidifier	Caitlin Hickie National Co-ordinator, TV Preservation (02) 9950 4128
2 Australian Centre for the Moving Image (formerly Cinemedia)	1	18 - 19°C, 35%	2400 cum	no	no	yes	Dedicated plant with Munters and Leibert dehumidifiers	Chris Undy chrisundy@acmi.net.au
3 Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) (also have three vaults maintained at 16°C)	Vinegar Store	5°C, 35%	3.8 sqm (12.9 cum)	no	yes	Paper filters	In-space a/c Munters dehumidifier	Tom Eccles (02) 6246 1133, tom.eccles@aiatsis.gov.au
	Vault 5		67.3 sqm (228.8 cum)			Paper filters		
4 Australian War Memorial (AWM)	2	12-14°C, 38-40%, 16-18 °C, 35-38%		NLA SSA	no	Water scrubbers	One has dedicated plant, the other has a shared air handler unit Munters desiccant wheel	Bill Fogarty bill.fogarty@awm.gov.au
5 Library and Information Service of Western Australia (LISWA)	1 (Another in the future)	10 ±2°C, 35±5% RH	41sqm	no	no	Crystals	Dedicated a/c unit with solid bed dehumidifier	Pat Griffiths pgriffiths@liswa.wa.gov.au
6 National Archives of Australia (NAA) ACT	1	10°C± 1.5°C 35% ± 3%	307.5 sqm [1168 cum]	no	yes	Pre-filters and carbon filters	Dedicated air handler unit Desiccant wheel dehumidifier	Andy Peluko, andyp@naa.gov.au (02) 6212 3466

Institution		How many Cool Stores?	Temp/RH	Size Sqm and/or cum	Use space else-where?	Conditioning Room?	Filtration system?	Type of air conditioning system and dehumidifier	Person to contact re cold store
7	NAA NSW	1	10°C, 35%	62 sqm [204.6 cum]	SSA	yes	activated carbon	Dedicated air handler unit.	Chris Lowger, chrisl@naa.gov.au
8	NAA Vic	1	10 °C, 35 %	160sqm [544cum] 1936.8 shelf metres	no	yes	panel filter, activated carbon filters, deep bed filters and activated carbon filters	Dedicated air handler unit. Desiccant wheel - lithium chloride	Les Cargill, lesc@naa.gov.au (03) 9881 6801
9	National Library of Australia	3	7-9 °C/30-40%	305 sqm [884.5 cum] approx 3,200 shelf metres		yes	yes	Munters desiccant wheel	Trevor Pidd tpidd@nla.gov.au (02) 6262 1663
			16-18°C/25-35% Tape store	85 sqm [255 cum]		no	yes	Munters desiccant wheel	
			16-18°C/25-35% Tape store	65 sqm [162.5 cum]		no	yes	Munters desiccant wheel	
10	Museum of Victoria (MOV)	1 small	5°C, 30%	1 cum	no	no		External to cold store Munters desiccant wheel	Trish Stokes, Manager Conservation tstokes@museum.vic.gov.au
		1 large (Jan 2002)		100 shelf metres		yes, but not controlled yet			
11	Powerhouse Museum (PM)	5 fridges	5°C, 25% (some differences between each fridge.)	0.4 cum each fridge	no	no		Fridges in a/c space. No BMS – T and RH values charted weekly using hygrotherms.	James Elwing jamese@phm.gov.au
12	Queensland State Archives (QSA)	2 (for microfilm only)	5°C, 35%	about 30sqm each	no	yes		Stand alone system	Brian Devaney Brian.devaney@dcil.gps.qld.gov.au
13	ScreenSound Australia (SSA)	6	6 at 16°C, 35 %	77.5 sqm [433 cum] and 158 sqm [880 cum]	NLA				Victoria Ramshaw (02) 6248 2000 (main switchboard)
		1 duping store	16°C, 40%	960 sqm [3,648 cum]					

Institution		How many Cool Stores?	Temp/RH	Size Sqm and/or cum	Use space else-where?	Conditioning Room?	Filtration system?	Type of air conditioning system and dehumidifier	Person to contact re cold store
14	State Library of Queensland (SLQ)	2	10°C, 35 %	31 sqm each	QSA houses preservation master microfilm	no			Grant Collins, grant.collins@slq.qld.gov.au (07) 3840 7841
15	State Records of NSW (SRNSW)	2 located at the Western Sydney Records Centre, Kingswood. New one being built soon.	20°C , 55% (for mag tape) 14°C , 40% (for microfilm) (both same size)	60 sqm [180 cum]		yes (very low access from 14°C store)	no		Sally Irvine-Smith Manager, Systems Control (02) 9673 1788 grrnsw@records.nsw.gov.au
16	Tasmania Museum & Art Gallery (TM&AG)	2	13°C , 35%	15-20 sqm [80 cum]	no				Patricia Sabine, Director tmagmail@tmag.tas.gov.au