FEDERATION INTERNATIONALE
DES ARCHIVES DU FILM
F I A F

HANDLING, STORAGE AND TRANSPORT OF CELLULOSE NITRATE FILM

INTERNATIONAL FEDERATION
OF FILM ARCHIVES

Published with the financial assistance of UNESCO, December 1991.

Introduction

With efforts to safeguard and preserve the motion picture film heritage increasing around the world, transport of cellulose nitrate film, both nationally and internationally, has also increased and, with it, the danger of fires.

Different countries have different standards and regulations for the handling and transport of nitrate film, and there are even countries where such regulations do not exist at all. Nitrate films are sometimes transported without any precautions which could lead to grave consequences, especially when they are sent by air.

Apart from the danger in transit, nitrate film represents a fire hazard for the archives themselves if not properly stored and handled, as testified by some fires on archives' premises. Some of them have been reported in the *FIAF Information Bulletin* (see Index in the *Bulletin FIAF* No. 43, p.44).

The FIAF Executive Committee decided therefore to produce guidelines for handling, storage and transport of cellulose nitrate film in collaboration with the FIAF Preservation Commission. The aim was to supply archives with information about the highest existing standards in this field and thus help them to have these implemented in their own work and in their national legislation. The guidelines would also help archives learn about the regulations they would have to comply with when sending nitrate film material abroad. Archives which do not have nitrate stock in their collections may find this information useful when they receive nitrate films from another country.

More detailed information on the handling, storage and transport of cellulose nitrate film is at Annex 1.

In January 1990 the FIAF Secretariat circulated a questionnaire (Annex 2) concerning the transport of nitrate film among all FIAF members and observers. This was answered by 36 archives. In June 1991 the questionnaire was sent out again with the purpose of achieving a wider coverage of archives and countries as well as to register any changes that might have occurred in the meantime. As a result, information has been obtained from 52 archives, representing 37 countries from all continents. A summary of this survey is at Annex 3.

Properties of Cellulose Nitrate Film

1. Cellulose nitrate film is highly flammable.

2. A burning reel of nitrate film cannot be extinguished by any means (water, foam, sand etc).

3 A nitrate fire generates very intensive heat (ca 1700°C) and at certain stages of combustion gives off large quantities of very toxic vapour (nitrogen monoxide and dioxide). This can affect breathing and can cause an explosion if it is not allowed to escape freely.

4. A nitrate fire can start through "spontaneous ignition" given certain conditions.

5. Cellulose nitrate is chemically unstable and gives off toxic, corrosive fumes. It must therefore be stored away from other materials.

Recommendations

Handling

1. Smoking is strictly forbidden in areas where nitrate film is being handled.

2. Keep the film away from sources of heat, such as room heaters, viewing table lamps and direct sunlight. Never leave magnifying glasses or spectacles (ie, convex lenses) in a nitrate handling area.

3. Make certain that the location of fire exits is known by all staff working in the area. Do not attempt to put out a nitrate fire; only use a fire extinguisher if it is non-nitrate material that has caught fire. Evacuate the building immediately and tell the fire brigade that there is nitrate film on the premises. On a regular basis, the Archive should ensure that the local fire brigade is thoroughly aware of the film's presence and its nature.

4. Have only one feature film or an equivalent number of short films in the work area. The rest should be kept in a specially built nitrate store. It is advisable to have nitrate transit boxes beside the benches so that there is never more than the absolutely necessary number of reels on a bench at any one time.

5. Wind slowly and check that the material is in good physical condition (perforations, joins, etc) before despatch.

6. Wind films tightly and evenly on central cores if they are duplicating material or viewing copy - or on reels if viewing copy. The wind of duplicating copies should be emulsion out, whereas the wind of viewing copies should be emulsion in. This is recommended by the Society of Motion Picture and Television Engineers (SMPTE) to avoid focus drift.

7. Do not tape films to the central core. When unwound, the sudden pull needed to release the film from the core might cause cinching of the film.

8. Tape down the film leader securely to prevent the convolutions from unwinding during transport as this could cause damage to the edges and outer parts of the film.

