



CELLULOSE ACETATE PROJECT

STAGE ONE

Final report

August 2000

CELLULOSE ACETATE PROJECT

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1 EXECUTIVE SUMMARY

Cellulose acetate, widely used as a carrier for photographic negatives, motion picture film, microfilm, microfiche and early magnetic audio recording, is subject to deterioration over time: the vinegar syndrome. Stage 1 of the *Cellulose Acetate Project* aimed to investigate the extent of the problem of deteriorating collections within Australia and strategies currently available for dealing with this problem. It also aimed to develop recommendations for further action.

A high number of Australian institutions participating in the *Cellulose Acetate Project* questionnaire reported visible signs of deterioration of their collections resulting from the vinegar syndrome. The questionnaire found a high level of uncertainty regarding the extent of deterioration with half of responding institutions having been unable to survey their collections. However, data from those institutions that were able to estimate levels of deterioration revealed that significant deterioration had already occurred. Visible signs occur only after deterioration is well-established. Therefore, these findings only represent the “tip of the iceberg” of the cellulose acetate problem.

Australian institutions are currently using a range of strategies, principally copying, low temperature/low humidity storage and segregation, to deal with their deteriorating cellulose acetate collections.

Lack of funding and expertise were the main constraints identified as preventing institutions from dealing effectively with the problem of deteriorating cellulose acetate collections. Most institutions surveyed expressed a willingness to contribute to cooperative strategies by sharing expertise or facilities.

This report recommends that the condition of cellulose acetate collections within Australian institutions be urgently assessed in order to identify actively deteriorating materials needing to be segregated and to assist in the prioritisation of material for copying. Assessment of the value and access requirements of materials should also be undertaken to assist in the management of collections.

Vinegar syndrome affected materials need to be segregated from non-affected materials and those institutions not currently using low temperature/low humidity storage should investigate doing so. A more detailed assessment of the cool storage space needs of Australian material appears to be needed. Low access off-site storage may be suitable for a significant amount of material, and cooperative arrangements for this type of storage need to be examined, particularly for actively deteriorating material.

Given the rate of deterioration of cellulose acetate collections, programs for copying material need to be developed and implemented. These programs should be developed with a recognition of the long-term access needs of copied materials and the costs associated with maintaining access to copied materials.

This report recommends that a cross-institutional working group be established to raise awareness of the importance of addressing the problem of deteriorating collections; share expertise for the development of best practices for conducting surveys and implementing strategies; negotiate cost-effective approaches for managing collections; and investigate funding options. A register of expertise in aspects related to dealing with cellulose acetate collections should be established and publicised. Coordinated copying programs that obviate expensive duplication of effort are also recommended.

2 INTRODUCTION

Cellulose acetate has been a widely used carrier for photographic still negatives, movie film, microfilm and audio. However, it is subject to slow deterioration, releasing acetic acid: this phenomenon is known as the ‘vinegar syndrome’. Accompanying this degradation are many visible signs of physical deterioration – shrinkage, channelling, buckling, the appearance of crystals and bubbles on the surface of the film – and ultimately, loss of the information carried on the film. The vinegar syndrome poses a serious threat to a large portion of our twentieth century documentary heritage. In response to this threat, the National Library of Australia (NLA) launched a project that aimed to examine strategies for dealing with deteriorating collections nationally.

2.1 Background to the Cellulose Acetate Project

The *Cellulose Acetate Project*, undertaken within the National & International Preservation Activities (NIPA) section of Preservation Services within the NLA, commenced in January 2000. During this month, Ceridwen Fraser was employed by the NLA to conduct a literature search and collate information on cellulose acetate deterioration, and strategies currently being used to manage deteriorating collections. From February to June, Angeletta Leggio continued this project by examining the scope of the problem in institutions around Australia and critically evaluating proposed strategies for dealing with deteriorating cellulose acetate collections. This report describes the findings of her study.

2.2 Cellulose Acetate Deterioration

Although created specifically for its apparent stability, cellulose acetate has been found to degrade in a manner that can be alarming in its speed and effect. Concern over the rapidity and extent of degradation has prompted widespread studies into its causes and possible solutions, particularly in the last ten to fifteen years.

Cellulose acetate is the generic term used to describe a variety of acetylated cellulose polymers. These include cellulose diacetate, cellulose triacetate and the mixed esters of cellulose acetate propionate and cellulose acetate butyrate. Both cellulose diacetate and cellulose triacetate may be acetylated on one, two or all three of the available sites on each glycopyranose ring. The degree of substitution, along with the solvents used during the manufacturing process, and plasticisers, such as triphenyl phosphate, which are usually used, determine the composition and properties of the acetate produced.

Cellulose acetate was first produced in 1869.¹ It was used in the photographic and film industries in 1909 when the Eastman Kodak Company produced a small quantity of cellulose acetate sheet film, which was expected to replace unstable cellulose nitrate.² However, due to technical limitations at the time, it wasn't until 1923³ that an adequate manufacturing process was found. This was used to produce 16 mm amateur motion picture film (home movies) on a

¹ D. Aubier, ‘Degradation Caused by Cellulose Diacetate: Analysis and Proposals for Conservation Treatment’, *Restaurator*, vol. 17, no. 2, 1996, pp. 130-143.

² C. R. Fordyce, ‘Motion-Picture Film Support, 1889-1976: An Historical Review’, *SMPTE Journal*, vol 85, 1976, pp. 493-495.

³ D. G. Horvath, *The Acetate Negative Survey Final Report*, University of Louisville Ekstrom Library Photographic Archives, 1987, p. 4.

large commercial scale.⁴ In 1925,⁵ Kodak was the first company to introduce a cellulose acetate “Safety” film in sheet form.

This material, known as cellulose diacetate, became brittle and shrunk within a short period, so modifications were made to increase its stability.⁶ In the early 1930s,⁷ mixed esters, such as cellulose acetate propionate and butyrate, were used to produce 16 mm and 8 mm amateur motion picture film, sheet film, aerial film and x-ray film. In the late 1940s,⁸ 35 mm film and microfilm were produced on cellulose triacetate. By 1951,⁹ production of cellulose nitrate in the USA had stopped, and motion picture film, microfilm and negatives were being produced on triacetate film. At last, many believed a stable carrier had been found. However, in the late 1950s,¹⁰ the Government of India reported a large number of deteriorating triacetate films to the Eastman Kodak Company. This prompted the company to investigate the stability of cellulose triacetate in the 1960s.¹¹ Since the 1970s,¹² many seriously deteriorating cellulose acetate collections have been found. Since the mid 1980s,¹³ research has been conducted to determine why cellulose acetates deteriorate, and how the mechanism can be reversed, slowed or stopped.

Cellulose acetate was experimentally used in magnetic tape audio recordings in 1932 by chemists from AEG. The magnetic particles were suspended in a solution of cellulose acetate and acetone with which the cellulose acetate substrate was coated. Small scale commercial production commenced in 1936 at BASF in Germany; however, wartime shortages caused the substitution of the preferred substrate with PVC. Other manufacturers commenced producing cellulose acetate tape from 1946 until 1964, when the use of polyethylene terephthalate (PET) rapidly replaced it. The new tape enabled thinner tape substrate suitable for use in the compact cassette.

The factors responsible for the hydrolysis of the acetyl side groups from the main cellulose chain appear to be numerous and are typically difficult to fully identify. Anecdotal accounts abound of widely varying rates of cellulose acetate deterioration that cannot be attributed to differences in storage conditions. However, moisture, acids and elevated temperature have all been shown to be crucial factors in controlling the rate of deacetylation.

Deacetylation of cellulose acetate requires the presence of water. While removal of water would effectively prevent hydrolysis of the acetyl side group from occurring, some water is necessary to prevent the acetate film from contracting and becoming brittle. As well as humidity control, low temperature storage has been demonstrated to result in very significant reductions in the rate of cellulose acetate deterioration.¹⁴

Acetic acid generated on deacetylation gradually diffuses to the surface of the film. Initially, the free acid is generated slowly, the rate of reaction being governed primarily by temperature and relative humidity. There is usually little evidence of cellulose acetate degradation during

⁴ Fordyce, *SMPTE Journal*, p. 494.

⁵ Horvath, *The Acetate Negative Survey Final Report*, p. 4.

⁶ Fordyce, *SMPTE Journal*, p. 494.

⁷ Fordyce, *SMPTE Journal*, p. 494.

⁸ Horvath, *The Acetate Negative Survey Final Report*, p. 4.

⁹ P. Z. Adelstein, J. M. Reilly, D. W. Nishimura, & C. J. Erbland, ‘Stability of Cellulose Ester Base Photographic Film: Part 1. – Laboratory Testing Procedures.’ *SMPTE Journal*. vol. 101, 1992, pp. 336-446.

¹⁰ Adelstein, Reilly, Nishimura & Erbland, *SMPTE Journal*, p. 336

¹¹ Adelstein, Reilly, Nishimura & Erbland, *SMPTE Journal*, p. 336

¹² Horvath, *The Acetate Negative Survey Final Report*, p. 4.

¹³ Adelstein, Reilly, Nishimura & Erbland, *SMPTE Journal*, p. 336

¹⁴ J. M. Reilly, *IPI Storage Guide for Acetate Film*, New York: Image Permanence Institute, 1993.

this induction period — visible signs of deterioration therefore only represent the “tip of the iceberg” of the problem. However, after the autocatalytic point has been reached, the levels of free acid rapidly increase as the presence of free acetic acid catalyses further deacetylation and the reaction rate is influenced mainly by the presence of the acidity.

High levels of free acid result in visible signs of deterioration such as shrinkage (through chain scission and loss of plasticiser and solvents), embrittlement (through chain scission); channelling, and the formation of crystals and bubbles on the surface (caused by migration of the plasticiser). The presence of acetic acid may also result in the appearance of a pink or blue colour arising from reversion of anti-halation dyes in the gelatine backing layer to a coloured form. Also, a distinct vinegar odour becomes evident. Reel-to-reel sound material is subject to oxide shedding and embrittlement. The time involved for materials to show signs of physical deterioration is difficult to predict.

Other factors that have been suggested to play a role in cellulose acetate degradation include: the presence of iron,¹⁵ the nature of the plasticiser,¹⁶ the presence of pollutants in the storage environment or residual chemicals from the manufacturing process.¹⁷ Finally, it should be mentioned that, while the vinegar syndrome is the major problem affecting cellulose acetate collections, this material is also subject to other forms of deterioration.

2.3 Strategies for Dealing with Deteriorating Cellulose Acetate Collections

Strategies currently available to assist in dealing with deteriorating cellulose acetate materials fall broadly into the following categories:

- Storage. This may include low temperature/low humidity storage; segregation of cellulose acetate materials; use of enclosures for storing cellulose acetate materials; or the use of acid scavengers to remove acids produced by deteriorating cellulose acetate.
- Copying onto other Media. For example, by duplication, photography, and digitisation.
- Use of Passive Indicators/Monitors, such as commercially produced strips, to indicate levels of deterioration.
- Treatment. For example, in the case of images, the removal of the emulsion from a deteriorating cellulose acetate substrate.

¹⁵ For example, see:

N. S. Allen. et al. ‘Acid-Catalysed Degradation of Historic Cellulose Triacetate, Cinematographic Film: Influence of Various Film Parameters’, *European Polymer Journal*, vol. 24, no. 8, 1988, pp. 707-712.

N. S. Allen. et al. ‘The Degradation and Stabilisation of Historic Cellulose Acetate/Nitrate Base’, *Journal of Photographic Science*, vol. 36, no. 3, 1988, pp. 103-106.

N. S. Allen. et al. ‘The Nature of the Degradation of Archival Cellulose-Ester Base Motion Picture Film: the Case for Stabilisation’, *Journal of Photographic Science*, vol. 36, no. 2, 1988, pp. 34-39.

N. S. Allen. et al. ‘Degradation and Stabilisation of Cellulose Triacetate Base Motion Picture Film’, *Journal of Imaging Science and Technology*, vol. 36, no. 1, 1992, pp. 4-12.

M. Jacobsen, ‘Determining New Standards for Long Term Storage of Film’, Online, Available: <http://www.dancan.dk/standards.html>. 23 March 2000.

M. Edge, et al. ‘Cellulose Acetate: An Archival Polymer Falls Apart’, *Preprints of Contributions to the Modern Organic Materials Meeting, Edinburgh, 14-15 April, 1988*, pp. 67-79.

¹⁶ W. E. Lee, & C. C. Bard, ‘The Stability of Kodak Professional Motion-Picture Film Bases’, *SMPTE Journal*, Nov. 1988, pp. 911-914.

Y. Shinagawa, M. Murayama, & Y. Sakaino, ‘Investigation of the Archival Stability of Cellulose Triacetate Film: the Effect of Additives to CTA Support’, *Polymers in Conservation*, Cambridge: Royal Society of Chemistry, 1992.

¹⁷ J. M. Reilly, *IPI Storage Guide for Acetate Film*. New York: Image Permanence Institute, 1993.

