Article: Recent Developments in Using, Storing, and Transporting Cellulose Nitrate Still Picture Film
Author(s): Andrew Robb
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Compiler: Brenda Bernier

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RECENT DEVELOPMENTS IN USING, STORING, AND TRANSPORTING CELLULOSE NITRATE STILL PICTURE FILM

Andrew Robb

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Disclaimer

The information provided is meant to be informative only. The author's expertise involves the conservation treatment of photographs and preservation of photograph collections. The author is not a lawyer, engineer, safety, or transportation expert. Consult with these professionals as you proceed with the housing, use, transportation, and disposal of cellulose nitrate materials.

The following is a summary of the author's thoughts and comments concerning the care and preservation of cellulose nitrate still picture film in light of recent revisions in 2001 to the National Fire Protection Association Standard NFPA 40-1997 *Standard for Storage and Handling of Cellulose Nitrate Motion Picture Film,* now known as National Fire Protection Association Standard NFPA 40-2001 *Standard for Storage and Handling of Cellulose Nitrate Film.* These are his opinions alone and do not necessarily represent official Library of Congress views or policies.

Summary

Nitrate film is a hazardous material (Class 4.1 Flammable Solid) and its storage and use are described in NFPA 40. Up to 2001 NFPA 40 applied only to motion picture film – cellulose nitrate still picture film was explicitly excluded. **The 2001 revision now explicitly includes still picture film formats such as 35mm and 120 roll films, and 4x5, 5x7, 8x10, 11x14 and x-ray sheet films.** It applies to **"all facilities that are involved in the storage and handling of cellulose nitrate based film."** (NFPA 2001, 40-4) While only a standard, many building and fire codes, as well as insurance policies, require compliance with fire standards such as NFPA 40. Thus not following the standard may have legal ramifications. It is critical that you and others in your institution be familiar with the most recent edition of this standard.

Cellulose Nitrate is a Hazardous Material (Class 4.1 Flammable Solid)

Since most cultural property is not hazardous, the fact that cellulose nitrate film is hazardous does create challenges and concerns in cultural institutions that possess it. The United States Department of Transportation describes photographs with a nitrate film base as "Films, nitrocellulose base, gelatine coated (except scrap) – UN1324." (CFR 49 2002, 173.101) Other materials containing cellulose nitrate (such as celluloid objects)

have other UN identification numbers. Within the DOT hazardous material classifications scheme, nitrate film is a Class 4.1 Flammable Solid. (CFR 49 2002, 173.2)

Class 1	Explosives
Class 2	Hazardous Gases
Class 3	Hazardous Liquids
Class 4	Hazardous Solids 4.1 Flammable Solid 4.2 Spontaneously Combustible Material 4.3 Dangerous When Wet Material
Class 5	Oxidizers
Class 6	Poisons and Infectious Agents
Class 7	Radioactive Materials
Class 8	Corrosive Materials
Class 9	Miscellaneous Materials

Nitrate film has a reputation for spontaneously combusting when not cared for properly. Research from the late 1940's shows there is a fire risk when cellulose nitrate film is in poor condition (unusable – in stages 3 and above – see chart below) and stored at high temperatures. Film in very poor condition ignited in a chamber held at 106°F for 17 days. (Cummings et al 1950) This research found that film in good condition was much less at risk of spontaneous combustion – "One reassuring aspect of the results of the tests to date is that no film in good condition has self-ignited." (Cummings et al 1950, 270)
However no matter the original condition of the film, nitrate fires are extremely difficult to extinguish and can create a very fast moving and destructive fire. People have died in cellulose nitrate fires. Common themes related to nitrate fires are poor storage practices, poor environmental conditions, carelessness, lack of attention to the collection, and lack of security. Put simply, nitrate film requires proper care and storage. If it receives care and attention and is not allowed to degrade to a poor condition, the risk of a fire is reduced.