9. Place the film in a can nearest to its size to avoid movement inside the can while it is being handled. If it is not possible to achieve a close fit, add packing materials to avoid movement. Some cans are equipped with hubs which fit into the centre of the core, thus preventing the film from moving around inside the can. Discard cans and reels which are bent, warped or rusty.

10. Pack the cans tightly inside the shipping container. In the case of feature films, it is desirable to ship all the reels of one film inside one container and not mix up the reels of several films.

11. Make certain all nitrate films (head and tail leaders) and their cans are clearly labelled "Flammable" or "Highly Flammable". The official warning label, "Flammable Solid", or an equivalent label preferably in red should be used.

12. Edge labels should be used on cellulose nitrate cans so that hazard symbols are visible when cans are stacked.

13. Risk phrase R11, *"Highly Flammable"*, and safety phrases S15, *"Keep Away From Heat"*, and S16, *"Keep Away From Sources Of Ignition - No Smoking"*, should be used.

Other considerations regarding handling of viewing copies

14. An archive that borrows a viewing copy for projection should not assemble the reels in any way without the prior consent of the owner.

15. When films are returned, it is important that they are shipped on the same cores or reels, and in the same cans and shipping containers in which they were received. No new labels should be added. The borrower must not use the labels of the cans for private notations, and should not add to the cans new labels which would obscure the original ones.

Storage

Storage conditions

The FIAF Preservation Commission recommends

Storage temperature for nitrate

4°C (39°F) +/- 1°C on a daily basis,
4°C (39°F) +/- 2°C on an annual basis.

Relative humidity

50% +/- 2% RH on a daily basis,
50% +/- 5% RH on an annual basis.

Maximum range: 40-60% RH.

Rate of fresh air intake

The rate of fresh air intake should allow the air to be gradually renewed over a period of 5 hours at 4°C. The Commission has not been able to find any research material which confirms this apparently arbitrary figure. However, the following empirical guideline applies: if it is possible to smell the nitrate, the air replenishment is insufficient.

Method of storage

The storage method is also important, since in long term storage, various stresses and strains in the material, and other variables, become significant. The Preservation Commission recommends certain rules about the canning and storage of motion picture film. Following are some of these rules:

1. Store film cans horizontally in stacks preferably no higher than 300 mm (about 1 foot) and, where possible, have all cans in the stack of the same diameter.

2. The containers should contain the film and a core or spool only - no paper, household plastic bags or other materials.

3. Cans for nitrate films should have one or more holes in the side (preferably towards the bottom) to permit the escape of decomposition gases.

Transport of Nitrate Film Material

The main potential dangers to film during transport are:

- temperature extremes and sudden changes;
- humidity extremes and sudden changes;
- vibration; and
- impact and crushing through rough handling.

Special precautions must be taken to avoid these dangers during transport.

General conditions

Nitrate film should be in transit for as short a period as possible. Insulation with thick packaging combined with high external temperatures, such as those caused by direct sunlight, might result in the film catching fire. Do not seal nitrate tightly. Transport it in air-conditioned vehicles.

Transport within storage premises

Even within film storage premises, nitrate film must always be carried in closed film cans.

When the temperature rises above 30°C the transport of nitrate film should be minimised. If possible, nitrate film should be transported in the early (cool) hours of the day. Transport distances should be minimised. When loading or unloading nitrate material in hot seasons, the cans should not be exposed to sunshine. Nitrate should be transported in cooled containers or refrigerated vans when possible.

Road transport

Film cans must not be transported loose, but must be placed into transit cases. The vehicles must be marked in accordance with the rules concerning the transport of dangerous goods. Film archives which have to transport nitrate material on a regular basis should use closed vans with insulated and preferably refrigerated cargo bays. The van should have some form of fire break wall, such as a metal bulkhead, between the cargo area and the driver. Trucks with open cargo platforms should not be used. No other flammable goods should be transported together with nitrate film. The van should be equipped with an additional number of small fire extinguishers for quenching external fires (not burning nitrate).