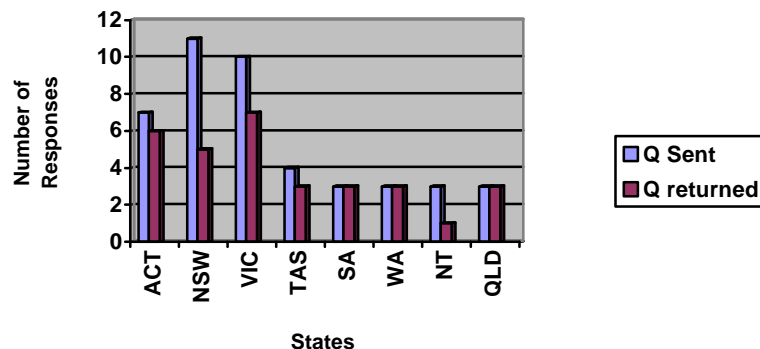
3 METHODOLOGY

A questionnaire (Appendix 1), designed to obtain information about the extent of cellulose acetate holdings and deterioration, existing resources and facilities to deal with cellulose acetate deterioration, access requirements and other needs and constraints of institutions, was sent to forty-four institutions around Australia. Institutions invited to participate were selected because they were considered likely to hold cellulose acetate materials and because, collectively, they represented a range of types of institutions from all States and Territories of Australia.

The questionnaire was devised by a workgroup team at the National Library of Australia, and piloted within the State Library of Victoria. A hardcopy questionnaire was mailed to the Directors of selected institutions, along with a cover letter. The questionnaire could also be completed online via a link from the project website: <http://www.nla.gov.au/preserve/ca.html>. Responses were collected in an Access database.

Thirty questionnaires were returned from twenty-nine institutions.¹⁸ An additional questionnaire was returned after the data had been analysed; results from this questionnaire are not included in the report. However, not all returned questionnaires included responses to every question. A list of respondents is given in Appendix 2. Data was collected from all Australian States and Territories (Figure 1).

Figure 1 Response (by State) to Cellulose Acetate Questionnaire



Other information presented in this report is derived from informal conversations with vendors and institutions dealing with cellulose acetate collections, both in Australia and overseas, as well as from a variety of literature sources. These are generally acknowledged through footnotes in the report.

¹⁸ One major institution returned two questionnaires: one for its collection located in Canberra and one for its collection held in another state.

4 EXTENT OF KNOWLEDGE OF CELLULOSE ACETATE DETERIORATION

Of the thirty respondents, fifteen had conducted surveys on parts of their cellulose acetate collections. Nine respondents had surveyed their negatives collections, ten their motion picture film collections, four their microfilm collections, two their microfiche collection, and four had surveyed their reel-to-reel collections. Although many institutions that had not conducted surveys reported evidence of deterioration, often they were not able to estimate the extent of deterioration within their collections. Although some smaller collections had been surveyed, in general it was the larger institutions that had been able to conduct surveys.

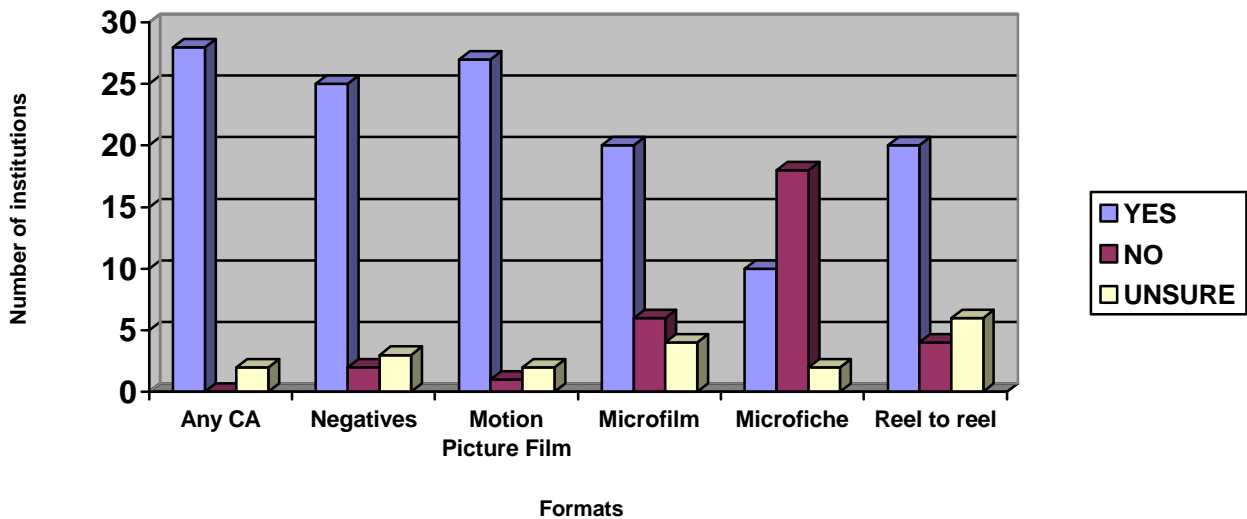
4.1 Summary

Half of the respondents reported that they had conducted surveys on parts of their cellulose acetate collections. More complete knowledge of the condition of cellulose acetate collections within Australia would assist in defining the extent of the deterioration problem nationally and enable institutions to manage their collections more effectively.

5 EXTENT OF CELLULOSE ACETATE HOLDINGS AND DETERIORATION

Most (28 of the 30 institutions surveyed) held cellulose acetate materials (Figure 2). The remaining two institutions were uncertain if their collections contained cellulose acetate.

Figure 2 Numbers of surveyed institutions holding cellulose acetate formats



Number of surveyed collections with (a) *any cellulose acetate*, and cellulose acetate (b) *negatives*, (c) *motion picture film*, (d) *microfilm*, (e) *microfiche* and (f) *reel-to-reel sound material* in their collections.

For each of the formats: negatives, motion picture film, microfilm and reel-to-reel sound material, institutions were asked to express the number of items they held by choosing from a selection of ranges (eg 50 000-100 000). They were also asked to select, from a group of percentages, which percentage best represented the proportion of their collection which was cellulose acetate. Therefore, in the following sections of the report, a range is given both for the total number of items held and the number of cellulose acetate items held.

5.1 Negatives

Of the thirty collections surveyed, twenty-five held flexible negatives produced between 1925 and 1970, and therefore likely to include cellulose acetate.

These twenty-five collections included a total of 3.6-6.5 million flexible negatives of which 1.0-2.0 million were estimated to be cellulose acetate.¹⁹

Table 1 Negatives

Number of respondents providing information about their negatives collections	Total number of negatives (any medium)	Number of cellulose acetate negatives	Number of respondents noting deterioration of their cellulose acetate negatives
25	3.6 - 6.5 million	1.0 – 2.0 million	22

Of the twenty-five respondents, twenty-two noticed either one or more signs of deterioration within their collections. These signs were: a vinegar odour and wavy, channelled or wrinkled negatives.

Of those that reported signs of deterioration, most (seventeen) had seen problems with black-and-white negatives, although deterioration of both colour and black-and-white negatives was reported by some (four).

Overall, the largest problem was found with 4x5" film, followed by medium format, 35 mm, 8x10" and panorama film. One collection had deteriorating aerial film. While fourteen respondents reported problems with more than one size, eight noted deterioration of one format only.

Only thirteen responses provided estimates for the percentage of deteriorated cellulose acetate within their photographic negatives collections. These ranged from 2 to 75%.

The table below gives estimates of the total number of negatives, the total number of cellulose acetate negatives, and the number and percentage of deteriorating cellulose acetate negatives held by these thirteen collections.²⁰

¹⁹ One major library did not include an estimate of the proportion of its negatives collection that was stored on cellulose acetate. The figure given in this report is based on an estimated 50% of this collection being cellulose acetate. The total number of negatives excluding this collection is 3.5-6.2 million of which 0.9-1.8 million items are estimated to be cellulose acetate.

²⁰ Data was obtained by calculating midpoints from estimated ranges provided by respondents.

Table 2 Estimated level of deterioration of cellulose acetate negatives

Thirteen surveyed collections			
Total number of negatives (any medium)	Number of cellulose acetate negatives	Estimated number of deteriorating cellulose acetate negatives	% of cellulose acetate negatives currently suffering from deterioration
4.2 million	1.1 million	0.18 million	16%

5.2 Motion Picture Film

Of the thirty collections surveyed, twenty-seven held motion picture film produced between 1923 and 1980 and therefore likely to include cellulose acetate.

It was estimated that these twenty-seven collections included a total of 0.5-1.2 million motion picture films, of which 0.3-0.7 million were estimated to be cellulose acetate.²¹

Table 3 Motion picture film

Number of respondents providing information about their motion picture film collections	Total number of reels of motion picture film	Number of reels of cellulose acetate motion picture film	Number of respondents noting deterioration of their cellulose acetate motion picture film
27	0.5 – 1.2 million	0.3 – 0.7 million	17

Of the twenty-seven collections with cellulose acetate motion picture film, seventeen respondents reported signs of deterioration (vinegar odour, wavy, wrinkled or shrinking film). Eleven of these reported three or more signs, indicating a very advanced state of deterioration.

Both colour and black-and-white motion picture films are known to be susceptible to vinegar syndrome, and most respondents reported deterioration of both. Deterioration was reported for all the following formats: 8 mm, 16 mm, 35 mm, and 9.5 mm, with deterioration of the most common 16 mm format being reported by the most number of respondents.

Data on the percentage of deteriorated cellulose acetate motion picture film was provided for eight collections. These ranged from 2 to 75%.

²¹ One major institution did not include an estimate of the proportion of its motion picture film collection which was cellulose acetate but did include an estimate of the percentage of cellulose acetate which was deteriorating. The figure in this report is based on an estimated 75% of this collection being cellulose acetate. The total number of reels of motion picture film excluding this collection is 0.4-0.9 million of which 0.2-0.5 million items are estimated to be cellulose acetate.

The table below gives estimates of the total number of reels of motion picture film, the total number of cellulose acetate reels, and the number and percentage of deteriorating cellulose acetate reels held by these eight collections.^{22 23}

Table 4 Estimated level of deterioration of cellulose acetate motion picture film

Eight surveyed collections			
Total number of reels of motion picture film (any medium)	Number of reels of cellulose acetate motion picture film	Estimated number of reels of deteriorating cellulose acetate motion picture film	% of cellulose acetate motion picture film currently suffering from deterioration
0.62 million	0.48 million	0.046 million	10%

5.3 Microfilm

Of the thirty collections surveyed, twenty held microfilm produced between 1940 and 1985 and therefore likely to contain cellulose acetate.

The seventeen²⁴ institutions which provided information about the extent of their microfilm holdings held a total of 0.5-1.0 million reels of microfilm of which 0.1-0.2 million were estimated to be cellulose acetate. Where collections included multiple copies (eg preservation master, printing master and service copy) of a title, respondents were requested to base their estimates solely on the preservation masters.

Table 5 Microfilm

Number of respondents providing information about their microfilm collections	Total number of reels of microfilm	Number of reels of cellulose acetate microfilm	Number of respondents noting deterioration of their cellulose acetate microfilm
17	0.5 – 1.0 million	0.1 – 0.2 million	9

²² As described in the previous footnote, one major institution did not include an estimate of the proportion of its motion picture film collection which was cellulose acetate, but did include an estimate of the percentage of its cellulose acetate motion picture film collection that was deteriorating. The figures in this table are based on an estimated 75% of this collection being cellulose acetate. Excluding this collection, the total number of reels of motion picture film is 0.44 million, of which 0.34 million is estimated to be cellulose acetate and 0.032 million deteriorating cellulose acetate, giving 9% deterioration (data based on seven collections).

²³ Data was obtained by calculating midpoints from estimated ranges provided.

²⁴ Three respondents did not include a size range for their microfilm holdings. Estimates were not included in the results. Two of these institutions were assumed to have small holdings.

Of the eighteen respondents to a question about signs of deterioration, nine had noticed deterioration (vinegar odour, wavy, wrinkled or shrinking film). Deterioration was reported in both 16 mm and 35 mm microfilm.

Only four respondents provided an estimate of the percentage of deteriorated cellulose acetate within their collections. These estimates ranged from 2 to 50%.

The table below gives estimates of the total number of reels of microfilm, the total number of cellulose acetate reels, and the number and percentage of deteriorating cellulose acetate reels of microfilm held by these four collections.²⁵

Table 6 Estimated level of deterioration of cellulose acetate microfilm

Four surveyed collections			
Total number of reels of microfilm	Number of reels of cellulose acetate microfilm	Estimated number of reels of deteriorating cellulose acetate microfilm	% of cellulose acetate microfilm currently suffering from deterioration
0.50 million	0.08 million	0.01 million	13%

5.4 Microfiche

The questionnaire did not enable the size of microfiche holdings to be determined. Of the thirty collections surveyed, ten held microfiche produced between 1940 and 1999, and therefore likely to contain cellulose acetate.

Two of the respondents reported signs of deteriorated cellulose acetate microfiche, but upon further discussion it was found that this applied to jacketed 16 mm microfilm rather than 105 mm microfiche. Interestingly, there is little information about the effects of the vinegar syndrome on microfiche collections in the literature. Given the size of microfiche holdings nationally, any potential problem would be on a very large scale.

5.5 Reel-to-reel sound material

Of the thirty collections surveyed, twenty held reel-to-reel sound material produced between 1946 and 1964 and therefore likely to include cellulose acetate.

The eighteen collections which gave information about the extent of their holdings included a total of 0.2-0.5 million reel-to-reels of which 0.05-0.14 million were estimated to be cellulose acetate.

²⁵ Data was obtained by calculating midpoints from estimated ranges.

