COLLECTIONS AT RISK

Motion picture film

CELLULOSE NITRATE, CELLULOSE ACETATE, POLYESTER

Introduction

This guide aims to assist small to medium collecting organisations and individuals to care for motion picture film materials in their collections, specifically common formats 8mm, 16mm and 35mm. Information in this guide is not intended to replace the advice of a trained professional but to provide the first steps in caring for motion picture film collections. This guide can be used in conjunction with other guides in this series: Digital, Floppy disk, Magnetic tape and Optical disc.

The information provided in this guide includes terminology and names of technologies and processes that are complex and specific to the format in focus. For many these terms and names may be challenging to recognise or understand. Please don't be discouraged, definitions can be clarified by consulting with a conservator, professional service provider, GLAM sector agencies as well as the references and further reading provided in this guide.

Background

Motion picture film emerged in the late 19th century with the convergence of new photographic techniques and the invention of flexible yet durable, transparent polymer materials. The combination of camera equipment and film enabled many photographic images to be captured and later viewed in rapid succession. Different films can vary in many ways, such as length, gauge or width, and presence of sound or colour. The type of polymer used as film support layer also varies. The earliest type, cellulose nitrate, is inherently unstable and highly flammable, requiring safe handling to avoid potentially catastrophic damage.

Assessment

A workstation for assessing motion picture film may be a simple desk with 60–80cm of space to examine unwound lengths of film. Additional space for equipment and note-taking is ideal. A light box or light pad, and a loupe or handheld magnifier are essential pieces of equipment for examining fine detail. A set of film winders enables easier transport for film examination. The space should be climate controlled with good ventilation.

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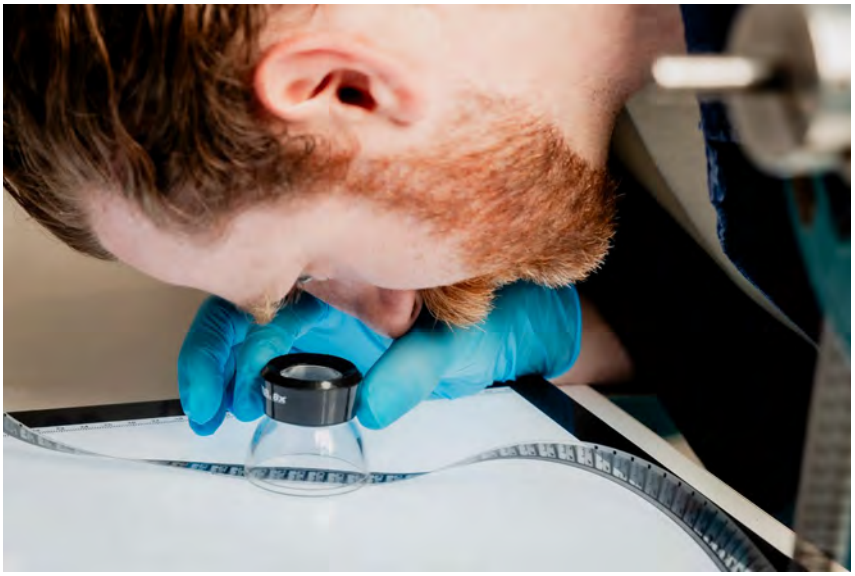
Film examined on a light pad



Media and materials

Some format details can be gathered easily through visual examination. Information may be inscribed on the film container or reel, or written on the film itself, but these details should be confirmed with further examination. Beyond identifying what is recorded on the film, assess the key details listed in the following table.

Table 1: Identifying properties of motion picture film

FORMAT DETAILS	DESCRIPTION AND COMMON EXAMPLE/S
Gauge	Determined by measuring the film width. Common gauges include 8mm, 16mm and 35mm.
Perforations	Holes punched uniformly along the film length to enable mechanical transport through projectors and other equipment. 35mm film is perforated on both edges; 16mm film can be perforated on one or both edges; 8mm film is perforated on one edge, with larger perforations denoting standard 8mm and smaller perforations for Super 8mm.