The journey should be made without stops. The driver must be made well aware of the dangers involved in the transport of nitrate film. It is advisable that the driver should be accompanied by a second person.

Railway transport

When film is transported by an archive's own staff, the staff can be suitably instructed in the nature of the material. When transported by railway, this is not possible, and protective packing is therefore important.

As with road transport, film cans containing nitrate material must be placed into transport containers labelled "Flammable Solid".

If possible, nitrate film should not be transported by rail during the hot seasons, because of possible prolonged periods of transport without air-conditioned storage.

Air transport

Transport of nitrate film by air should follow strictly the Dangerous Goods Regulations (30th Edition, effective 1st January 1989) published by the International Air Transport Association (IATA). It can be obtained from the following address: Publications Assistant, International Air Transport Association, 26 Chemin de Joinville, 1216 Cointrin, Geneva, Switzerland.

The IATA Regulation UN 1324 Class 4.1 gives the appropriate instructions regarding labelling. Packaging instruction 400 gives appropriate information about the type of packaging that should be used.

Posting of nitrate material

This form of transport should be avoided. However, if nitrate film has to be posted, the containers have to be labelled "Flammable Solid". National and International rules concerning the transport of dangerous goods, and railway and postal regulations, have to be observed.

ANNEX 1

Handling, Storage and Transport of Cellulose Nitrate Film : Further Details

(The following text is based on "Preservation of Moving Images and Sound" *by Henning Schou* et al., *other papers in the* FIAF Preservation Commission Technical Manual *and* "Guidelines for the Handling and Transport of Nitrate Film" *compiled by David Francis and Henning Schou)*

Cellulose nitrate and its stability

The first successful, flexible and transparent film base was made in 1889. This was celluloid, a highly flammable, relatively unstable material consisting mainly of cellulose nitrate, and a plasticiser (camphor) to eliminate brittleness.

Cellulose nitrate cinematographic film is also known as "cellulose nitrate", "nitrate", "nitrocellulose", "celluloid", "inflammable film", "flammable film" or just "flam film".

Western European and North American film stock manufacturers discontinued the production of cellulose nitrate around 1951, and acetate film then replaced nitrate during the next three years in most parts of the world except China and the USSR, where nitrate film was used until the 1960s. One of the major laboratories in London continued using nitrate leaders on negatives until the early 1960s, and a nitrate grading chart even longer. These nitrate leaders were not produced in Britain after 1951, but some laboratories had stocks of nitrate leaders which they continued to use in conjunction with films on safety base. All gauges narrower than 35 mm before the introduction of Pathe 28 mm film in 1912 were on a safety base, although 28 mm negative was nitrate. That means that 8 mm, 9.5 mm, 16mm, 17.5 mm are all safety gauges. However, one should be aware that the Biokam 17.5 mm film introduced in 1899 and Ernemann in 1903 are nitrate. Gaumont Chrono de Poche 15 mm film, which is similar in form to the Biokam film, was also made on nitrate stock. Any films which may be older than 1909 should be expected to be nitrate.

Cellulose nitrate film base has two major weaknesses: flammability and chemical instability.

Cellulose nitrate can burn without oxygen because the inherent nitro-groups act as an oxidant. For this reason, a reel of nitrate can burn at the centre without oxygen almost as well as on the surface where oxygen is present - the only difference being that combustion without oxygen takes place without flames. Nitrate film will therefore burn without flames under water, sand, foam and so on, as well as in an enclosed film cassette on a projector. Such a situation should be avoided, for example by inserting Davy safety nets in projector cassettes, because explosive gases will otherwise be formed.

A single strip of burning nitrate film can be extinguished by water, carbon dioxide snow, and the like which cool the film to a temperature below the ignition point (ca 160°C or ca 320°F). However, a fire in a roll of nitrate film is impossible to quench because the coolant cannot penetrate to the centre of the combustion, and the roll burns with an almost explosive ferocity.