Table 7 Reel-to-reel sound material

Number of respondents providing information about their reel-to-reel sound collections	Total number of audio reel-to-reels	Number of cellulose acetate audio reel-to-reels	Number of respondents noting deterioration of their cellulose acetate audio reel-to-reels
18	0.2 – 0.5 million	0.05 – 0.14 million	8

Of these eighteen collections, eight had noticed either signs of brittleness and/or oxide shedding. The questionnaire did not ask for further details regarding other types of deterioration for this format.

Four responses provided an estimate of the percentage of deteriorated cellulose acetate within their collections. These estimates ranged from 2 to 5%.

The table below gives estimates of the total number of audio reel-to-reels, the total number of cellulose acetate audio reel-to-reels, and the number and percentage of deteriorating cellulose acetate audio reel-to-reels held by these four collections.

Table 8 Estimated level of deterioration of cellulose acetate reel-to-reel sound material

Four surveyed collections			
Total number of audio reel-to-reels (any medium)	Number of cellulose acetate audio reel-to-reels	Number of deteriorating cellulose acetate audio reel-to-reels	% of cellulose acetate reel-to-reel sound material currently suffering from deterioration
0.22 million	0.090 million	0.0018 million	2%

5.6 Summary

Most institutions surveyed held cellulose acetate materials. Estimates of the number of these cellulose acetate materials for each format are: 1.0-2.0 million flexible negatives; 0.3-0.7 million reels of motion picture film; 0.1-0.2 million reels of microfilm and 0.05-0.14 million audio reel-to-reels.

The questionnaire revealed that the extent of deterioration of cellulose acetate materials nationally is poorly defined. However, data from those institutions that were able to estimate levels of deterioration, revealed that significant deterioration had already occurred. Because visible signs of deterioration only become apparent after deterioration is well established, it can be assumed that items in these collections are in the advanced stages of deterioration. Naturally, levels of deterioration will increase over the years as cellulose acetate collections continue to age, with the rate being influenced by storage conditions.

6 EXISTING RESOURCES AND FACILITIES

The questionnaire collected data about existing resources and facilities to deal with deteriorating cellulose acetate collections.

Most of the respondents indicated that they would like to become involved in collaborative strategies. Specifically, the following resources were nominated as being potentially available to a collaborative approach:

- *Assistance with assessing other collections*
- *Provision of access to film editing suite to assess movie film*
- *Assistance with materials testing*
- *Assistance with the preparation of guidelines and procedural documents, and providing comments and advice as needed*
- *Participation in a national working group to develop/advise/coordinate/implement “best practice” for collection surveys, implementing strategies, negotiating cost-effective approaches (eg consortia), purchase of equipment/materials and sponsorship*
- *Use of collection as testbed for a project*
- *Engaging in discussion/debate with others dealing with cellulose acetate collections*
- *Sharing of expertise*
- *Supervision and hardware ie computer and scanners*
- *Provision of bibliography of resources about the vinegar syndrome and strategies to deal with deteriorating collections*
- *Hosting email discussion list*

A list of resources that institutions are currently willing to publicise is given in Appendix 3 of this report.

6.1 Low temperature and humidity (cool) storage

Sixteen respondents are using or have used low temperature and humidity (cool) storage as a strategy for their cellulose acetate collections. Twelve are using their own low temperature and humidity store, and seven are using one belonging to another institution. (Some of these collections are using both their own and others' facilities.) Four are using storage in another State.

Questionnaire respondents used five low temperature and humidity storage facilities located in Canberra (ACT), three in New South Wales, three in Victoria, and one each in Tasmania, Western Australia and Queensland.

6.2 Summary

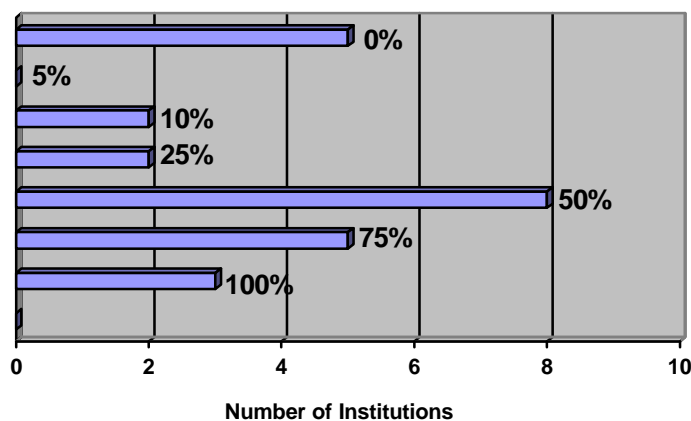
Most institutions surveyed expressed a willingness to contribute to cooperative strategies for dealing with deteriorating cellulose acetate collections by sharing expertise or facilities. Many indicated a willingness to discuss solutions to the deterioration problem with others engaged in dealing with this problem.

Cooperative arrangements or leasing agreements for cool storage space currently exist between a number of institutions. The questionnaire did not provide data on the total space available or the willingness of cool store owners to accept deteriorating material. However, it is believed likely that the amount of material exceeds the cool storage space currently available and that cool store owners would generally not wish to store actively deteriorating material with other material. A more detailed assessment of the cool storage space needs of Australian material appears warranted. This assessment should take account of the access needs and levels of deterioration of material.

7 ACCESS REQUIREMENTS

Survey participants were asked to provide estimates of the percentage of their cellulose acetate collections that could go into low access off-site storage (Figure 3). Five major libraries indicated that between 50% and 100% of their collections could go into low access off-site storage.

Figure 3 Percentages of cellulose acetate collections that could be stored in low access off-site storage



Institutions were asked: “Up to what % of your cellulose acetate collections could go into off-site storage?” The numbers of institutions selecting each percentage value are displayed in this Figure.

When asked to describe access requirements of their collections, respondents highlighted the difficulty in providing accurate information, and the variability in access from collection to collection within a single institution and in a single collection from time to time.

Further information regarding the frequency of access to the collections, by format, is provided in Table 9. The access requirement selected most often by institutions holding negatives collections was “weekly”. For microfilm, “daily” and “weekly” were selected by most institutions holding this format. However, for reel-to-reel sound material, most institutions selected “monthly” access, and for motion picture film, the most popular response was “less frequently than monthly”.

Table 9 Access requirements of cellulose acetate collections

	Several Times a day	Daily	Weekly	Monthly	Less Frequently than Monthly	Total number of respondents to this question
Negatives	0	4	6	4	3	17
Motion Picture Film	1	5	2	1	8	17
Microfilm	2	4	4	0	2	12
Reel-to-Reel Audio	0	1	3	4	0	8

Respondents were asked whether immediate (within 36 hours) or immediate on-site access were required. They were also asked to nominate whether their collections were on open access to the public. Table 10 shows the range of responses by format to these questions.

While most of the microfilm and negatives collections were reported to require immediate (within 36 hours) access, less than half of motion picture film and half of the reel-to-reel sound collections surveyed had this requirement. Numbers of institutions that also provided immediate on-site access were generally similar to the numbers of those providing immediate access. However, for reel-to-reel sound material, on-site access was only required by one institution.

Table 10 Percentage of respondents indicating access requirements (negatives, motion picture film, microfilm, reel-to-reel sound material)

	Open Public Access	Immediate (within 36 hours)	Immediate on-site
Negatives	17%	71%	60%
Motion Picture Film	12%	40%	40%
Microfilm	57%	66%	66%
Reel-to-Reel Audio	23%	50%	7%

7.1 Summary

The majority of respondents indicated that 50% or more of their cellulose acetate collections could go into low access off-site storage. Photographic negatives and microfilm collections were generally accessed more frequently than motion picture film and reel-to-reel sound collections. Immediate and immediate on-site access were also required for a lower proportion of motion picture film and reel-to-reel sound collections than for the other two formats.

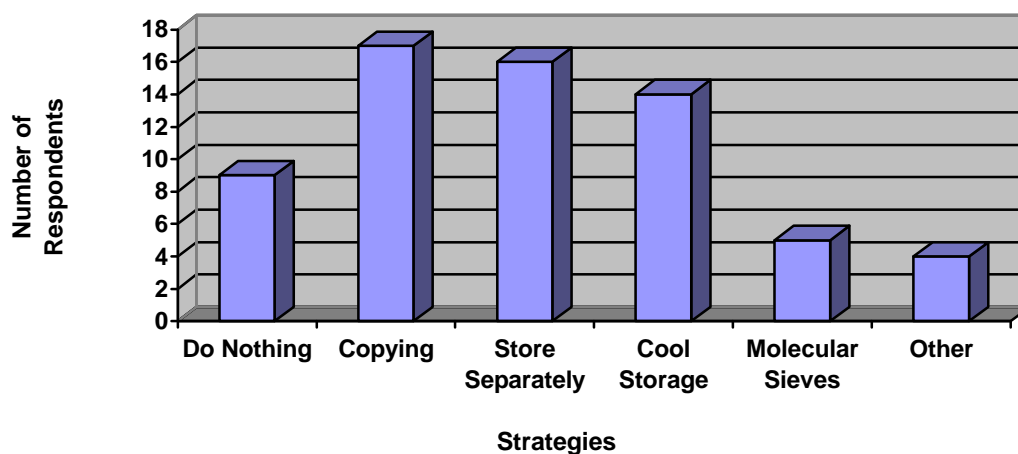
The data suggests that off-site cool storage may be feasible for a significant amount of material held in Australian collections. However, inevitably even a single collection will contain material with a diversity of access needs. Decisions about storage requirements and copying priorities will therefore generally require a more detailed assessment of the access needs of material than our questionnaire was able to collect.

8 STRATEGIES FOR DEALING WITH DETERIORATING CELLULOSE ACETATE COLLECTIONS

A range of strategies has been employed by Australian institutions for managing deteriorating cellulose acetate collections. This section of the report presents both data provided by these institutions and a discussion of each of these strategies.

Twenty-nine of the thirty collections surveyed provided responses to a question asking what strategies they had been able to use for their cellulose acetate collections (Figure 4).²⁶ Some institutions nominated more than one strategy.

Figure 4 Strategies for dealing with deteriorating cellulose acetate collections



Number of surveyed collections using the following strategies (a) do nothing, (b) copying (c) storing separately, (d) cool storage, (e) molecular sieves and (d) other, for their cellulose acetate collections. The use of air extraction systems utilising carbon filters in storage areas, ventilation and drilling holes into enclosures to vent the material were strategies nominated by those who answered “other”.

²⁶ Data presented in this Figure is derived from responses to Question 5 of the Cellulose Acetate Questionnaire.

Twenty-six respondents provided comments on what preservation strategy they considered to be the most cost-effective solution for deteriorating collections. The following comment, provided by a major institution with holdings of all formats examined in the questionnaire, summarises most of the comments made by other respondents.

A combination of cold storage, good ventilation, good packaging and molecular sieves is probably the most cost-effective approach. However this only buys time, it doesn't stop deterioration. Copying has to be an element of any long-term preservation strategy but the costs of this are high.

Also mentioned by other respondents were the need to isolate vinegar syndrome affected materials and the use of continuous risk management programs.

The implementation of any strategy will benefit from the sharing of knowledge and expertise developed in institutions employing that strategy.

8.1 Storage

Storage environments can be controlled to reduce the risk of cellulose acetate deterioration in a number of ways. These include low temperature and low relative humidity (RH) storage; the use of enclosures; segregation of material; and the use of acid scavengers to minimise further deterioration catalysed by the presence of acetic acid.

8.1.1 Low Temperature and Relative Humidity Storage

8.1.1.1 Results

Of the thirty collections surveyed, sixteen mentioned low temperature and humidity (cool) storage as one of the most cost-effective means of managing deteriorating cellulose acetate collections. Of thirty respondents, sixteen²⁷ were using low temperature and low humidity (cool) storage facilities for cellulose acetate materials. Of these, eleven were using cool storage for their negatives, eight for their motion picture film, ten for their microfilm, five for their microfiche, and four were using cool storage for their reel-to-reel sound material.

Twelve surveyed collections owned a low temperature and low humidity (cool) facility. The temperatures utilised for collections were generally between 5 and 10 °C, although some were higher. Reported humidities of cool stores were mainly between 30-35 %RH, with one low temperature store being maintained at 45 %RH.

Some institutions are involved in leasing arrangements of their low temperature and humidity (cool) facilities. This survey did not collect information about how well this arrangement worked or the availability of cool storage space within Australia. However, it is believed likely that the amount of material exceeds the cool storage space currently available and that, due to the damaging autocatalytic effect of acetic acid released by deteriorating cellulose acetate, many institutions would be reluctant to accept deteriorating material. For this reason also, some institutions have chosen to separate deteriorating cellulose acetate material from non-affected material.

²⁷ Data was obtained from responses to Questions 10, 17, 26, 35 and 45 of the Cellulose Acetate Questionnaire.

8.1.1.2 Discussion

Storing cellulose acetate at low temperature and humidity is the most common and effective way to slow down the chemical mechanisms causing cellulose acetate to deteriorate. To minimise deacetylation, storage temperatures should be as low as possible (preferably below 10 °C or ideally below 0 °C), and a relative humidity (RH) between 20 and 30 %RH should be maintained.²⁸ Values of relative humidity below 20 %RH should be avoided as this may cause brittleness and shrinkage of film.

