

NFPA[®]

40

**Standard for
the Storage and Handling
of Cellulose Nitrate Film**

2019



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NFPA® 40

Standard for the

Storage and Handling of Cellulose Nitrate Film

2019 Edition

This edition of NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Film*, was prepared by the Technical Committee on Hazardous Chemicals. It was issued by the Standards Council on May 4, 2018, with an effective date of May 24, 2018, and supersedes all previous editions.

This edition of NFPA 40 was approved as an American National Standard on May 24, 2018.

Origin and Development of NFPA 40

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Film*, was developed by the National Board of Fire Underwriters Committee of Consulting Engineers and was first adopted by NFPA in 1910, under the title *Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film*. Amendments were adopted in 1915, 1919, 1922, and 1926. A complete revision was adopted in 1931, with further amendments in 1936, 1939, 1946, and 1947. Extensive revisions were also made in 1953. The technical requirements of the early editions of NFPA 40 were based on extensive fire tests conducted by motion picture film manufacturers. With the reorganization of the committee in 1960, the Technical Committee on Explosives was given responsibility for NFPA 40. However, in 1970, responsibility was transferred to the Technical Committee on Storage, Handling, and Transportation of Hazardous Chemicals. The 1953 edition of NFPA 40 was reconfirmed in 1962. Amendments were adopted in 1967, and the 1967 edition was reconfirmed in 1974.

In 1979, the Technical Committee on Storage, Handling, and Transportation of Hazardous Chemicals debated whether to withdraw the document because cellulose nitrate motion picture film had not been manufactured for more than 20 years. However, due to the large quantities of cellulose nitrate motion picture film in various archives, the committee decided to revise NFPA 40 and to maintain it as an active NFPA standard as long as archive collections are being maintained. (The Library of Congress, the Smithsonian Institution, the U.S. military services, and others have great quantities of such film, which is slowly being reprinted onto safety film.) An updated edition was adopted in 1982 and reconfirmed in 1988.

The 1994 edition of NFPA 40 reflected a partial revision of the standard to improve its usability, adoptability, and enforceability, and to update old terminology. In addition, the Technical Committee on Hazardous Chemicals clarified the requirements relating to protection of film cabinets and vaults with automatic sprinkler protection, as well as clarifying the requirements for decomposition vents.

For the 1997 edition, the terminology and provisions relating to long-term storage of cellulose nitrate motion picture film were updated to be consistent with the terminology used in the film storage industry. This was done in response to new storage facilities for cellulose nitrate films that were being built, and clarification was needed for consistency between the standard's provisions for vault construction and various building code requirements. Those changes were reflected throughout the standard. Provisions for handling cellulose nitrate motion picture films also were updated within the safety limits previously established by the Technical Committee on Hazardous Chemicals. However, the committee reduced the number of rolls of cellulose nitrate motion picture film allowed to be present in a shipping room to reduce the potential hazard to persons working in the area. Other changes were editorial in nature to bring the document into conformance with the 1986 edition of the *Manual of Style for NFPA Technical Committee Documents*.

The 2001 edition expanded the scope of the document to include flat film, making NFPA 40 the single document that addressed cellulose nitrate film storage. Before that revision, NFPA 42, *Code for the Storage of Pyroxylin Plastic*, had covered flat film storage, but the requirements did not address it adequately. Several changes were made to the storage chapter of NFPA 40 to reflect the safety

concerns with flat film. Restructuring changes also were made to make the document conform to the 2000 edition of the *Manual of Style for NFPA Technical Committee Documents*, including eliminating several exceptions, changing the chapter order, and moving nonmandatory material to the annexes. In addition, the title of the standard was changed to *Standard for the Storage and Handling of Cellulose Nitrate Film*.

The 2007 edition was essentially a reconfirmation of the 2001 edition of the document.

The 2011 edition included amendments to the requirements for applying the standard to new and existing facilities so that the equivalency provision applied correctly. Research by FM Global that was concluded in 2000 was incorporated in revisions to film vault fire protection. The committee provided an annex item that provided information on converting sheets of flat film to roll film equivalencies because storage requirements in the standard are based on roll film quantities. The committee also revised the standard to comply with the 2004 edition of the *Manual of Style for NFPA Technical Committee Documents*.

The 2016 edition clarified how the storage requirements in NFPA 40 apply to both motion picture film and flat film. Explanatory material expanded on the flat-film to roll-film equivalencies developed in the 2011 edition to include mass, volume, and number of rolls or sheets of film. The committee also revised recommendations for the inspection, reformatting, and disposal of unstable nitrate film to accurately reflect the variable nature of nitrate decay.