Under controlled laboratory conditions, none of a limited number of nitrate samples in various stages of decomposition ignited until temperatures exceeded 160°C (320°F). However, even at an external temperature as low as 40°C (104°F), the film may ignite because, at this temperature, heat can accumulate within the reel faster than it can be dissipated. This has been the apparent cause of several nitrate fires started through "spontaneous ignition".

From the moment of manufacture, cellulose nitrate slowly decomposes. Some of the unstable chemical bonds between the cellulose and the nitro-groups break. This results in the release of heat and of nitrogen oxides, mainly nitrogen dioxide, which accelerates the process, as the reaction products accumulate. This decomposition may take many years, with no external signs of disintegration. However, eventually the gases bleach the photographic image. This is the first stage of decomposition. The emulsion carrying the image becomes sticky - second stage - then the reel becomes soft and exudes blisters of "nitrate honey" and a pungent smell - third stage. In the fourth and fifth - the final stages, the film congeals into a solid mass and then disintegrates into brown powder giving off an acrid odour. A reel of decomposing nitrate might show signs of all five stages at the same time. These final stages of decomposition may occur in a matter of a few months.

It is only possible to rescue the film in the first and second stages of decomposition. It needs immediate treatment - redevelopment or drying - and instant copying.

Without the use of an accelerated ageing test it is impossible to predict just how long it will take before a nitrate film reaches the first stage of visible decomposition, that is, image fade due to the bleaching effect of nitrogen dioxide.

Nitrate films, even if original negatives, are too volatile to be categorised as archival material and must have stable acetate or polyester "safety" copies made from them if their visual and sonic contents are to survive. Even after such copies have been satisfactorily made, the nitrate material, which may be the best photographic material available, is not discarded. If it is still in a usable condition, it is stored in a controlled environment awaiting further use - perhaps for copying on a second occasion, for instance, after improved preservation techniques have been developed.

Handling of Nitrate Stock

Room requirements

All rooms where nitrate films are handled should be considered as involving fire hazards. That is why their structural and fire prevention design must conform with the relevant regulations of the country concerned. In rooms where nitrate material is handled or transported, fire and heat radiators must not be used. Light sources have to be secured in such a manner as to prevent their contact with nitrate stock, and, should the lamp break, the hot fragments must not come into contact with the nitrate stock.

Smoking must be absolutely forbidden in such rooms. All rooms where nitrate stock is handled should be equipped with fire extinguishers in conformity with the size of the room. Heat radiators used in the rooms should be equipped with covers which should have a minimum inclination of 50° in order to prevent personnel from placing nitrate stock on the heater through carelessness. Rooms where nitrate stock is handled must have two exits. Windows of such rooms should not be barred and they should be marked adequately if used as emergency exits.

Work benches have to be arranged in such a way as to provide easy access to the evacuation routes. Such evacuation routes must always be clear and not blocked by objects. With the exception of the nitrate film being handled, no nitrate films should be present at the work stations. Any nitrate stock not actually being worked upon must be stored in film cans or cabinets.

Where there are several handling appliances (for example, rewind benches and low-tension viewing tables) for nitrate film in one room, it is recommended the appliances be placed at a considerable distance from each other, so that a possible fire may not spread to other appliances. Another alternative is to place these appliances in separate booths or in nitrate transit boxes.

Technical examination

Examine every film carefully as soon as possible after it has arrived in the archive and make up a technical record.

Tests prior to storage

Tests for distinguishing between nitrate and acetate stocks

It is necessary to ascertain whether a film has a nitrate or an acetate base. This distinction, which has to be made in order to store the two types separately, can be carried out in one or more of the following ways. Note that nitrate film is almost always 35 mm in width - never 16 mm, 8 mm or current colour 70 mm. Be aware of nitrate leaders on safety film - particularly negatives - and nitrate laboratory test frames.

Edge markings

For decades, film with an acetate base has been marked "Safety" on one or both edges of the film, outside the perforations. However, this information should be treated with some caution because the marks could have been printed through from an earlier generation with a different base.

Float test

The organic and toxic liquid trichloroethylene has a specific gravity between that of acetate and that of nitrate film. This means that while a small piece punched from a nitrate film will sink, a punching of acetate film will float on the surface of trichloroethylene. However, the test is not completely reliable.