The Image Permanence Institute's *Storage Guide for Acetate Film*²⁹ provides data to assist in assessing the effect of storage conditions on the life expectancy of cellulose acetate collections. If, for example, degrading film is stored at 21 °C and 50 %RH, it will take approximately five years for the level of free acidity to double. If the same film continues to be stored at 21 °C, but the relative humidity is lowered to 20 %RH, the time taken for a doubling in free acidity is extended to approximately twenty years. At a temperature of 10 °C and 50 %RH, the *IPI Storage Guide for Acetate Film* wheel predicts it will take approximately twenty-five years for the levels of free acidity in the film to double. At 10 °C and 20 %RH, this time will increase to approximately one hundred years.

In addition, the storage climate should be relatively stable, with limited temperature and RH fluctuations over an extended period.^{30 31} These fluctuations will cause expansion and contraction of the film, leading to physical damage.³² An acclimatisation area should also be included to condition material and to prevent condensation once material is removed from cool storage and placed in ambient conditions.

For long-term storage, it is recommended that cellulose acetate be stored in areas with good air circulation to ensure that any acetic acid generated does not accumulate and accelerate deterioration. Cool storage facilities may be constructed to achieve the segregation of cellulose acetate or deteriorating cellulose acetate material from other materials by the construction of compartments with separate refrigeration and dehumidification systems.

Generally, low temperature and low humidity storage areas will be purpose built and engineered and may be walk-in units. Moisture content should be controlled using a desiccant (either titanium enhanced silica gel or lithium chloride) type dehumidification system/unit in conjunction with a typical refrigeration system. Atmospheric pollutants, solid particles and gaseous impurities should be removed from the air through the use of mechanical filters, and washing or absorbers.³³ In case of operation problems and shut-down, independent and redundant refrigeration and dehumidification systems may be installed.³⁴ When building these

²⁸ These ranges are recommended by the *IPI Storage Guide for Acetate Film*.

²⁹ The *IPI Storage Guide for Acetate Film* includes a wheel for estimating the effect of a particular storage environment on the life expectancy of cellulose acetate film. The effect of the amount of time spent out of storage may also be estimated.

³⁰ ISO 5466:1992(E), *Photography – Processed safety photographic films – Storage practices*, International Organization for Standardization, Switzerland, section 7.1.

³¹ ANSI/NAPM IT9.11-1993, *Processed Safety Photographic Films – Storage*, American National Standard for Imaging Media, New York.

³² M. Jacobsen, Determining New Standards for Long Term Storage of Film. On-line: <http://www.dancan.dk/standards.html>

³³ ISO Standard 5466:1992(E), Section 7.3.

³⁴ H. Wilhelm, *The Permanence and Care of Colour Photographs: Traditional and Digital Colour Prints, Colour Negatives, Slides, and Motion Pictures*, Preservation Publishing Company: Grinnel, 1993, p. 709.

types of storage units, it is imperative that they are completely sealed. Correctly constructed and sealed storage units will lead to greatly improved efficiency and lower maintenance costs.

The construction of a low temperature/low humidity store will require collaboration between preservation, collection management and building facilities staff to ensure the needs of the collection material as well as requirements of the Buildings Management System (BMS) are met.

8.1.1.3 Costs

The cost of low temperature and low humidity storage includes either the costs of leasing cool storage space or the costs of constructing and maintaining a cool store. Estimates of some of these costs are given in Appendix 4 of this report. Maintenance costs will vary considerably depending on the temperature and humidity parameters chosen, how well sealed the unit is, how much it is accessed, air flow rates and whether air is recirculated. The effect of these parameters on the expected lifetime of the material may be calculated using *IPI Storage Guide for Acetate Film* wheel.

8.1.1.4 Summary

Approximately half of the surveyed institutions use cool storage for parts of their cellulose acetate collections. These cool stores generally operated under temperature and humidity parameters that would be expected to significantly increase the lifetimes of cellulose acetate material stored within them.

Cool storage offers a relatively inexpensive strategy for slowing down cellulose acetate deterioration significantly. It is suitable for both small and large collections and for all cellulose acetate formats.

In constructing a low temperature/low humidity storage system, optimal construction including adequate sealing is crucial in ensuring the effective running of the facility at relatively low cost in the long term.

The costs of low temperature/low humidity storage will be significantly greater for material which is accessed frequently, due to increased energy costs associated with entering the controlled environment, and the costs of retrieving, acclimatising and delivering this material to the user. The life expectancy of this material will also be reduced.

Storing cellulose acetate that is exhibiting signs of deterioration separately from material that is not obviously degrading will prevent acetic acid from accelerating deterioration within this material.³⁵

It is of concern that a significant amount of cellulose acetate material in Australian collections is not being kept in low temperature/low humidity stores. A more detailed assessment of the cool storage space needs of Australian material appears warranted. This assessment should take account of the access needs and levels of deterioration of material.

³⁵ A. Tulsi Ram, et al. 'Simulated Aging of Processed Cellulose Triacetate Motion Picture Films', *Journal of Imaging Science and Technology*, vol. 36, no. 1, Jan / Feb 1992.

8.1.2 Enclosures

8.1.2.1 Results

The questionnaire did not collect data on the types of enclosures used for cellulose acetate within Australian institutions. However, informal discussions lead us to suspect that polypropylene, polyethylene and polyester are widely used, due to their relatively low cost (compared with paper), availability, and inertness and that paper enclosures are used to a lesser extent. A number of large institutions are using polypropylene and polystyrene enclosures to store cellulose acetate motion picture film.

A number of institutions aerate their motion picture films to reduce the build up of acetic acid. Minimisation of acetic acid build up may be achieved by not closing enclosures completely or by lifting the lids of the enclosures.³⁶ The drilling of holes in enclosures, to allow acetic acid to escape, was also reported.

8.1.2.2 Discussion

Enclosures create the immediate storage environment for cellulose acetate materials, and their material and design are therefore extremely important factors in film preservation.

Enclosures offer the advantages of physical protection for the cellulose acetate material, the possibility of excluding potentially damaging pollutants or acidic vapours, and may even be used to remove acid from the immediate storage environment. However, some enclosure materials have the potential to promote degradation and enclosed storage also has the disadvantage of preventing any generated acetic acid from escaping, thereby also promoting degradation.

The type of enclosures chosen will depend on the type and size of collections, and funds available.

ISO Standard 10214:1991 *Photography – Processed photographic materials – Filing enclosures for storage* states that:

“...the choice of enclosure depends on the degree of protection required, the frequency of use, and the application of the photographic material.... Suitable plastic enclosure materials are uncoated polyester, [poly(ethylene terephthalate)], polyethylene and polypropylene as they are generally inert, unplasticised and have good chemical stability...highly plasticised sheetings or coatings shall not be employed...metals used...shall be non-corrosible, for instance, anodised aluminium or stainless steel. The use of steel is permissible provided the surface is well protected by lacquer, enamel, tinning, plating, or some other corrosion-resistant finish...pressure sensitive and ether-linked products should be avoided.”

Tests have shown that

“buffered and non-buffered paper enclosures, placed in contact with degrading acetate films act as acid receptors. Due to the presence of alkali reserve, buffered paper reduces the acidity to a lower level.”³⁷

³⁶ M. Jacobsen, 'Film Storage and Spotting the 'Vinegar Syndrome'', Paper presented at the 136th Technical Conference and World Media Expo, October 12 – 15, 1994. Los Angeles, USA.

³⁷ J-L Bigourdan, P. Z. Adelstein, & J. M. Reilly, 'Effect of Paper Alkaline Reserve on the Chemical Stability of Acetate Base Sheet Film', *Topics in Photographic Preservation*, vol. 7, AIC Photographic Materials Group, Washington, 1997, pp 42 – 54.

Interestingly, some researchers have concerns that polypropylene, polyethylene, or a copolymer of the two, may speed up deterioration due to the presence of peroxides in these commercially produced materials. They suggest that the enclosure and not the film itself may initiate degradation, and that film, if correctly processed and washed, may be more stable than these polymers.³⁸

*MicroChamber*TM paper or boxes have also been used as acid receptors and absorbers³⁹ for cellulose acetate materials. None of the respondents to the questionnaire reported the use of this material.

Aluminium cans have been recommended for the storage of motion picture film. Tin-plated metal has been known to rust and may accelerate deterioration associated with the vinegar syndrome with iron particles acting as catalysts for deacetylation. (Iron may also be present as magnetic particles on information carriers. These include sound strips on motion picture films, and audio reel-to-reels.⁴⁰)

To combat the build-up of acetic acid caused by a sealed environment, enclosures may be opened to the storage environment through ventilation systems. Ventilation may be achieved, for example, by drilling holes in cans or boxes used to store motion picture film. Vented cans in a vault that has good air circulation should ensure minimal degradation of the film from acid build-up. Venting needs to take into account the potential damage caused by acetic acid vapour to other material stored in the area.

Procedures such as loose winding of materials on reels, which allows air circulation will assist also. Some institutions have used molecular sieves in sealed containers to absorb released acid.

A system which involves sealing materials that have been conditioned using a film conditioning apparatus known as FICA (made by the Swedish Film Institute) may be one approach to providing an optimal storage environment for cellulose acetate materials in cold storage. However, in common with other sealed enclosure methods, the presence of acetic acid would need to be addressed.

8.1.2.3 Summary

Avoidance of enclosure materials known to promote cellulose acetate degradation represents part of any strategy to address the problem of deterioration. Suitable enclosures for storing cellulose acetate include photographic activity tested (PAT) buffered and unbuffered paper or board, inert plastics, such as polyester or polypropylene, and aluminium cans for motion picture film. Selection of an enclosure system which prevents accumulation of acetic acid will also prevent the acceleration of acid-catalysed degradation.

³⁸ M. Edge, 'The Decay of Polymers in Information Storage Carriers', *Technology and Our Audio-Visual Heritage: Technology's role in preserving the Memory of the World*, Fourth Joint Technical Symposium, Jan 27 – 29 1995, London, Technical Coordinating Committee, pp. 20 - 30.

³⁹ This material was suggested as a possible option to investigate, by Ramona Duncan-Huse, on the 18.2.00, to an enquiry posted by the NLA on the *CoOL consdist*.

⁴⁰ M. Jacobsen, Film Storage and Spotting the 'Vinegar Syndrome'.

8.1.3 Acid Scavengers

8.1.3.1 Results

Of twenty-nine respondents to a question regarding strategies used for cellulose acetate collections, five institutions stated that they were using molecular sieves. Most were being used within motion picture film collections; however, two institutions may be also using them for their negatives collections.

8.1.3.2 Discussion

Acid Scavengers, for example Kodak™ Molecular Sieve,⁴¹ are placed in enclosures to slow down the accumulation of acid and other by-products of cellulose acetate deterioration and therefore retard further deterioration.⁴²

Acid scavenging molecular sieves are made from sodium aluminium silicate zeolites,⁴³ and other proprietary ingredients. These have a regular geometric chemical structure capable of trapping specific molecules by their shape. Molecules, such as acids, are drawn into the sieve by their attraction to water, which the sieves absorb.

It is recommended that films be carefully monitored, and molecular sieves replaced every two years when used at room temperature, or every 10-15 years at lower temperatures⁴⁴ to ensure replacement occurs when the acid scavenger has become fully saturated.

Potential problems associated with molecular sieves include solvent loss⁴⁵ and excessive (although slow) desiccation of the film.^{46 47}

Materials should be aerated, and replacement carefully monitored to ensure saturation of the sieve does not occur. Monitoring film material for excessive desiccation should also be performed periodically.

8.1.3.3 Costs

Any proposal to use molecular sieves within a collection should incorporate ongoing replacement costs. A major cost is the staff time required to place and replace acid scavenging molecular sieves. The cost of placing acid scavenging molecular sieves within cellulose acetate collections will be dependent upon how often sieves are replaced and the number of

⁴¹ Further information about the Molecular Sieve is available from Gary O'Brien, Kodak (Australasia) Pty Ltd Tel (61 2) 9870 4283.

⁴² Douglas Nishimura, Research Scientist at IPI, personal e-mail correspondence, 23/6/00; and Brenda Keneghan, Polymer Scientist, Victoria & Albert Museum, personal email correspondence, 18/2/00; describe tests carried out at the Image Permanence Institute and the Victoria & Albert Museum which provide evidence for efficacy of this strategy.

⁴³ H. Wilhelm, *The Permanence and Care of Colour Photographs: Traditional and Digital Colour Prints, Colour Negatives, Slides, and Motion Pictures*.

⁴⁴ *Tips on Using Molecular Sieve* (FPC, Kodak)

⁴⁵ Douglas Nishimura, Research Scientist at IPI, personal e-mail correspondence, 23/6/00.

⁴⁶ William T. Murphy, 'Storage of Acetate Film Materials: A Discussion at the National Archives Records Administration', *Journal of Film Preservation*, vol. 23, no. 48, April 1994, Online, <http://orson4.filmv.ucla.edu/fiaf/english/jour.html>

⁴⁷ A. Tulsi Ram, et al, 'The Effects and Prevention of the 'Vinegar Syndrome'', *Journal of Imaging Science and Technology*, vol. 38, no. 3, 1994, pp249-261.

molecular sieves used per item (approximately 3 sieves are required for each 2000 ft 16 mm reel).⁴⁸

8.1.3.4 Summary

Acid scavengers only slow down deterioration; they cannot reverse it. Requiring staff time to monitor and change sieves periodically, they may offer a suitable storage strategy if ideal temperature/humidity storage conditions cannot be maintained or in conjunction with cool storage.