In the 2019 edition, the terms *standard roll* and *single- and double-roll containers* were replaced by terminology used by modern archivists. A new definition for *decomposition* was added, along with a new requirement for inspection and maintenance of portable fire extinguishers to comply with NFPA 10. Changes were made to the extended term storage vault requirements to allow for flexible storage configurations. Requirements for openings in, and exhaust capacities of, projection booths were revised to reflect modern practices and equipment, and a new requirement for temperature and humidity control was added.

Technical Committee on Hazardous Chemicals

Robert J. James, Chair
UL LLC, IL [RT]
Rep. UL LLC

Elizabeth C. Buc, Fire & Materials Research Laboratory, LLC, MI [RT]

Chris M. Connealy, Texas Department of Insurance, TX [E]

Edwin D. Cope, Cope Engineering, TX [SE]

Dirk Der Kinderen, U.S. Department of Transportation, DC [E]

Mark J. Dossett, San Diego Fire-Rescue Department, CA [E]
Rep. California Fire Chiefs Association

Henry L. Febo, Jr., Holliston, MA [SE]

Kathleen A. Franklin, U.S. Environmental Protection Agency, DC [E]

Martin T. Gresho, FP2Fire, Inc., CO [SE]

Peter Paul Howell, Mark V, Inc., WV [SE]

Noel Hsu, Orica U.S.A. Inc., CO [M]
Rep. The Fertilizer Institute

Paul A. Iacobucci, Akzo Nobel, IL [M]
Rep. SPI/Organic Peroxide Producers Safety Division

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Kevin Kreitman, Albany Fire Department, OR [E]

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R. Kenneth Lee, Axiall LLC, AR [M]

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Ken Scott Mueller, CHS - Cenex Harvest States, IL [U]
Rep. Agricultural Retailers Association

Eugene Y. Ngai, Chemically Speaking LLC, NJ [SE]

Anthony M. Ordile, Haines Fire & Risk Consulting Corporation, NJ [SE]

Jerald Pierrottie, Lonza Group Ltd., LA [M]

Michael Reilly, Fairfax County Fire & Rescue Department, VA [L]
Rep. International Association of Fire Fighters

Jerrold Sameth, Compressed Gas Association, Inc., NJ [M]

John Louis Schumacher, Advanced Engineering Investigations, CO [SE]

Milton R. Shefter, Miljoy Ent. Incorporated, CA [U]
(VL to Document: NFPA 40)

Jonathan Thomas Shriner, U.S. Architect of the Capitol, DC [U]
(VL to Document: NFPA 40)

Ronald Thomas, Institute of Makers of Explosives, UT [M]
Rep. Institute of Makers of Explosives

Irene Villanueva Uriarte, FM Global, MA [I]
Rep. FM Global

James O. Vigerust, Jr., CB&I, NM [SE]
Rep. NFPA Industrial Fire Protection Section

Jerry W. Wallace, Safety Engineering Laboratories, Inc., MI [SE]

Alternates

James C. Belke, U.S. Environmental Protection Agency, DC [E]
(Alt. to Kathleen A. Franklin)

James Carver, El Segundo Fire Department, CA [E]
(Alt. to Mark J. Dossett)

Joseph Carl Chew, Haines Fire And Risk Consulting, Corp., NJ [SE]
(Alt. to Anthony M. Ordile)

Richard A. Craig, Compressed Gas Association, VA [M]
(Alt. to Jerrold Sameth)

Peter Dluzneski, Arkema Inc., PA [M]
(Alt. to Paul A. Iacobucci)

Richard H. Ferguson, Axiall LLC, PA [M]
(Alt. to R. Kenneth Lee)

Steve Ferrara, Carolina Eastern - Vail Inc., NY [U]
(Alt. to Ken Scott Mueller)

Heather Millikan Heckman, University Of South Carolina, SC [U]
(VL to Document: NFPA 40)
(Alt. to Milton R. Shefter)

Scott M. Heyworth, FP2Fire, Inc., FL [SE]
(Alt. to Martin T. Gresho)

Zachary John Jason, Advanced Engineering Investigations, CO [SE]
(Alt. to John Louis Schumacher)

John A. LeBlanc, FM Global, MA [I]
(Alt. to Irene Villanueva Uriarte)

Kathleen Nehmer, Pond & Company, MA [SE]
(Voting Alt.)