Burning test

The Preservation Commission does not recommend this method because it can be unreliable and unsafe, and because it consumes the film.

Ultraviolet fluorescence

Certain manufacturers, such as Kodak, incorporate a small amount of fluorescent chemical in the acetate film base - and this will fluoresce when viewed under ultraviolet light.

Please refer to the *FIAF Preservation Commission Technical Manual* for further details and tests, such as solubility tests and the diphenylamine test.

Accelerated ageing test of nitrate

The object is to test all new acquisitions and current holdings of nitrate film to determine the stage of decomposition each reel has reached. The decomposition conditions vary with each individual film, so the test has to be conducted on each reel, or even on different parts of a reel, such as differently tinted and toned sections, and on different brands or ages of stock.

The test involves heating a small punching of about 7 mg of film in a test tube containing an indicator dye, such as alizarin red or congo red, which changes colour as it absorbs the nitrogen dioxide formed during the accelerated decomposition. The time elapsed before the colour change occurs is proportional to the remaining useful life of the film.

Although the results are not accurate enough to determine the absolute amount of useful life left in the film, the values will determine the relative instability of the film compared to others in the collection. This will allow determination of priorities for copying the film onto safety stock so that the film that is likely to deteriorate soonest can be placed first on the list for copying. The importance of the test is that it provides this valuable information before any of the visible signs of decomposition have occurred. When they appear, there is already damage to the record and only an inferior copy can be made - unless it is still possible to rejuvenate the film.

The subject matter of nitrate films in the first and second stage of decomposition can be saved by instantaneous treatments such as bleaching and redevelopment, and by drying - followed immediately by archival duplication.

Decomposing nitrate films have to be separated at once and stored away from other material.

Inspection of nitrate film

Nitrate stocks should be checked at intervals of not more than two years. The older the film the shorter the period between inspections. Film archives conducting ageing tests should carry out their checks at intervals in accordance with the results of the ageing tests. An advantage derived from regular checks is that gases formed in the process of decomposition escape during rewinding.

ANNEX 2

Fédération Internationale des Archives du Film

Secrétariat
190, rue Franz Merjay
B – 1180 Bruxelles
Tel: (32–2) 343 06 91
Fax: (32–2) 343 76 22

GUIDELINES FOR THE SHIPMENT OF NITRATE FILM
Second Questionnaire (June 1991)

1. Is there a legislation on transport of dangerous goods in your country? YES/NO
1A. If yes, is nitrate film specifically mentioned? YES/NO

2. Are your national airlines or airlines operating in your country prepared to carry nitrate film? YES/NO
2A. If yes, which of them?

3. Do the airlines referred to above rely on the IATA regulations for the packaging of nitrate film? YES/NO
3A. If no, what packaging regulations do they implement?

4. Can you freely transport nitrate film by road within your own country? YES/NO
4A. If no, please give details of restrictions.

5. Does nitrate film have to be carried in special vehicles in your country? YES/NO
5A. If yes, - what warning signs are required on those vehicles?

- how many people have to be in the driving cab?

6. Will road transport companies carry nitrate film in your country? YES/NO
6A. If yes, how does it have to be packed?

7. Can you transport nitrate film on your national railways? YES/NO
7A. If yes, what regulations exist for packing film to be sent by rail in your country?

8. Which, if any such exist, of your national shipping lines or shipping lines operating in your country are prepared to carry nitrate film?

8A. How do they require nitrate film to be packed?

9. Can you project nitrate film in your archive's cinema? YES/NO
Can you project nitrate film on your archive's premises? YES/NO

9A. If yes, do you have to have two projectionists in the box during nitrate projections? YES/NO

10. Do you have a film laboratory in your country which is prepared to copy nitrate film to archival standards? YES/NO

11. Do you have a video transfer facility in your country which will transfer nitrate film to videotape? YES/NO

12. If there was a stock manufacturer in your country at the end of the nitrate era, when did they last manufacture nitrate film?