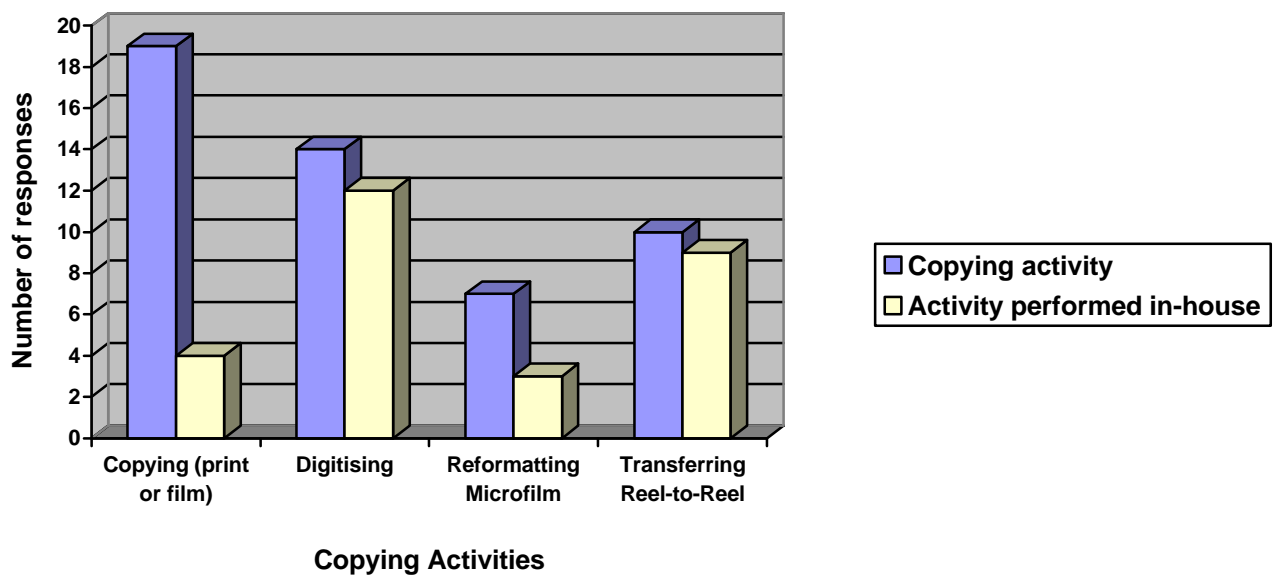
⁴⁸ *Tips on Using Molecular Sieve* (FPC, Kodak)

8.2 Copying

8.2.1 Results

A total of twenty-four respondents⁴⁹ were engaged in a copying program for their cellulose acetate collections. These activities included copying to print or film, digitising material, reformatting microfilm, and transferring audio material to a different carrier, digital or analogue. Copying was being carried out both in-house and/or by an outside contractor.

Figure 5 Copying methods used for cellulose acetate material



Number of surveyed collections using these strategies: (a) copying to print or film, (b) digitising, (c) reformatting microfilm, and (d) transferring reel-to-reel. The column on the right hand side represents the number of respondents performing these tasks *in-house*.

Of the twenty-four respondents, nineteen reported that they were copying for both preservation and access purposes. Five stated that they were only copying for access. All of those copying for access only were also digitising material. Only three of the major libraries were digitising their cellulose acetate collections.

Of the seven respondents who reported that they were reformatting microfilm onto polyester film, all stated that they were involved in a three-tier (preservation master, printing master and service copy) preservation program for microfilm. These seven respondents included five major libraries, and two other major collecting institutions.

Ten respondents were transferring reel-to-reel to another format. Of these, three were transferring to audio cassette only. Other respondents were transferring to a number of formats which included: digital audio tape (DAT), CD-R, polyester reel, and audio cassette.

⁴⁹ Data was obtained from Question 7 of the Cellulose Acetate Questionnaire.

The survey did not collect data on the number of copies or generations produced for each recording,⁵⁰ or sound quality.⁵¹

8.2.2 Discussion

Due to the inherent instability of cellulose acetate, theoretically all information contained on this medium that is to be retained will need to be transferred to another medium. However, due to the resource-intensive nature of copying projects, and the high degree to which storage strategies can increase life expectancies for cellulose acetate collections, the combination of copying and storage strategies will inevitably be used by most Australian institutions. Copying also has the potential to reduce the need for handling the original, prolonging its life expectancy. Prioritisation of material to be copied, based on condition, value and use will assist in targeting copying activity.

Choice of which copying method is to be used will be dependent on the use and value of the collection. Inevitably, no copy will carry as much information as the original and so in many cases institutions will choose to keep original material as well as copies. For copying for preservation purposes it is vitally important that technical specifications that ensure that copies will be accessible in the long term are adopted. Preservation standards, where they exist, should be adhered to. A quality control program is an important part of any copying project. It is sensible to store duplicates away from originals, in case of disaster.

8.2.3 Analogue Copying

Analogue copying refers to the copying or transfer of information to another substrate.⁵² Polyester film or reel is considered to be most suitable for long-term preservation. Video is not considered to be a suitable format to copy motion picture film to for long-term access.

Copying or duplicating to film can be done using *optical, direct duplicate* (contact), *inter-positive duplicate* (contact) and *interpositive duplicate negative* (reduced format, long roll) systems (see Appendix 5 for details).

To ensure long-term stability, all photographic film or paper copies should be properly processed and washed according to standards. Toning properly processed and washed films or prints will also improve the stability of the silver image. *Guidelines for Preservation Microfilming in Australia & New Zealand*⁵³ outlines standards and issues regarding the capture and storage⁵⁴ of microform material. These standards include the use of silver halide polyester film for long-term stability, resolution and density tests, and quality control procedures.

⁵⁰ It was not determined whether a range of formats were used for each recording.

⁵¹ For guidelines regarding sound preservation on polyester reels, see the Audio Engineering Society AES22-1997, *Recommended practice for audio preservation and restoration-storage and handling- storage of polyester-base magnetic tape*.

⁵² Silver halide on polyester film is considered the most stable material for film. For photographic paper, silver halide on either fibre or resin coated paper is recommended.

⁵³ National Library of Australia, *Guidelines for Preservation Microfilming in Australia & New Zealand*, Canberra, 1988.

⁵⁴ AS3674 – 1989, *Storage of Microfilm*, Standards Australia, under review.

8.2.4 Digitisation

Digitisation refers to the conversion of non-digital material to digital form – that is, a form that uses a binary numerical code to represent variables. A wide variety of materials as diverse as still images, sound and moving images may be digitised.

While digitisation offers great advantages for access, allowing users to find, retrieve, study and manipulate material, reliance on digitisation as a preservation strategy could place much material at risk. Rapid obsolescence of digital technologies and media instability render the digitised object vulnerable to loss.

When undertaking digitisation, aspects such as the selection of storage devices, the size of the digital file created, and the format used, need to be considered. The method by which material will be accessed and the assignment of metadata to support both access to the material and its preservation need also to be considered.⁵⁵ The high costs associated with maintaining access to and describing digitised items make it sensible to consider long-term access at the point of capture and so choice of technical specifications is crucial. Following digitisation, decisions will also need to be made about storage and the levels of compression that can be tolerated.⁵⁶ The incorporation of periodic migration or emulation programs as part of the maintenance of digital collections also needs to be planned.⁵⁷

In selecting materials for digitisation, the benefits of the enhanced accessibility afforded by digitisation will be greatest for those materials that are in high demand. Materials that are also of high value and in deteriorating condition would benefit from digitisation, although carrying this out in the conjunction with microfilming ("the hybrid approach") will provide the best assurance of long-term accessibility.

The high costs involved in the digitisation of film, fears of obsolescence, or high cost in maintaining access in the long term, and rights issues "make large-scale digitisation projects daunting and, in many cases, wholly impractical."⁵⁸ However, the access advantages, and the opportunity to "add value" with digitised scripts, reviews and stills have provided the incentive for some film digitisation projects.

8.2.5 Reel-to-Reel Sound Material

Copying of reel-to-reel sound material can be both analogue and digital. Physical formats for storing recorded reel-to-reel include CD-R, polyester reel and DAT. Current practice at the NLA is to migrate the content of acetate recordings onto the following digital and analogue formats: CD-R, 10 inch safety analogue reel and audio cassette.⁵⁹ Audio cassettes are used for access purposes only. It appears that digital mass storage systems will be used increasingly in the future.

⁵⁵ See *Digitisation Subgroup of the Corporate Management Forum IT Working Group* (Australian Commonwealth), Draft (6 June 2000) *Principles for Digitisation* (Chair: Katy Gillette, National Museum of Australia)

See also The National Library of Australia's *Digitisation Policy 2000-2004*
<http://www.nla.gov.au/policy/digitisation.html>.

⁵⁶ Storage, PADI website <http://www.nla.gov.au/padi/topics/10.html>

⁵⁷ The true cost of this is yet unknown. The need for migration and emulation is considered to be an integral part of any long-term digitisation program. It is estimated that these issues need to be addressed approximately every 5 years, and associated costs considered.

⁵⁸ C. Owen, T. Pearson, S. Arnold, 'Meeting the Challenge of Film Research in the Electronic Age', *D-Lib Magazine*, Performing Arts Data Service, University of Glasgow, March 2000, vol. 6, no. 3.

⁵⁹ Specifications for copying can be obtained by contacting the National Library of Australia, Sound Preservation and Technical Services section.

8.2.6 Costs

Copying costs will vary greatly depending on the copying methods chosen. Appendix 4 provides some estimates of costs for a variety of copying processes for a range of formats. Prior to copying, institutions should consider whether the quality of the original cellulose acetate material is sufficient to warrant copying. Although, for example, the cost of microfilming original hard copy material is much greater than duplication of existing microfilm (see Appendix 4), this may provide a better option if the original material still exists and the cellulose acetate copy is badly deteriorated or is a poorly produced copy.

Consultation with organisations that already have expertise with particular copying methods is recommended prior to embarking on a copying project. Due to the high cost of copying, determining whether copies of material already exist in other Australian institutions and joint copying projects may be desirable.

8.2.7 Summary

Most respondents to the questionnaire were carrying out some copying activities for their cellulose acetate collections. All who reported that they were reformatting microfilm onto polyester were using a three-tier (preservation master, printing master and service copy) preservation program. Although five institutions reported that they were copying for access purposes only, it is difficult to assess the degree to which preservation considerations are influencing copying procedures.

Copying strategies and specifications adopted should reflect the use that will be made of the material. Assessment of material will assist in deciding which material should be copied first. This will generally be material that is accessed frequently, is in an advanced stage of deterioration, or is of high value.

8.3 Passive Indicators/Monitors

8.3.1 Results

The use of indicators was implied by only one respondent to the questionnaire.⁶⁰

8.3.2 Discussion

There are several available methods for monitoring the extent of degradation within cellulose acetate collections. Most passive methods involve the use of some type of acid detector. Passive indicators, or monitors, can be used to measure the level of acidity, and therefore the extent of deterioration, within cellulose acetate collections. Indicators do not stop or delay the onset of the vinegar syndrome, but provide information that can assist in the management of cellulose acetate collections – for example, by assisting in the selection of the most appropriate strategy to adopt or in prioritising material for copying.

Indicators currently on the market include the IPI A-D (Acid Detection) strips, Dancan's Dancheck strips or buttons, and M-Check or Film Decay Detector (FDD). Indicators usually contain a dye⁶¹ that changes colour in the presence of acid, on a paper support. Indicating

⁶⁰ One respondent, a major library, commented that they were segregating cellulose acetate materials above 5% free acidity. However, discussions with a number of Australian institutions lead us to believe that passive indicators are used in a number of collections.

⁶¹ This dye is most likely bromocresol-green, sodium salt indicator.

strips are placed in contact with the cellulose acetate film within an enclosure. Easy to use, and non-destructive, they enable monitoring to be carried out at ambient temperatures⁶² and provide a relatively quick result.⁶³ For strip testing of film, aeration of the material prior to testing is recommended.

The main limitation with these types of indicators is that they are unable to give precise acidity level measurements just prior to the autocatalytic point.⁶⁴ Therefore, predictions of how much time is available prior to the material deteriorating to an unusable state, have a high level of uncertainty. Nevertheless, the consensus amongst participants at the recent Joint Technical Symposium in Paris 2000, was that the indicators were adequate for the level of monitoring generally being carried out in collecting institutions.

Other limitations which researchers are currently looking at ways to improve include:⁶⁵

- indicators don't give *instant* response on the condition of the film;
- the requirement for indicators to be in full contact with the film to give an accurate reading.

An article by Fischer and Reilly⁶⁶ discusses the use of Danchek and Film Decay Detector (FDD) monitors in collections. These detectors are sold in a button form and are used to detect the build-up of acetic acid in 35 mm motion picture film cans. Holes are drilled into the side of the cans, so that the indicator is directly exposed to the air in the can but can be viewed from the outside. Both indicators may be used as long-term monitors.

8.3.3 Costs

While relatively inexpensive to purchase, passive indicators require human time to place in enclosures with cellulose acetate material and to retrieve and record results. For large collections, sampling may be the only possible way of monitoring material.

8.3.4 Summary

Passive indicators offer a useful tool in the management of cellulose acetate collections by providing a method of determining the extent of deterioration.

⁶² Although some indicators have been known to cause variable results at ambient temperatures.

⁶³ Anywhere between 2-96 hours depending on the product.

⁶⁴ For example, some strips may not give an accurate reading in the middle 0.5 range.