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FORMAT DETAILS	DESCRIPTION AND COMMON EXAMPLE/S
Soundtrack	Audio signal recorded on film, synchronised and running alongside the image. Optical sound can appear like a waveform (known as variable area) or a continuous barcode (known as variable density) and is commonly found on 35mm and 16mm films. Magnetic sound is identified by an opaque, bronze-brown stripe, sometimes found on 16mm and Super 8mm films.
Edge codes	Printed markings located along the film edge beside or between perforations. Edge codes may include stock details including brand names (Kodak, AGFA, etc), whether the base material is 'nitrate' or 'safety film', and some codes include symbols to indicate the year of manufacture (see Kodak reference for more). Edge codes are printed by film manufacturers but can also be transferred from one stock to another during certain duplication print processes – a potential cause for inaccurate stock identifications.

L-R: 35mm, 16mm, Super 8mm and standard 8mm

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Motion picture film has two fundamental components. A transparent plastic polymer called the 'base' provides structural support balancing flexibility and toughness, and an 'emulsion' comprised of image-forming materials suspended in a gelatin binder. Photosensitive silver halide particles form black-and-white images, and colour images are often made with additional layers of dye couplers and filters.

Several polymers have been used in the manufacture of film bases. Identifying the base material is a key factor in determining preservation needs. The following table provides information about common base materials, usage dates and identifying properties.

Table 2: Usage periods and identifying properties of common motion picture film bases

BASE MATERIAL	MANUFACTURE DATES AND USAGE	IDENTIFYING PROPERTIES
Cellulose nitrate	1890s–1951. Common use for professional film productions.	Film manufactured after 1920 will likely have 'NITRATE' printed on edge code. May emit a chlorine-like smell.
Cellulose diacetate	1920s–1950s. Used for amateur film productions and home movies.	'SAFETY' or 'S' may be printed on edge code. May emit a camphor or mothballs smell.
Cellulose triacetate	1940s–present. Prolific usage for amateur and professional productions.	'SAFETY' or 'S' may be printed on edge code. May emit a vinegar smell. Wound film appears opaque when resting on light source.
Polyester	1990s–present. Common for archival and cinema distribution prints.	'CRONAR' or 'ESTAR' may be printed on edge code. Wound film appears translucent when resting on light source.

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Condition issues

Film deterioration can manifest differently depending on the film stock and storage conditions. Some key issues are listed below.

- Cellulose base films are particularly susceptible to chemical decomposition, where polyester films are far more resistant.
- Cellulose nitrate is a highly flammable material and chemically unstable. Its decomposition process releases harmful gases which further degrade the film and can damage neighbouring materials.
- Cellulose triacetate is susceptible to 'vinegar syndrome', a degradation process initiated by a chemical reaction with water, often moisture in the air. Harmful acetic acid is released causing further degradation and possibly damaging neighbouring materials. Eventually film may become blocked by adhering to itself. Acid detection strips can measure the level of acetic acid being released to indicate the rate of degradation.

16mm film with A-D strip measuring vinegar syndrome degradation

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- Shrinkage can occur from chemical decomposition of the film base. Distortion can occur from uneven shrinkage. Films with advanced shrinkage or distortion are at greater risk of mechanical damage when handled by sprocket-driven equipment such as a projector. A film shrinkage gauge can provide precise measurements in percentage.
- Embrittlement can occur from advanced decomposition. Chemical additives introduced at manufacture for flexibility can migrate to the film surface and crystallise, appearing like efflorescence.
- Mould can grow on gelatin in the emulsion layer and may destroy the image. The extent of growth is dependent on relative humidity (RH), temperature, time and the quality of nutrients. Mould can grow at 20°C when relative humidity is above 65%.
- Fading colour occurs with the breakdown of organic dyes. Certain dyes are more stable than others, often resulting in a palette shifting towards one colour.