Cellulose Nitrate is an Unstable Material

Nitrate film degrades unless it is stored at reduced temperatures and relative humidities just like its chemical cousin, cellulose acetate or "Safety" film (because unlike nitrate film it does not readily burn). As cellulose nitrate degrades it not only becomes more easily combustible it also may become adhered together, brittle, and discolored. Silver images will fade. Without preservation measures, the film will become completely unusable. Cold storage is needed for its long-term preservation.
Five Stages of Cellulose Nitrate Film Deterioration (Cummings et al 1950)

Stage 1	Amber discoloration of base
Stage 2	Gelatin emulsion is tacky and may be slightly adhered to other materials
Stage 3	Portions are soft, contain bubbles, and have strong noxious odor
Stage 4	Entire film is soft, adhered overall, viscous froth may be apparent
Stage 5	Partially or fully disintegrated into a brownish acrid powder

National Fire Protection Association Standard NFPA 40-2001 *Standard for Storage and Handling of Cellulose Nitrate Motion Picture Film*

This is available through the NFPA website in both electronic and hardcopy formats. If your institution has cellulose nitrate film or believes it may possess cellulose nitrate film**, it is absolutely essential that you have and are familiar with this standard.** The link to the webpage for NFPA is: http://www.nfpa.org. Search "NFPA 40"

The following information from NFPA 40 is not meant to supplant the need to understand NFPA 40 in its entirety, rather it is included to describe the quantity limits discussed in the standard.

NFPA 40 - Use

NFPA 40, 9.23 & 9.24

"The total quantity of nitrate film outside of storage cabinets or vaults shall be limited to one motion picture feature or subject per work station, not to exceed 40 standard rolls or 12,192 m (40,000 ft) [200 lbs] in rooms where film is prepared for printing."
"The total quantity of nitrate film that is not in containers in all workrooms shall not exceed two standard rolls or 610 m (2000 ft) [10 lbs] in rooms where film is prepared for filming.

NFPA 40, 5.1.2

"Every room… where nitrate film is …stored or handled in quantities greater than 23 kg (51 lb) 10 standard rolls)) shall be protected by an automatic sprinkler system that is installed in accordance with the requirements for Group II extra hazard occupancies of NFPA 13, *Standard for the Installation of Sprinkler Systems*."

NFPA 40 - Storage

Quantity Limits for Nitrate film

NFPA 40, 6.1 General

"Nitrate film, which is not in process or being worked on, shall be stored as follows:
"(1) Amounts exceeding 11 kg (25 lb (5 standard rolls) [defined in NFPA 40, 3.3.8 as "1000ft of 35mm motion picture film"]) but not exceeding 340 kg [750 lb (150 standard rolls)] shall be stored in approved cabinets or in vaults.
(2) Amounts exceeding 340 kg [750 lb (150 standard rolls)] shall be stored in vaults.
(3) Extended term storage film [defined in NFPA 40, 3.3.4 as "film of value for record purposes that will be kept in permanent storage"] shall be stored in extended term storage cabinets or extended term storage vaults, which are subject to the limitations of Sections 6.1 (1) and (2)."

Summary of Storage Limits

0-25 lbs	Extended Storage Cabinet No explicit description of storage for less than 25 lbs in NFPA 40
25-51 lbs	Extended Storage Cabinet
51-375 lbs	Extended Storage Cabinet with automatic sprinkler & vent
>750 lbs	Extended Storage Vault NFPA 40, 6.3.3 “Vaults shall have temperature controlled to maintain temperature at 70°F (21°C) or less.

The standard does not comment significantly on weight limits in regard to an institution storing film in separate groups in separate spaces or buildings. The standard does indicate that the upper limit of a film cabinet is 375 lbs (75 rolls), while quantities over 750 lbs (150 rolls) are to be stored in vaults. No upper limit is stated in the section on extended term cabinets, in this summary the figure from the section on film cabinets has been cited.

While the standard only describes weight equivalents for motion picture film, listed below is a conversion chart for nitrate still picture film that we have used at LC since 1992. We use a limit of 5 lbs per workstation.