⁶⁵ Other types of indicators being developed by the Centre for Archival Polymeric Materials.

M. Edge, 'The Decay of Polymers in Information Storage Carriers'

⁶⁶ M. C. Fisher & J. M. Reilly, 'Use of Passive Monitors in Film Collections', *Topics in Photographic Preservation*, vol 6, 1995, AIC Photographic Materials Group, Washington, pp. 11-40.

8.4 Treatment

8.4.1 Results

None of the respondents stated in the questionnaire that they were using treatments for recovering information on cellulose acetate material.

8.4.2 Discussion

The treatment of degraded or degrading cellulose acetate film is complex. Emulsion stripping by using solvents to separate the emulsion from the cellulose acetate material and washing of film to remove acetic acid have been used to treat cellulose acetate materials. Although the commercial firm, *The Chicago Albumen Works*,⁶⁷ reports a high success rate with their acetate stripping and recovery service, these techniques are not always successful and involve risks to the material. They are complicated, time-consuming and expensive, and are most probably only applicable to individual items rather than entire collections.

The Chicago Albumen Works performs treatments for six months of the year (winter months), during which time they currently only treat one thousand negatives. *The Chicago Albumen Works* has offered to enter into discussions regarding the establishment of a similar work program in Australia. This would probably require the collaboration, commitment and resources of a number of institutions.

8.4.3 Costs

Some costs for treating cellulose acetate material are given in Appendix 4. They are given in US\$ and include stripping, duplicating and the return of the pellicle (but not insurance, shipping and handling to the USA). A more cost-effective approach if treatment options were to be widely adopted within Australia, would be the establishment of a laboratory within Australia.

8.4.4 Summary

The high costs associated with treating material prohibit this option from being used to treat large quantities of material. While treatment may be an option for individual items, it is not a feasible strategy for dealing with the bulk of deteriorating cellulose acetate materials. Treatments also entail some risk to the item.

8.5 Resource Implications

The size of most institutions' holdings means that resources are insufficient for copying or transferring to other media in the short term. Storing material more optimally offers a relatively inexpensive means of significantly extending the lifetime of cellulose acetate.

Treatments are highly expensive and unlikely to be used to any great extent for cellulose acetate material.

In general, choice of one copying strategy over another will be determined by the purpose for which the material will be used. For example, for material that is frequently accessed, the comparatively expensive digitisation option may be chosen for the advantages it offers in

⁶⁷ Contact: Doug Munson, Chicago Albumen Works, dmunson@albumenworks.com, www.albumenworks.com.

terms of ease of transmission and access. For often used material, it might well be considered that the costs of periodically migrating the digital files to new operating systems will be worth the expenditure.

Evaluation of collections in terms of condition, use and value is an essential first step in any attempt to determine the most suitable and cost-effective method for dealing with cellulose acetate collections.

In comparing the costs of the various copying strategies, it is essential to consider the costs of storing cellulose acetate material while copying is taking place, after copying has taken place (if cellulose acetate is to be kept) as well as storage and maintenance costs for copied items on new media. Other costs to be taken into consideration include staff time for preparing material for copying and quality control procedures. Storage strategies will include maintenance costs and costs for the retrieval of items.

In his article, “The Preservation of Acetate Film Materials – A Cost Benefit Analysis for Duplication and Cool/Cold Storage”,⁶⁸ Steven Puglia presents a framework designed to facilitate conducting a cost-benefit analysis for comparing duplication with cool/cold storage. As part of duplication costs, he includes the actual cost to duplicate each item, the cost to inspect the duplicates, and the cost to store the originals while they are being duplicated. He calculates storage costs at a variety of different environmental conditions, corresponding to a range of life expectancy values.

He emphasises that for large collections, improved storage is vital to complete the project –

“storage is considerably less expensive than ... duplication ... and it could be combined with prioritised duplication of only the actively deteriorating negatives, the negatives that are of high value, and the negatives that are requested frequently.”

“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 acetate film materials to extend the usable life.”

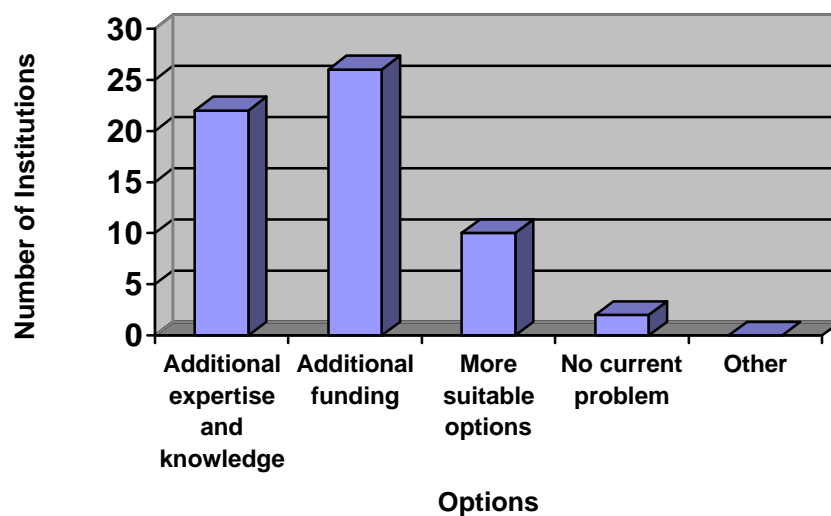
Cost estimates for some of the strategies discussed in this report are given in Appendix 4.

⁶⁸ S. Puglia, ‘The Preservation of Acetate Film Materials: A Cost Benefit Analysis for Duplication and Cool / Cold Storage’, *Topics in Photographic Preservation* vol. 6, 1995, AIC Photographic Materials Group: Washington pp50-79.

9 IDENTIFIED NEEDS AND CONSTRAINTS

Twenty-six respondents believed that further funding was required by their institution to deal more effectively with the problem of cellulose acetate deterioration. Additional expertise and knowledge was nominated by twenty-two respondents and “more suitable options” was nominated by ten respondents as being helpful in dealing more effectively with deteriorating collections (Figure 6).

Figure 6 Types of resources required to deal with deteriorating cellulose acetate material



The questionnaire asked, “What would help you deal effectively with the problem (of cellulose acetate deterioration)? The number of surveyed collections nominating each of the following responses are shown in this Figure: (a) additional expertise and knowledge, (b) additional funding, (c) more suitable options (d) no current problem, and (e) other.

Twenty-five respondents commented on the issues and constraints needing to be considered in developing a strategy for dealing with their collections. The majority considered funding and the high cost of copying as a major constraint. This was followed by lack of expertise, knowledge, and staff to assess the problem and perform tasks associated with managing the problem.

Other problems included lack of space and suitable storage facilities, size of collections, limitations with available local outsourcing options, building redevelopment, and copyright and ownership issues with copying material. The reluctance of others within their institution to view addressing the problem as a priority was also cited as a difficulty.

9.1 Summary

Funding and expertise were the main constraints encountered by most of the institutions. The data suggests that there is a need to promote an awareness of the problem to senior managers within Australian institutions.

10 CONCLUSIONS

Most institutions surveyed held cellulose acetate materials. Estimates of the number of these cellulose acetate materials for each format are: 1.0-2.0 million flexible negatives; 0.3-0.7 million motion picture film; 0.1-0.2 million reels of microfilm and 0.05-0.14 million audio reel-to-reels.

The questionnaire revealed that the extent of deterioration of cellulose acetate materials nationally is poorly defined. Half of the respondents reported that they had conducted surveys on parts of their cellulose acetate collections. More complete knowledge of the condition of cellulose acetate collections within Australia would assist in defining the extent of the deterioration problem nationally and enable institutions to manage their collections more effectively.

Data from those institutions that were able to estimate levels of deterioration revealed that significant deterioration had already occurred. Given that visible signs generally occur only after deterioration is well-established, this survey was necessarily limited to uncovering only the “tip of the iceberg” of the cellulose acetate problem. Naturally, levels of deterioration will increase over the years as cellulose acetate collections continue to age, with the rate being influenced by storage conditions.

Most institutions surveyed expressed a willingness to contribute to cooperative strategies for dealing with deteriorating cellulose acetate collections by sharing expertise or facilities. Many indicated a willingness to discuss solutions to the deterioration problem with others engaged in dealing with this problem.

Cooperative arrangements or leasing agreements for cool storage space currently exist between a number of institutions, although the questionnaire did not provide data on the total space available or the willingness of cool store owners to accept deteriorating material. A detailed assessment of the cool storage space needs of Australian material, which takes account of the access needs and levels of deterioration of material, appears warranted.

The majority of respondents indicated that 50% or more of their cellulose acetate collections could go into low access off-site storage. Data collected appears to indicate that, for many Australian institutions holding cellulose acetate material, investigation of low access (possibly off-site) storage is warranted. Decisions about storage requirements and copying priorities will require institutions to make a detailed assessment of the access needs and nature of their material.

A range of strategies has been employed by Australian institutions for managing deteriorating cellulose acetate collections.

Approximately half of the surveyed institutions use cool storage for parts of their cellulose acetate collections. Cool/low humidity storage offers a relatively inexpensive strategy for significantly improving the life expectancy of cellulose acetate. The costs of low temperature/low humidity storage will be greater for material that is accessed frequently.

Storing cellulose acetate that is exhibiting signs of deterioration separately from material that is not obviously degrading will retard deterioration within this material. Avoidance of enclosure materials known to promote cellulose acetate degradation as well as selection of an enclosure system that prevents accumulation of acetic acid will constitute part of any strategy to address the problem of deterioration. The use of acid scavenging molecular sieves may also be used to slow deterioration but requires staff time to monitor and change sieves periodically.

Most respondents to the questionnaire were carrying out some copying activities for their cellulose acetate collections. All who reported that they were reformatting microfilm onto polyester were using a three-tier (preservation master, printing master and service copy) preservation program. It is difficult to assess the degree to which preservation considerations are influencing copying procedures for other formats. Copying programs are expensive; collections should therefore be monitored and an assessment of the material should be used to prioritise and guide copying programs.

Generally, funding and expertise were the main constraints encountered by most of the institutions in dealing with their cellulose acetate collections. The data suggests that there is a need to promote an awareness of the problem to those responsible for allocating funding within Australian institutions.

11 RECOMMENDATIONS

11.1 Assessment

- The condition of cellulose acetate collections should be urgently assessed. Clearer definition of the condition of collections will assist in identifying actively deteriorating materials needing to be segregated, will guide the selection of material to be copied, and may assist in finding funding.
- Cellulose acetate collections should be assessed for the levels of use and value of materials that they contain to assist in making decisions about the management of the collection.
- Assessment tools should be developed to assist with evaluating cellulose acetate materials in collections and the identification of appropriate strategies to deal with these collections.
- A detailed assessment of the cool storage space needs of Australian material appears warranted. This assessment should take account of the access needs and levels of deterioration of material.

11.2 Strategies

- Where possible, materials affected by the vinegar syndrome should be isolated from non-affected materials.
- Investigation of low access off site storage appears warranted for some Australian collections.
- Institutions not currently storing their collections in low temperature/low humidity stores should investigate doing so.
- Enclosure materials known to promote deterioration should be avoided.

- Programs for copying cellulose acetate materials should be developed and implemented following assessment of collections.
- Consideration of the issues associated with maintaining long-term access to copied material should be considered at the time of copying. Preservation standards, where they exist, should be adhered to. The cost of maintaining access to the copied material should be considered prior to copying.

11.3 Cooperation

- A cross-institutional working group should be established to:
 - raise awareness of the importance of addressing this issue;
 - share expertise for the development of best practice for conducting surveys and implementing strategies;
 - negotiate cost-effective approaches to managing deteriorating collections;
 - investigate funding opportunities.
- A register of expertise in aspects related to dealing with cellulose acetate collections should be developed and publicised.
- Cooperative arrangements for low temperature/low humidity stores should be examined. This may be particularly useful for the storage of deteriorating materials.
- Coordinated copying programs that include identifying copies of materials existing within Australia (and thereby avoiding costly duplication of effort) should be examined.
- Coordination and cooperation between institutions with motion picture and reel-to-reel sound holdings that includes the provision of support and advice for smaller collections is recommended.

12 ACKNOWLEDGEMENTS

The National Library of Australia wishes to acknowledge the contribution of all who provided information about their cellulose acetate collections or their research into strategies to deal with deteriorating collections. Those who provided invaluable data through the completion of questionnaires are thanked; institutions that returned surveys are listed in Appendix 2.

ScreenSound Australia, and the State Library of Victoria are thanked for their assistance in the development of the Cellulose Acetate Questionnaire.

Douglas Nishimura (Image Permanence Institute), Mick Newnham, Peter Shaw (ScreenSound Australia) and Chris Lowger (National Archives of Australia) are thanked for their advice and generosity in providing responses to numerous questions that arose in the course of this project.

APPENDICES

APPENDIX 1
CELLULOSE ACETATE QUESTIONNAIRE

CELLULOSE ACETATE PROJECT
QUESTIONNAIRE



We urge you to complete the questionnaire online at <http://www.nla.gov.au/preserve/ca.html>. Part 1 should be completed. The National Library of Australia encourages you to also complete Part 2.- the additional details which you provide in this section will contribute to the quality of the results. Please return this questionnaire by 5th May 2000.

Name of Institution:

Address:

Person completing questionnaire:

Position:

Telephone number:

E-mail:

PART 1

GENERAL (circle which applies)

1. Do you have any cellulose acetate material in your collections? YES NO UNSURE

Do you have any of these materials within your collections?