12A. Did they use identifying marks on the film which would enable an archivist to tell when the stock was manufactured? YES/NO

13. Any other comments:

(Name of person signing the questionnaire)

ANNEX 3

List of the Archives Which Have Answered the Questionnaire

Argentina	Fundación Cinemateca Argentina (Buenos Aires)
Australia	National Film and Sound Archive (Canberra)
	The State Film Archives of Western Australia (Perth)
Austria	Österreichisches Filmarchiv (Vienna)
Bangladesh	Bangladesh Film Archive (Dhaka)
Brasil	Cinemateca Brasileira (São Paulo)
	Cinemateca do Museu de Arte Moderna (Rio de Janeiro)
Bulgaria	Bulgarska Nacionalna Filmoteka (Sofia)
Canada	Moving Image and Sound Archives (Ottawa)
China	China Film Archive (Beijing)
Cuba	Cinemateca de Cuba (Havana)
Denmark	Det Danske Filmmuseum (Copenhagen)
Ecuador	Cinemateca Nacional del Ecuador (Quito)
Germany	Bundesarchiv - Filmarchiv (Koblenz - Berlin)
	Deutsches Filmmuseum (Frankfurt)
	Deutsches Institut für Filmkunde (Frankfurt - Wiesbaden)
	Stiftung Deutsche Kinemathek (Berlin)
Finland	Suomen Elokuva - Arkisto (Helsinki)
France	Cinémathèque de Toulouse (Toulouse)
	Cinémathèque Française (Paris)
	Service des Archives du Film / CNC (Bois d'Arcy)
Greece	Tainiothiki tis Ellados (Athens)
Hungary	Magyar Filmintezet / Filmarchivum (Budapest)
India	National Film Archive of India (Poona)
Iran	National Film Archive of Iran (Tehran)
Israel	Steven Spielberg Jewish Film Archive (Jerusalem)
Italy	Cineteca Italiana (Milano)
Mexico	Cineteca Nacional (Mexico)
Netherlands	Audiovisual Archive / Rijksvoorlichtingsdienst (The Hague)
North Korea	National Film Archive of D.P.R.K. (Pyongyang)
Norway	Norsk Filminstitutt (Oslo)
Poland	Filmotka Narodowa (Warsaw)
Spain	Filmoteca Española (Madrid)
	Filmoteca de la Generalitat Valenciana (Valencia)
Sweden	Cinemateket / Svenska Filminstitutet (Stockholm)
Switzerland	Cinémathèque Suisse (Lausanne)
Thailand	The National Film Archive (Bangkok)
Turkey	Sinema-TV Enstitüsü (Istanbul)
United Kingdom	Department of Film / Imperial War Museum (London)
	National Film Archive (London)
	Scottish Film Archive (Glasgow)
Uruguay	Archivo Nacional de la Imagen - SODRE (Montevideo)
	Cinemateca Uruguaya (Montevideo)
USA	Department of Film / Museum of Modern Art (New York)
	Film Department / International Museum of Photography at George Eastman House (Rochester)
	Pacific Film Archive (Berkeley)
	UCLA Film and TV Archive (Los Angeles)
	Human Studies Film Archives/ National Museum of Natural History (Washington)
Russia	Gosfilmofond (Moscow)
Vaticano	Filmoteca Vaticana
Yugoslavia	Jugoslovenska Kinoteka (Belgrade)
Zimbabwe	National Archives of Zimbabwe / Audiovisual Archive (Harare)

Summary of Information Regarding Handling and Transport of Cellulose Nitrate Film

This is a summary of the information obtained from 52 FIAF archives representing 37 countries from all continents.

Legislation

Thirty-two countries have national legislation on transport of dangerous goods. In 16 of them nitrate film is specifically mentioned.

Four countries appear to have no legislation and one did not supply an answer to that question.

Transport by air

In 22 countries the national airlines, or other airlines operating in the country, are prepared to carry nitrate film. Almost all of these countries implement the IATA regulations for packaging; however, one archive did not specify the packaging regulations and another mentioned only "special packaging".

In 13 countries no airlines are prepared to carry nitrate film material and the archives from two countries did not answer this question.