Nitrate Weight Equivalency Estimates

Format	5 lbs. (LC use limit per workstation)	<50 lbs. (storage limit unvented cabinet)
35mm motion picture	1000 ft (1 reel)	10,000 ft (10 reels)
8 x 10	135	1350
5 x 7	320	3200
4 x 5	700	7000
35mm still picture (5 frames)	2855	28550
2 x3	2000	20000
2 1/4 x 3 1/2	6000	60000

Lack of Commercial NFPA 40 Compliant Storage Space

By our investigations, there is very little commercial NFPA 40 compliant storage space. In 2002 we could find no acceptable commercial facility that had the capacity to store a large amount of nitrate film. There may be space available for smaller amounts of film.

Duplication, Disposal and Transportation of Nitrate film is Expensive

As a hazardous material, various regulations and laws cover the transport and disposal of nitrate film. (CFR 36 2003, CFR 40 2003, CFR 49 2002) This can be a costly endeavor. In some institutions the response to concern over nitrate film is that "we should just get rid of it" or "copy it". Both are expensive to do and typically cost as much or more than proper storage of hazardous materials. A publication available from Eastman Kodak *Safe Handling, Storage and Destruction of Nitrate-Based Motion Picture Films* Eastman Kodak Publication H-18*2* describes proper disposal. (Eastman Kodak 1998) This document is available from Eastman Kodak's website.

NFPA 40 Includes Very Little Explicit Information Concerning Storage of Nitrate Still Picture Film

NFPA 40 has been a standard for cellulose nitrate motion picture film since 1919 and includes useful information about how the standard should be implemented for motion picture film. For example, quantity limits for film are given in both rolls of film and pounds. Unfortunately the same level of guidance is not given for still picture film; no weight equivalency is given for still picture film. There is also the issue with vault design recommendations described in Chapter 6 and Annex A, only storage of motion picture film is described. Storage of still picture nitrate film is not addressed. The standard does not address storage of nitrate film in explosion proof freezers or refrigerators, a common practice for nitrate still picture film. (Wilhelm and Brower 1993)

The best resource concerning storage of still picture nitrate film is an article written in 1953 by J.M. Calhoun of Eastman Kodak. Calhoun states his opinion that "still-camera nitrate negatives are much less hazardous that motion picture films… because the former are usually stored in envelopes which reduces the mass of film in intimate contact and decreases the likelihood of decomposition or ignition." (Calhoun 1953, 3) He adds, "the very much better record which has been established for preservation by nitrate amateur negatives compared with motion picture films, undoubtedly, is due to the smaller quantity involved in any one storage area and the practice of keeping still negatives in paper envelopes with better access to the air." (Calhoun 1953, 6) Also in the article is a 1952 statement from a NFPA official "I have reviewed our files of fire reports covering the last fifty years and find no reports of fires caused by nitrate negatives stored in quantities that would customarily be found in homes or offices where the film was used for amateur purposes." (Calhoun 1953, 6)

The author understands that a more recent Swedish storage standard also states that nitrate still picture film is less of a fire risk than nitrate motion picture film. The author is pursuing this standard; please contact him if you are interested in it.

Freezer Storage

Freezer storage for nitrate film is described in great detail by Henry Wilhelm in Appendix 19.1 "Freezer Storage for Permanent Preservation of Cellulose Nitrate Still-Picture Negatives and Motion Pictures" in his book *The Permanence and Care of Color Photographs*. (Wilhelm and Brower 1993, 675-685) Many institutions have used this method for caring for photographic materials that require cold storage (nitrate, acetate, and color photographs). This has been a very viable option for preservation of smaller quantities of film. The author knows of no nitrate fires caused by the use freezer or cold storage.

Equivalency in NFPA 40

While the standard explicitly describes vaults and cabinets for extended term film and does not include information about explosion proof freezers, this may remain a viable option, upon approval of your fire marshal, due to the notion of "equivalency" described in Section 1.5 of the standard.

NFPA 40 1.5 Equivalency

"1.5.1 Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed in this standard, provided that technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency and that the system, method, or device is approved for the intended purpose. 1.5.2 The specific requirements of this standard for existing building shall be permitted to me modified by the authority having jurisdiction to allow alternative arrangements that will secure as nearly equivalent safety to life and protection of film from fire as practical. However, in no case shall the modification afford less safety to life than compliance with the corresponding provisions contained in this standard for existing buildings."