(circle which apply)

- | | | | | |
|----|--|-----|----|--------|
| a. | Plastic or Flexible negatives produced between 1925-1970 | YES | NO | UNSURE |
| b. | Motion Picture Film produced between 1923-1980 | YES | NO | UNSURE |
| c. | Microfilm produced between 1940-1985 | YES | NO | UNSURE |
| d. | Microfiche produced between 1940-1999 | YES | NO | UNSURE |
| e. | Reel to Reel Sound produced between 1946-1964 | YES | NO | UNSURE |

If you have answered NO for Questions 1 or all parts of question 2: you have now completed this survey. Thank you.

CONDITION

- 3a. Has a survey been conducted on any cellulose acetate material in your institution to determine its condition? YES NO
- 3b. If YES, specify type of material listed in 2. (eg; flexible or plastic negatives, motion picture film, microfilm/fiche, reel to reel sound) that was identified as showing deterioration.

Complete 4a-4c if a survey hasn't been conducted: (circle which applies)

- 4a. Have you identified deteriorating cellulose acetate material? YES NO
- 4b. Have you noticed any strange odours, especially a vinegar smell, in the area where your cellulose acetate collections are stored? YES NO
- 4c. If YES for 4a or 4b, what type of material listed in 2. is stored in the area?

STRATEGIES

- | | | |
|--|--|--------------------------|
| 5. What strategies have you been able to use for your cellulose acetate collections? | No strategies implemented | <input type="checkbox"/> |
| | Copying (either print, film or digitisation) | <input type="checkbox"/> |
| | Store cellulose acetate separately | <input type="checkbox"/> |
| | Using cool storage | <input type="checkbox"/> |
| | Using molecular sieves | <input type="checkbox"/> |
| | Other (specify) | <input type="checkbox"/> |
- (tick all which apply)**

6. What would help you deal effectively with this problem? (**tick all which apply**)

Additional expertise and knowledge	<input type="checkbox"/>
Additional funding	<input type="checkbox"/>
More suitable options	<input type="checkbox"/>
No current problem with acetate collections	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>

7. What copying activities, listed below, does your organisation use for cellulose acetate materials? (Indicate if done in-house). (circle which apply)

Copying to film or print	YES	In-house	Transferring sound material	YES	In-house
Digitising material	YES	In-house	Reformatting microfilm	YES	In-house

8. Are the activities listed in 7. for *access* purposes (for the public to view) only, *preservation* purposes (used as a surrogate for the original) or *Both*? **Access Both** **Preserve NA**

ACCESS & STORAGE (circle which apply)

9. Up to what % of your cellulose acetate collections could go into low access off-site storage?

0% 2% 5% 10% 25% 50% 75% 100%

10a. If you store cellulose acetate material in cool storage (below 16°C), does the store belong to your institution? **YES** **NO** **NA**

10b. Do you store other material with cellulose acetate in cool storage? **YES** **NO** **NA**

10c. Optional: Please specify which institution owns the cool store you are using.

10d. Optional: Please specify what types of cellulose acetate material listed in 2. is stored in cool storage.

11. Please comment on the access requirements for your cellulose acetate collection including the frequency with which material is accessed, how immediately this access is required, and the range of access requirements for different material in the collection.

COMMENTS (please attach additional pages if required)

12. What preservation strategy do you consider to be the most cost-effective solution for managing your deteriorating cellulose acetate collections, and why?

13. What issues/constraints need to be considered in developing a strategy for dealing with your collection?

14. Are you interested in becoming further involved in a collaborative project with the NLA, to develop cost-effective solutions to deal with deteriorating cellulose acetate collections? YES or NO Comment, and state what commitment you or your organisation may be able to give.

Thank you for completing Part 1 of this questionnaire. Details are confidential, but collated results may be incorporated into a Masters thesis being undertaken at the University of Canberra as part of the Conservation of Cultural Materials program, or for any purposes which the National Library of Australia sees fit.

PART 2

Complete only the sections in this questionnaire relating to cellulose acetate materials that your institution holds. Ignore sections relating to materials that your institution does not hold. Thank you.

PLASTIC OR FLEXIBLE NEGATIVES

15a. Estimate the number of negatives (on any medium) in your collection (tick which applies)

1-1000	<input type="checkbox"/>	1000-5000	<input type="checkbox"/>	5000-10,000	<input type="checkbox"/>	10,000-25,000	<input type="checkbox"/>
25,000-50,000	<input type="checkbox"/>	50,000-100,000	<input type="checkbox"/>	100,000-250,000	<input type="checkbox"/>	250,000-500,000	<input type="checkbox"/>
500,000-750,000	<input type="checkbox"/>	750,000-1 million	<input type="checkbox"/>	Over 1 million	<input type="checkbox"/>		<input type="checkbox"/>

15b. How do you calculate the number of negatives in your collection? (tick which applies)

Number of individual items	<input type="checkbox"/>
Titles	<input type="checkbox"/>
Number of images per negative	<input type="checkbox"/>
Number of strips of film	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>

16. Estimate % of cellulose acetate negatives in your collection.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

17a. At what temperature and relative humidity are your cellulose acetate negatives stored?

°C	%RH
<input type="text"/>	<input type="text"/>

17b. If not known, are they stored in a controlled environment?

YES NO

18a. Are cellulose acetate negatives in your collection accessed?

YES NO

18b. If YES, how often is access to the collection?

Several times a day daily weekly monthly once a year Other (please specify)

18c. Is immediate (within 36 hours) access required?

YES NO

18d. Are any of the cellulose acetate negatives on open access to the public?

YES NO

18e. Do you need immediate on-site access to the negatives?

YES NO

19. Has a condition survey been conducted on the cellulose acetate negatives?

YES NO

Have you found plastic/flexible negatives in your collection that show the following signs of deterioration? (circle below which apply)

YES NO

wavy smell like vinegar wrinkled channelled

If answer for 20. is NO, do not continue with this section of the questionnaire relating to plastic or flexible negatives.

21. Are the deteriorating cellulose acetate negatives: (circle which apply) Colour? B&W? Both?

22. What format is the deteriorating film? (circle which apply)

35 mm Medium format eg: 6x7 or 6x6 etc 4x5" 8x10" panorama Other (please specify)

23. Estimate % of cellulose acetate negatives showing signs of cellulose acetate deterioration.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

24. Complete only the sections in this questionnaire relating to cellulose acetate materials that your institution holds. Ignore sections relating to materials that your institution does not hold. Thank you.

MOTION PICTURE FILM

24. Estimate the number of motion picture film (on any medium) in your collection (tick which applies)

1-1000	<input type="checkbox"/>	1000-5000	<input type="checkbox"/>	5000-10,000	<input type="checkbox"/>	10,000-25,000	<input type="checkbox"/>
25,000-50,000	<input type="checkbox"/>	50,000-100,000	<input type="checkbox"/>	100,000-250,000	<input type="checkbox"/>	250,000-500,000	<input type="checkbox"/>
500,000-750,000	<input type="checkbox"/>	750,000-1 million	<input type="checkbox"/>	Over 1 million	<input type="checkbox"/>		<input type="checkbox"/>

If you hold multiple copies (eg. preservation master, access copy) of a title, please answer the following questions in this section just for the preservation master.

25. Estimate % of cellulose acetate motion picture films in your collection.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

26a. At what temperature and relative humidity are your cellulose acetate films stored?

°C	%RH

26b. If not known, are they stored in a controlled environment? YES NO

27a. Are cellulose acetate motion picture films in your collection accessed? YES NO

27b. If YES, how often is access is to the collection?
 Several times a day daily weekly monthly once a year Other (please specify)

27c. Is immediate (within 36 hours) access required? YES NO

27d. Are the cellulose acetate films on open access to the public? YES NO

27e. Do you need immediate on-site access to the cellulose acetate films? YES NO

28. Has a condition survey been conducted on the cellulose acetate films? YES NO

29. Have you found cellulose acetate motion picture films in your collection that show the following signs of deterioration? (circle which below apply) YES NO

wavy smell like vinegar wrinkled shrinking

If answer for 29. is NO, do not continue with this section of the questionnaire relating motion picture film.

30. Are the deteriorating cellulose acetate motion picture films Colour? B&W? Both?
 (circle which apply)

31. What format is the deteriorating cellulose acetate motion picture film? (circle which apply)

8 mm 16 mm 35 mm Other (please specify)

32. Estimate % of cellulose acetate motion picture film showing signs of cellulose acetate deterioration.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

Complete only the sections in this questionnaire relating to cellulose acetate materials that your institution holds. Ignore sections relating to materials that your institution does not hold. Thank you.

MICROFILM

33. Estimate the number of microfilm (on any medium) in your collection (tick which applies)

1-1000	<input type="checkbox"/>	1000-5000	<input type="checkbox"/>	5000-10,000	<input type="checkbox"/>	10,000-25,000	<input type="checkbox"/>
25,000-50,000	<input type="checkbox"/>	50,000-100,000	<input type="checkbox"/>	100,000-250,000	<input type="checkbox"/>	250,000-500,000	<input type="checkbox"/>
500,000-750,000	<input type="checkbox"/>	750,000-1 million	<input type="checkbox"/>	Over 1 million	<input type="checkbox"/>		<input type="checkbox"/>

If you hold multiple copies (eg. preservation master, printing master and service copy) of a title, please answer the following questions in this section just for the preservation master.

34. Estimate % of cellulose acetate microfilms in your collection.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

35a. At what temperature and relative humidity are your cellulose acetate microfilms stored?

°C	%RH

35b. If not known, are they stored in a controlled environment? YES NO

36a. Is cellulose acetate microfilm within your collections accessed? YES NO

36b. If YES, how often is access to the collection?

Several times a day daily weekly monthly Once a year Other (please specify)

36c. Is immediate (within 36 hours) access required? YES NO

36d. Is cellulose acetate microfilm on open access to the public? YES NO

36e. Do you need immediate on-site access to cellulose acetate microfilm? YES NO

37a. Is your institution reformatting cellulose acetate microfilm to polyester film? YES NO

37b. If YES, are you producing 3 tier generation archival copies? (eg. preservation master, printing master and service copy) YES NO

38. Has a condition survey been conducted on the cellulose acetate microfilms? YES NO

39. Have you found microfilms in your collection that show the following signs of deterioration? (circle which below apply) YES NO

wavy smell like vinegar wrinkled shrinking

If answer for 39. is NO, do not continue with the section of the questionnaire relating to microfilm (go to 42.)

40. What format is the deteriorating microfilm? (circle which apply)

16 mm 35 mm 105 mm Other (please specify)

41. Estimate % of cellulose acetate microfilm showing signs of cellulose acetate deterioration.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

42. Have you found cellulose acetate microfiche within your collections, showing signs of cellulose acetate deterioration? YES NO

Complete only the sections in this questionnaire relating to cellulose acetate materials that your institution holds. Ignore sections relating to materials that your institution does not hold. Thank you.

REEL TO REEL SOUND

43a. Estimate the number of reel to reels (on any medium) in your collection (tick which applies)

1-1000	<input type="checkbox"/>	1000-5000	<input type="checkbox"/>	5000-10,000	<input type="checkbox"/>	10,000-25,000	<input type="checkbox"/>
25,000-50,000	<input type="checkbox"/>	50,000-100,000	<input type="checkbox"/>	100,000-250,000	<input type="checkbox"/>	250,000-500,000	<input type="checkbox"/>
500,000-750,000	<input type="checkbox"/>	750,000-1 million	<input type="checkbox"/>	Over 1 million	<input type="checkbox"/>		<input type="checkbox"/>

43b. Does this figure include 16 mm Magfilm? YES NO

44. Estimate % of cellulose acetate reel to reels in your collection.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

Note: Do not include disks known as *Acetates* in the figures above

45a. At what temperature and relative humidity are your cellulose acetate reels stored?

°C	%RH

45b. If not known, are they stored in a controlled environment? YES NO

46a. Are cellulose acetate reels within your collections accessed? YES NO

46b. If YES, how often is access to the collection?

Several times a day daily weekly monthly Once a year Other (please specify)

46c. Is immediate (within 36 hours) access required? YES NO

46d. Are cellulose acetate reel to reels on open access to the public? YES NO

46e. Do you need immediate on-site access to cellulose acetate reels? YES NO

47a. Are you transferring reels to another format? YES NO

47b. If YES, please specify format you are using (eg: cassette tape, CD-R, DAT, polyester reels, etc.)

48. Has a condition survey been conducted on the cellulose acetate reels? YES NO

49. Have you found reels in your collection that have become brittle or are suffering form oxide shedding? YES NO

If answer for 49. is NO, do not continue with this section of the questionnaire relating to reel to reel material.

50. Estimate % of cellulose acetate reels showing signs of cellulose acetate deterioration.

0% 2% 5% 10% 25% 50% 75% 100% Unsure

Thank you for completing Part 2 of this questionnaire. Details are confidential, but collated results may be incorporated into a Masters thesis being undertaken at the University of Canberra as part of the Conservation of Cultural Materials program, or for any purposes which the National Library of Australia sees fit.