Transport by road

Archives in 20 countries declared that nitrate film can be freely transported by road, with no restrictions. Six of them stated that special vehicles must be used.

In 15 countries nitrate film cannot be freely transported by road. The restrictions range from restrictions in weight, special packaging and labelling, as well as warning signs on the vehicles, to special transport declarations or police permits for transports over 1,000 kg.

Special vehicles are required in 13 countries, but the archives became less specific when asked about warning signs on these vehicles.

Only 10 archives have supplied information that the driver of the vehicle transporting nitrate film material on the roads should be accompanied by another person.

In 23 countries road transport companies are prepared to carry nitrate film.

Twenty-two countries have regulations about the packaging of nitrate films when transported by road; in two countries there are no specific requirements. The archives from 13 countries did not supply information.

Transport by railway

In most of the countries it is possible to transport nitrate film on the railways. In two of them there are restrictions not allowing transport during the warm season, and no transport of nitrate films is allowed on passenger trains in the USA.

Packaging regulations exist in most of the countries where railway transport is possible. The packaging regulations are mainly requirements for metal containers, labelling and weight restrictions. British Rail, for example, requires a half-inch wooden lining to film transit cases.

Transport by ship

The archives of only 13 countries have affirmed that shipping lines are prepared to carry nitrate film. Five archives have no shipping lines operating in their countries because of their geography and the archives from 12 countries were unable to supply information.

The packaging requirements vary from compliance with the International Maritime Code to "special packaging", "double metal cases and special containers" and "Flammable" labelling.

Projection of nitrate films

Twenty-five out of 52 archives can project nitrate films both in their cinemas and on their premises.

Sixteen archives cannot project nitrate films at all.

Three archives can project nitrate films in their cinemas but not on their premises, and six archives can do this only on the premises. One archive did not supply an answer.

Nineteen of the archives require two projectionists in the projection room during the screening of nitrate films.

Copying of nitrate film

In 26 countries film laboratories exist which are prepared to copy nitrate film. In 23 countries there is a video facility which can transfer nitrate film to videotape. (21 countries have both, 9 countries have neither, 7 have either a film laboratory or a video facility.)

Nitrate stock manufacturing

Fourteen countries had a nitrate stock manufacturer at the end of the nitrate era. Most of them stopped manufacturing nitrate film between 1950 and 1956. The exceptions are China, which stopped nitrate film production in the beginning of the 1960s - and the USSR where this took place in 1965-66.

In 13 countries there has never been a manufacturer of nitrate stock. Archives from 10 countries did not supply information.

Identifying marks on the nitrate film which would enable an archivist to tell when the stock was manufactured were used in 10 countries.

Scrap nitrate film should be stored in containers made from fireproof materials. These containers should be closed by means of covers and emptied daily.

Conservation treatments prior to storage

Removal of oil, dirt, residual developing chemicals and other components, which might otherwise damage the material with time, may be necessary prior to storage to ensure the continued complete physical survival of the material.

The basic principle underlying restoration and rejuvenation is to eliminate as many physical defects as possible in material prior to copying for preservation, and hence to return the material to a condition as close to its original state as possible. The processes and practices involved are generally labour and skill intensive; specialised equipment may be needed in some cases. Several of the more common practices are described below.

Cleaning

The aim of cleaning is to remove oil, grease and dirt with an organic solvent such as 1,1,1-trichloroethane in a stabilised form. This chlorinated hydrocarbon is also known as methyl chloroform and trichlor, and has proprietary brand names such as Genklene P (from ICI), Dow S (from Dow Chemicals) and CF2 (from Lipsner-Smith).

Compared with other chlorinated hydrocarbons, 1,1,1-trichloroethane has a relatively low toxicity. However, good ventilation is necessary in rooms where the solvent is used.

It is wise to clean a film as soon as possible because the above contaminants will penetrate deeper, spread further, and the dirt will cause more abrasion the longer it is allowed to act.

Cleaning can be carried out by hand or by machine. If the condition of the film permits, cleaning by a suitable machine, using either ultrasonic agitation or rotating brushes, is the more satisfactory method. Brushes have been found more effective for removal of embedded dirt.