Last Year of Nitrate Manufacture by Kodak in U.S.

(Calhoun 1953)

X-Ray	1933	
Roll Film (35mm)	1938	
Sheet Film	1939	Kodak nitrate sheet film has a "V" notch adjacent to the corner
Aerial Film	1942	
Roll Film (616, 620, etc.)	1950	
Motion Picture (35mm)	1951	

8mm and 16mm films were never made with cellulose nitrate by Kodak

"At the present time [1953] nitrate film base has almost ceased to be used in the United States… The situation is quite different in most of Europe and Asia where nitrate is still the predominant base for photographic film." (Calhoun 1953, 3)

Reduce risk

Take steps to prevent a fire from occurring in the storage area.

Obtaining NFPA 40 compliant storage cannot occur overnight. Steps should be taken immediately to store it in a secure and safe space to reduce the risk of an accidental or intentional fire. While not addressed in NFPA 40, some experts have stated that still picture film stored in sleeves and boxes does reduce the risk. (Calhoun 1953, 6) Film in good condition (that is in usable condition) stored in a normal environment (70°F, 50% RH) will not spontaneously combust. However as the film ages in that environment it will degrade and eventually (in years, decades or centuries) become deteriorated and more of a fire risk. In addition it will become so deteriorated that it becomes unusable. Cold storage is needed to preserve this material in its present condition.

Examine nitrate holdings

Quantify the amount and condition of cellulose nitrate film.

To show good stewardship of these materials you must know both the amount and condition of your nitrate holdings to proceed with planning and implementation of compliant storage.

Read and become familiar with NFPA 40

After doing this you are likely to be more conversant with this fire safety standard than others in your institution and possibly your fire marshal. Demonstrating your institution's knowledge of the standard will increase the fire marshal's confidence in your approach.

Please call or email the author with your comments and questions

Over the past year the author has been in contact with a growing group of people with questions such as yours. It is his hope that with enough interest and contact among people that a facility may be built that institutions can use for nitrate storage.

Andrew Robb
Senior Photograph Conservator
Library of Congress
Conservation Division
Washington, DC 20540-4530
202 707-1175
anro@loc.gov

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Cellulose nitrate polymers vary in the amount of actual cellulose nitrate in their composition, from collodion photographic emulsions with a 10.5% concentration, to photographic flexible film bases with a 12% concentration, to explosive weapons-grade gun cotton with a 12.5% concentration.Â Nitrate is often confused with the cellulose ester films, including acetate, diacetate, and triacetate negatives, which deteriorate in a similar fashion. Cellulose ester films are described in Section B.1. Paper-based photographs are never nitrate.Â Nitrate motion picture film was used to create educational film strips, amateur films, training films, travel films, and amateur and commercial motion picture releases, both silent and with sound. When nitrate film is transported using a commercial vendor, packing must comply with DOT Shipping Regulations in 49 CFR 172. In 2012, the US adopted the 16 section Safety Data Sheet to replace Material Safety Data Sheets, formerly used when transporting nitrate. This became effective on December 1, 2013. These new Safety Data Sheets comply with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). By June 1, 2015, employers were required to have their workplace labeling and hazard communication programs updated as necessary â€“ including all MSDSs replaced with SDS-fo...Â Additional Reading: Recent Developments in Using, Storing, and Transporting Cellulose Nitrate Still, Picture Film. Although a proper definition of â€œpure celluloseâ€ has not yet been found, the term â€œcelluloseâ€, as commonly used by chemists, is restricted to a product which may be obtained from raw cotton by...Â The resulting product, termed â€œstandard celluloseâ€, is now usually employed as the starting material in structural investigations. During the last one hundred years an enormous mass of experimental data has accumulated from which conflicting views and opposing conceptions have emerged, each of them offering evidence as to the true chemical constitution of cellulose. Many of these suggestions, however, have been based on data interpreted by several workers in support of their favorite theories which reveal only part of the picture and fail to allow a comprehensive generalization.