APPENDIX 2

INSTITUTIONS PARTICIPATING IN THE CELLULOSE ACETATE SURVEY⁶⁹

ACT Heritage Library
Albany Public Library and Local Studies Collection
Archives Office of Tasmania
Australian Broadcasting Corporation
Australian Institute of Aboriginal and Torres Strait Islander Studies
Australian War Memorial
Botanic Gardens of Adelaide and State Herbarium Library
Cinemia
City of Melbourne
Library and Information Service of Western Australia
Macleay Museum (University of Sydney)
Museum Victoria
National Archives of Australia
National Library of Australia
Northern Territory Library and Information Service
Performing Arts Museum
Powerhouse Museum
Queensland Museum
Queensland State Archives
ScreenSound Australia
State Library of New South Wales
State Library of Queensland
State Library of South Australia
State Library of Tasmania
State Library of Victoria
State Records New South Wales
State Records of South Australia
Tasmanian Museum and Art Gallery
University of Melbourne Archives
Western Australian Museum

⁶⁹ Because a response from one of the listed institutions was received after data had been analysed, data from this institution was not incorporated into this report; one institution returned two questionnaires.

APPENDIX 3

Resources currently available within Australia for dealing with deteriorating cellulose acetate collections

The following resources were offered by institutions that indicated that they were happy for their resources to be publicised. A list of other resources (not linked to institutions) is available in the report (Existing Resources and Facilities).

The State Library of South Australia currently hosts the discussion list, *Microlink*, a forum for the exchange of practical issues and ideas amongst microfilming practitioners within Australia and internationally (<http://www.slsa.sa.gov.au/microlink/>). It has offered this list as a forum to discuss issues related to cellulose acetate microfilm collections.

As part of the Cellulose Acetate Project, the National Library of Australia has conducted a literature review of papers about cellulose acetate and the management of deteriorating collections. It has also compiled an annotated bibliography of references. Both these resources are available to other institutions dealing with cellulose acetate collections (contact: Hilary Berthon, email: hberthon@nla.gov.au).

The Digital & Audio Preservation Resources (DAPR) area of Preservation Services at the National Library is willing to offer guidance to other institutions transferring cellulose acetate reel-to-reel sound material (contact: Shelley Grant, email: sgrant@nla.gov.au).

ScreenSound Australia provides support for institutions dealing with cellulose acetate motion picture film collections through its *Distributed National Collection* program. It will provide:

- Informal advice for short answer queries (e.g. over-the-phone);
- on-line technical terms glossary and archival advice help desk (coming to the ScreenSound Australia website soon);
- conservation advice for motion picture, audio and video collections.

It offers the following fee-for-service items:⁷⁰

- advice on audio visual media collection management as a paid consultancy (collection survey, development of preservation policies etc);
- training in audio visual media management and preservation (either via the SSA/UNSW internet based course or by individually contracted services);
- conservation services for motion picture, audio and video collections (examination and condition reporting, cleaning, repair etc; subject to internal priorities);
- duplication of motion picture film (B&W only at the moment), audio and video. Also digital restoration of audio components (film sound, or video sound tracks included; subject to internal priorities);
- reformatting of film, audio and video materials onto more stable media or more commercially saleable formats; subject to internal priorities.

Enquiries regarding this can be directed to Mick Newnham, Engineering & Research Group. He can be contacted by telephone (02) 6248 2118 or email: mick_newnham@screensound.gov.au.

⁷⁰ ScreenSound Australia determines the amount of external work it undertakes.

APPENDIX 4

COSTS

All costs quoted are subject to many variables; costs provided below are intended as a guide only.

Low temperature/low humidity store

The cost of building a cool store will vary according to the location and design of the store. The construction costs will include the purchase of land, construction, shelving, sprinkler control, the installation of refrigeration and dehumidification systems, security and electricity. In addition, items such as bar coders, labels, a tracking system, data loggers and trolleys will need to be budgeted for. Cost estimates will also need to take into account the construction of an acclimatisation room.

A cool store operating at 8 °C /35 %RH, may be expected to incur annual energy costs of approximately \$180 per square metre.⁷¹ It is important to note, however, that the design of a cool store, its building fabric, air-conditioning control strategy and access control will be crucial in determining ongoing maintenance costs.⁷²

Puglia⁷³ provides storage density values for microfilm, motion picture film and photographic negatives, thus enabling calculation of the annual cost of maintaining individual items of each of these formats.

Costs associated with providing access to material in cool storage also need to be considered. These include the increased cost of maintaining temperature and humidity parameters in a frequently accessed area and a staff cost for retrieval of items.

Acid Scavengers

The cost of acid scavenging molecular sieves is approximately \$0.75 per unit.⁷⁴ If 5 min. are allowed for placing each molecular sieve, the cost per unit will be around \$2.55. It is recommended that molecular sieves be replaced every 2 years if stored at ambient temperatures, and every 10 to 15 years if stored at 2 °C at 20-30 %RH; 3 molecular sieve packets, each containing 12.5 g desiccant, are required for each 2000 ft 16 mm reel or 1000 ft 35 mm reel motion picture film.⁷⁵

⁷¹ Calculation based on National Library of Australia data.

⁷² Information provided by Chris Lowger (chrisl@naa.gov.au), National Archives of Australia.

⁷³ S. Puglia, 'The Preservation of Acetate Film Materials: A Cost Benefit Analysis for Duplication and Cool / Cold Storage', *Topics in Photographic Preservation* vol. 6, 1995, AIC Photographic Materials Group: Washington pp50-79.

⁷⁴ Information supplied by Kodak (Australasia).

⁷⁵ Molecular sieve brochure (FPC, Kodak) supplied by Kodak (Australasia).

Passive Indicators

The following costs were obtained for passive indicators:

IPI A-D (Acid-Detection) strips (packet of 250 strips): US\$45.00 for order of 1-4 kits; US\$36.00 for order of 5-9 kits; US\$27.00 for order of 10+ kits.⁷⁶

Dancan Dancheck 2-hour Acidity Tester: US\$45.00 for order of 1 kit; US\$36.00 for order of 2-5 kits; US\$31.50 for order of 6-9 kits; US\$22.50 for orders over 10 kits.⁷⁷

Dancheck Acetate (window place in film can to monitor changes) US\$100.00.⁷⁸

If IPI A-D strips are purchased for (Australian) \$0.19, and 5 Min. allowed for placing and checking each strip and recording results, the cost per unit will be \$2.00.

Copying

The table below provides estimates of the costs of copying photographic negatives using a variety of print/duplication methods.⁷⁹

Negatives

Film/Print Options	Per unit cost (commercial)	Per unit cost (in-house)
35 mm duplicate negative (silver halide)	\$2.00	\$1.00
6x7 duplicate negative (silver halide)	\$3.00	\$2.00
5x4 duplicate negative (silver halide)	\$9.00	\$7.00
8x10 duplicate negative (silver halide)	\$20.00	\$20.00
B&W print (RC 13x18 cm)	\$6.00	\$4.00
B&W print (fibre 13x18 cm)	\$22.00-\$35.00	\$7.00
Sepia toning (13x18 cm)	+ 50% duplication cost	\$2.00

In addition to these costs, staff time will be required for the preparation of the material to be copied, administrative and quality control tasks, and, in the case of material copied in-house, for the actual copying process.

Digitisation costs for photographic negatives will likewise vary depending on the quality of the image desired. Commercial costs of digitisation for 75-170 MB greyscale high resolution preservation copies will vary between \$0.27-\$0.65 per MB.⁸⁰ (Low resolution scanning

⁷⁶ A-D Strips brochure (IPI).

⁷⁷ <http://www.dancan.dk/speedtest.html>

⁷⁸ <http://www.dancan.dk/dancheck.html>

⁷⁹ Costs were derived from information obtained from a variety of service providers including: Photographic Services, National Library of Australia; IMAGE LIBRARY, State Library of New South Wales; Museum Victoria; Prism Digital Imaging.

⁸⁰ See previous footnote.

producing 1-10 MB files will cost approximately \$1.00 per MB).⁸¹ The cost of storing digital files will also need to be considered.

Staff time will be required for the preparation of material to be scanned, for the administration of the digitisation project, to carry out quality control, and, in the case of in-house digitisation projects, for image capture. Costs for cataloguing and archiving digital material will also need to be considered as will data manipulation costs (commercial providers charge approximately \$120 per hour for this). The costs of maintaining access to digital material in the long term are largely unknown but may be expected to be significant.⁸²

Motion Picture Film

The table below provides costs for the duplication of motion picture film.⁸³

	per ft 16 mm	per ft 35 mm
Colour Interpositive Duplicate For Print Material	\$2.80	\$3.00
Colour duplicate if negative exists	\$2.34	\$3.17
B&W Silent (cost based on 400 ft carrier)	\$1.10	\$1.40

These costs do not include costs associated with copying material that is damaged, or for producing an access copy where the negative does not exist. Also, commercial laboratories do not print to black-and-white stock but will use colour stock instead. If you only have a print and not a negative, again the cost increases as you will need to produce an interpositive first, and then duplicate. Staff time required for administration and quality control tasks will also contribute to the overall cost of copying.

Microfilm

The table below gives copying costs based on a standard reel of microfilm.

Copying existing reel to silver halide polyester. (Costs below based on a <i>standard</i> reel)	Per unit cost (per reel)
16 mm (1000 frames)	\$25.00-\$50.00
35 mm (500 frames)	\$30.00-\$36.00
105 mm (approx 49 frames per fiche)	\$2.10-\$5.10

In addition, staff costs for the administration of the copying project, preparation of material to be copied and quality control would need to be included in the cost estimate (it is estimated that these tasks would take approximately 30 mins per reel). By comparison, the cost of filming hard copy material is considerably greater with costs per standard frame being \$0.24 (16 mm), \$0.75 (35 mm) and \$0.24 (105 mm) - staff costs for preparation and quality control need to be added. However, if the original material still exists, filming this may be preferable for badly deteriorated or poorly produced cellulose acetate microfilm.

⁸¹ See previous footnote.

⁸² Costs, PADI website <http://www.nla.gov.au/padi/topics/5.html>.

⁸³ Costs derived from data supplied by ScreenSound Australia and a commercial provider.

Sound Transfer

The cost of copying sound recordings that are in good physical and audio condition is currently approximately between \$130 - \$160 per recorded hour of tape. This price is exclusive of blank media costs. Current practice at the NLA is to migrate the content of acetate recordings onto the following digital and analogue formats: CD-R, 10 inch safety analogue reel and audio cassette. The cost of supplying blank media to produce these three formats is approximately \$40 per recorded hour. Staff costs for administration of transfer and quality control should be included in the cost estimate.

Treatment

The costs of treating cellulose acetate photographic negatives (includes stripping, duplicating and the return of the pellicle) are approximately: US\$53.25 (original 4x5"), US\$72.70 (original 5x7") and US\$115.95 (original 8x10").

APPENDIX 5

Methods of duplication onto film

The main methods of duplication onto film (such as polyester) are optical, direct duplicate, interpositive duplicate negative (contact) and interpositive duplicate negative (reduced format, long roll system).

Optical System

The optical system uses a film camera or digital camera to produce copies of the original. Traditionally these originals are captured on film, which is then used to produce negatives, prints, or 'hardcopies'. The copies can be used as duplicate negatives/films, used to produce microfilms, or prints.

The benefit of using this type of system is that it enables the original to be enlarged or reduced at relatively low cost, particularly if reducing the original to a size that can be captured on a continuous roll of film.

However, considerable loss of detail and image quality along with compressed tonal ranges, are a disadvantage of this system. If using a digital camera, a large image file would be necessary to capture all of the required information from the original.

Direct Duplicate System

This system involves the placement of the original in direct contact with duplicating film or contact printing onto sensitised paper. A specific type of *duplicating* film is required to produce a copy negative from another negative. This type of system enables a copy the same size as the original to be produced which produces a sharp image in one step thereby limiting flare, and image and resolution loss.

Disadvantages include the high cost of this type of film and the low production capacity (only one copy can be produced at a time). There is also the possibility that some originals will be placed under stress during copying.

The use of a LogEtronic print/negative duplicating system for aerial films may be worth considering, as this can be done commercially and at relatively low cost.

Interpositive Duplicate System

This is similar to the system described above, but uses a two step process. The original is placed in contact with another film, giving a positive image. This is then placed in contact with another film to obtain a negative. The benefits of this type of system are that copies are the same size as the original and, by producing two copies, an *access* along with a *preservation* copy are produced that have accurate tone reproductions. By using filters, stains and defects can also be reduced.

The disadvantages of this system include the high costs associated with purchasing the film and the image and resolution loss resulting from the production of two copies. Other factors to consider are the low production capacity resulting from the two-step process and possible stress caused to some originals during copying.

Interpositive Duplicate System (reduced format, long roll)

This system is the same, in principle, as the interpositive duplicate system described above. In this case, however, roll film, which is smaller in format than the original, is used to produce the copy. This results in some loss of image detail.

Negatives or Prints

Factors such as access, use and resources should be considered when deciding whether to produce surrogate negatives or prints for your institution. For negatives, polyester film is the only preservation quality material. Specifications for all films used for any duplicating program should be carefully evaluated. Cellulose triacetate continues to be used today in the manufacture of films.

Over the years there has been some discussion regarding the long-term use of resin coated (RC) papers. It appears that properly processed, washed and toned RC prints may be anticipated to have a similar life expectancy to fibre prints. Due to the instability associated colour materials, these should not be considered for any long-term preservation strategy.

Processing and washing

Any newly produced film or print material intended for long-term archival keeping should be thoroughly processed and washed according to archival standards. They may also be toned to protect image silver from chemically deteriorating.