Handling

Film should be handled as little as practicably possible to avoid undue damage.

- Cellulose nitrate is a hazardous chemical, categorised by Safe Work Australia as an explosive.[1] Exercise caution upon discovering nitrate film, move it away from any heat sources and seek advice from experienced professionals.
- Use nitrile gloves or clean, bare hands to hold the film by its edges while winding slowly. Avoid cotton gloves as these can catch on film splices or damaged perforations and cause further damage.

Preservation

Films are inherently at risk of deterioration from physical access and their material nature. Preventive conservation can help to prolong the functional life of film and should be prioritised.

Preventive conservation

- Keep films in a climate-controlled space at a low temperature and 30–50% relative humidity with minimal fluctuations. Lower temperatures are better at slowing down chemical reactions that cause film decomposition. Storing reels long term in frost-free freezers is a good solution for small collections.

[1] Safe Work Australia, '*Cellulose nitrate*', *Hazardous Chemical Information System*, 2016.

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Film cans in storage

- Wind films for storage using moderate tension; tight enough to prevent unravelling but loose enough to allow some airflow to reduce the risk of blocking. Rewind to greater tension in preparation for transport or viewing to prevent movement and potential scratches. Fasten film ends down with photo-safe tape.
- Ventilated plastic cans are an ideal housing solution to avoid the build-up of harmful decomposition by-products.
- Store films horizontally on shelves, stacked no higher than five reels, with the lowest shelving at least 15cm off the floor to mitigate the risk of water damage in the event of flooding.

Migration

Migration is a key method for ensuring ongoing access to motion picture recordings on film, by capturing the contents in a digital format, also referred to as digitisation. Consider using a professional digitisation service provider.

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Film scanning service providers have varying capabilities and options for video quality. Digitisation requires significant resourcing commitment, including the up-front cost of scanning and the ongoing cost of maintaining digital storage. Consider the significance and condition of films in your collection to help determine priorities.

Potential treatment

- Remove surface dirt and dust using air dispensed by a bulb blower or wipe film with a soft anti-static microfibre cloth.
- Remove grime or adhesive residue with a cotton tip wetted with isopropyl alcohol. Use slow, controlled actions to carefully roll over the affected surface from the edges to the centre.
- Reinforce broken perforations with film splicing tape. A film splicer can be used to easily perforate the tape.

Disposal advice

Deciding when to dispose of film due to deterioration can be challenging, as future technologies may enable material to be digitised in ways not yet possible. Local government councils can provide relevant advice on hazardous waste disposal and recycling options.

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Recommendations for further reading

Association of Moving Image Archivists (AMIA), *Identifying and Handling Nitrate Film*, AMIA, 2008.

G Hill, *Care of Plastic Film-based Negative Collections – Technical Bulletin 35*, Canadian Conservation Institute, Government of Canada website, 2020.

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J Reilly, *IPI Storage Guide for Acetate Film*, Image Permanence Institute, Rochester Institute of Technology, 1996.

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Library of Congress, *Care, Handling, and Storage of Motion Picture Film*, Library of Congress website, n.d.

National Archives, *Motion Picture Film Guidance: Important Characteristics of Motion Picture Film Formats*, National Archives website, 2023.

National Archives of Australia (NAA), *Preserving motion picture film*, NAA website, n.d.

National Film and Sound Archive of Australia (NFSA), *Technical Preservation Handbook*, NFSA website, n.d.

Te Rua Mahara o te Kāwanatanga – Archives New Zealand, *Te tiaki i ngā kiriata – Care of motion picture film*, Te Rua Mahara o te Kāwanatanga – Archives New Zealand website, 2024.

All photos by Matto Lucas. Captured onsite at ACMI in the Blackmagic Design Media Preservation Lab.