Brian P. Sampson, Safety Engineering Laboratories, Inc., MI [SE]
(Alt. to Jerry W. Wallace)

David S. Shatzer, Shatzer & Associates Consulting, PA [SE]
(Alt. to Edwin D. Cope)

Clark D. Shepard, ExxonMobil Corporation, TX [M]
(Alt. to Joyce Miles)

Robert Suarez, Des Moines Fire Department, IA [L]
(Alt. to Michael Reilly)

Nonvoting

David Chicca, OSHA, DC [E]
Rep. Occupational Safety & Health Administration

Richard S. Kraus, API/Petroleum Safety Consultants, VA [M]
Rep. TCC on Flammable and Combustible Liquids

Laura E. Moreno, NFPA Staff Liaison

Patrick A. McLaughlin, McLaughlin & Associates, ID [U]
Rep. TC on Industrial, Storage, & Miscellaneous Occupancies

Kathy A. Landkrohn, U.S. Department of Labor, DC [E]
Rep. Occupational Safety & Health Administration

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Committee Scope: This Committee shall have primary responsibility for documents on, and maintain current codes for, classes of hazardous chemicals and codes for specific chemicals where these are warranted by virtue of widespread distribution or special hazards.

Contents

Chapter 1 Administration	40- 6	Chapter 6 Storage of Nitrate Film	40- 9
1.1 Scope.	40- 6	6.1 General.	40- 9
1.2 Purpose.	40- 6	6.2 Film Cabinets.	40- 9
1.3 Application.	40- 6	6.3 Vaults Other Than Extended Term Storage Vaults.	40- 10
1.4 Retroactivity.	40- 6	6.4 Extended Term Storage Cabinets.	40- 11
1.5 Equivalency.	40- 6	6.5 Extended Term Storage Vaults.	40- 12
1.6 Approval of Plans.	40- 6		
Chapter 2 Referenced Publications	40- 6	Chapter 7 Handling of Nitrate Film	40- 13
2.1 General.	40- 6	7.1 General Conditions.	40- 13
2.2 NFPA Publications.	40- 6	7.2 Containers Required.	40- 13
2.3 Other Publications.	40- 7	7.3 Shielding.	40- 13
2.4 References for Extracts in Mandatory Sections. (Reserved)	40- 7	7.4 Scrap and Discarded Film.	40- 13
		7.5 Transportation.	40- 13
Chapter 3 Definitions	40- 7	Chapter 8 Motion Picture Projection and Special Processes	40- 13
3.1 General.	40- 7	8.1 Enclosures for Motion Picture Projectors.	40- 13
3.2 NFPA Official Definitions.	40- 7		
3.3 General Definitions.	40- 7	Chapter 9 Special Occupancies	40- 14
Chapter 4 Construction Requirements and Arrangements of Buildings	40- 8	9.1 Motion Picture Film Exchanges.	40- 14
4.1 Construction.	40- 8	9.2 Motion Picture Film Laboratories.	40- 14
4.2 Exits.	40- 8		
4.3 Explosion Venting.	40- 8	Annex A Explanatory Material	40- 14
4.4 Space for Workers.	40- 8	Annex B Additional Information on Cellulose Nitrate Film	40- 18
4.5 Tables and Racks.	40- 8	Annex C History of Cellulose Nitrate Film Use and Storage	40- 19
4.6 Electrical Equipment.	40- 8	Annex D Informational References	40- 19
4.7 Heating, Cooling, and Refrigeration Equipment.	40- 8	Index	40- 21
4.8 Duct Systems.	40- 8		
Chapter 5 Fire Protection	40- 9		
5.1 Automatic Sprinklers.	40- 9		
5.2 Water Supplies.	40- 9		
5.3 Portable Fire Extinguishers.	40- 9		

NFPA 40

Standard for the

Storage and Handling of Cellulose Nitrate Film

2019 Edition

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

1.1* Scope.

1.1.1* This standard shall apply to all facilities that are involved with the storage and handling of cellulose nitrate-based film.

1.1.2 This standard shall not apply to the storage and handling of film having a base other than cellulose nitrate.

1.2 Purpose. Based on minimum requirements for safety to life and property from fire, this standard shall provide for the storage and handling of cellulose nitrate film.

1.3 Application.

1.3.1 This standard gives general provisions regarding the storage and handling of cellulose nitrate film and special provisions for such occupancies as motion picture projection

booths, nitrate film vaults, and laboratories handling nitrate film. These special provisions shall apply in addition to any and all general provisions that are applicable.

1.3.2* The grouping of the special provisions under the heading of special occupancies is merely for convenience in the application of this standard. Any particular process or operation in any type of occupancy shall be governed by the provisions that are given for that process or operation, whether under the heading of that occupancy or any other heading, unless otherwise specifically provided herein.