Washing and soaking

Washing or soaking with water is carried out in order :

- to remove some kinds of dirt which are not dissolved by 1,1,1-trichloroethane;
- to remove residual chemicals; and
- to diminish fine emulsion scratches.

Washing or soaking should not be carried out if the nitrate film has reached a certain stage of decomposition. Generally, such film should not be washed until a test on at least one frame of each reel has confirmed that the emulsion has not become water soluble through decomposition.

Film repair

Where film has become ripped or buckled, or where perforations have been torn, it is necessary to repair the damage by hand. The purposes of hand repair are to make the film mechanically fit to go through a printing machine or projector satisfactorily.

Projection of nitrate stock

Only nitrate films which are not preservation or duplicating copies may be projected. The films should be subjected to a technical check prior to projection. The aim is to avoid the projection of badly damaged or decomposed films so that the risk of destruction or fire is reduced. Film projectors for nitrate film should be equipped with a fire loop switch which, in case of fire, automatically closes the shutters over the projection and viewing windows. Two persons must always be present in the projection room when nitrate film is being shown.

Storage

The rate of decomposition of cellulose nitrate films roughly doubles with every temperature increase of 6°C. Storage therefore needs to be as cold as possible. Moderate relative humidity is also necessary, to prevent the nitrogen dioxide gas, which is created during deterioration, from reacting with water in the atmosphere and in the photographic emulsion. This reaction forms acid which will attack the film.

When the storage temperature is reduced by 6°C, the production of nitrogen dioxide will be reduced by approximately 50%; that is, by lowering the temperature from 24°C to 4°C, the amount of nitrogen dioxide will be reduced to less than one tenth of the production at 24°C. This means that the rate of fresh air intake could be greatly reduced with lower storage temperature.

Nitrate films must always be stored away from other materials because of the formation of harmful nitrogen dioxide during nitrate decomposition. Ideally, the items in the nitrate collection should be split up and stored according to the degree of instability; that is, the most unstable films should be stored separately from the medium unstable material which again should be isolated from the most stable nitrate.

It is essential to know, and to adhere to, the regulations concerning legal rules and fire codes for storage and use of cellulose nitrate films. The most important of these rules is that nitrate stores must be located at a safe distance - at least two hundred metres - from accommodation and work areas.

Maintenance

Every few years, it is essential to rewind and examine each reel of film to monitor the deterioration. However, there is no widely accepted practice, and few archives have sufficient staff to implement such maintenance procedures consistently. An inspection of a sample of material is better than no examination at all.

Storage buildings

A nitrate film vault should be an isolated, purpose-built depot exclusively used for the storage of nitrate material. It should be a single storey building which satisfies all fire and legal requirements, such as that all materials used for the construction must be fire rated.

The building should be partitioned into fire resistant, concrete compartments, each of which can hold a maximum of 2,500 kg (approximately 300,000 m or 1,000,000 feet) of nitrate film. The vaults should be as small as can be afforded. Each compartment should have doors opening outwards into a corridor, and be equipped with pressure vents to the outside.

The depot should be fully air conditioned, and the temperature and relative humidity should be continually measured, recorded and monitored.

The fire alarm and extinguishing system should be as sophisticated as one can afford.

In case of a fire, only local sprinklers in the burning vault(s) and external sprinklers should be activated and thus cool the walls so the fire does not spread. Water in other vaults would seriously damage the remaining part of the nitrate collection.

Alarm systems should be able to warn not only of fire but also of a malfunction of the air conditioning equipment, or of illegal intrusion.

For further details, please read "Handling, Preservation and Storage of Nitrate Film" in the *FIAF Preservation Commission Technical Manual.*

Cautioning of personnel

All personnel involved in the handling, storage or transport of nitrate material should be informed about the dangers of nitrate stock at regular intervals, because there is always the risk of people being unaware or forgetful of the dangers associated with cellulose nitrate. This danger has to be counteracted by relevant instruction given at regular intervals.