1.4 Retroactivity. Because nitrate film deteriorates with age, the provisions of this standard shall be retroactive. Where improvements have been made over previous editions of this standard, the incorporation of these changes in existing facilities shall be required particularly where cellulose nitrate film storage will continue.

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 buildings shall be permitted to be modified by the authority having jurisdiction to allow alternative arrangements that will secure, as nearly as practical, equivalent safety to life and protection of film collections from fire. 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. (See also 1.5.1.)

1.6 Approval of Plans. Before any building is constructed for use as a cellulose nitrate film occupancy, any nitrate film vault is built, any enclosure for motion picture projection is installed, or any screening room is installed, complete plans for the proposed construction or installation shall be submitted for approval to the authority having jurisdiction. These plans shall show in detail all proposed construction and structural changes, means of protection to be provided, the heating system and its protection, electrical equipment, and the character and location of exposures. The plans also shall indicate the maximum amount and types of film to be handled or stored in each area.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2017 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 70®, *National Electrical Code*®, 2017 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2019 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2019 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2018 edition.

NFPA 101®, *Life Safety Code*®, 2018 edition.

NFPA 220, *Standard on Types of Building Construction*, 2018 edition.

NFPA 221, *Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls*, 2018 edition.

2.3 Other Publications.

2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2014 edition.

2.3.2 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2008, revised 2013.

2.3.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evalua-

tion of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1* Cellulose Nitrate Film. Motion picture sound recording, still, or flat film that is coated on a support or base consisting essentially of cellulose nitrate.

3.3.2 Decomposition. The transformation of a substance into simpler substances or basic elements brought about by exposure to heat, light, or chemical or biological activity. (See *Annex B for information on the decomposition of cellulose nitrate film.*)

3.3.3* Extended Term Storage. Storage having an indefinite duration (i.e., for the functional life of the film element and intended to protect and conserve the useful life of the film as long as possible).

3.3.4 Extended Term Storage Cabinet. A specially constructed and equipped enclosure that is used for the extended term storage of cellulose nitrate motion picture film.

3.3.5 Extended Term Storage Film. Film of value for record purposes that will be kept in permanent storage.

3.3.6* Extended Term Storage Rack. A rack that is intended for use in extended term storage of high value or permanent record film.

3.3.7* Extended Term Storage Vault. A specially constructed and equipped storage room with both a 4-hour fire rating and an inside volume that does not exceed 28 m³ (1000 ft³).

3.3.8 Film Cabinet. A specially constructed and equipped enclosure for the storage of up to 170 kg (375 lb) of cellulose nitrate motion picture film.

3.3.9* Vault. A specially constructed and equipped storage room with both a 4-hour fire rating and an inside volume that does not exceed 21 m³ (750 ft³).

3.3.10 Vent.

3.3.10.1 Decomposition Vent. A vent to permit the escape of gases resulting from decomposition or from incomplete combustion of nitrate film.

3.3.10.2 Explosion Vent. A vent to relieve explosion pressures resulting from ignition of a mixture of decomposition gases and air.

Chapter 4 Construction Requirements and Arrangements of Buildings

4.1 Construction.

4.1.1* Nitrate film shall be stored or handled only in buildings of Type I construction as defined in NFPA 220.

4.1.1.1 Decomposition vents and explosion vents shall be of noncombustible construction.

4.1.2 All rooms where nitrate film is stored or handled shall be separated from each other and from all other parts of the building by partitions having a fire resistance rating of at least 1 hour.

4.1.2.1 The partitions shall be constructed in accordance with NFPA 221.

4.1.2.2 Film vaults shall be permitted to meet the requirements of Section 6.3 or Section 6.5.

4.1.2.3 Partitions shall be continuous from floor to ceiling and shall be anchored securely to walls, floors, and ceilings.

4.1.3 Openings in partitions shall be protected by approved fire doors having a 1-hour fire resistance rating and installed according to NFPA 80.

4.2 Exits.

4.2.1 All rooms where nitrate film is handled, except film vaults, shall be provided with aisles having a minimum width of 910 mm (36 in.).

4.2.1.1 For existing rooms, the minimum aisle width shall be permitted to be 760 mm (30 in.).

4.2.1.2 The minimum aisle width for film vaults shall be 760 mm (30 in.).

4.2.2 Rooms where nitrate film is handled shall have two or more exits that are remote from each other.

4.2.2.1 Film vaults shall not be required to comply with the exit provision of 4.2.2.

4.2.3* Doors shall swing in the direction of exit travel. Where not clearly identifiable, exits shall be marked by an "EXIT" sign meeting the requirements of NFPA 101.

4.3 Explosion Venting.

4.3.1* Explosion venting shall be provided in rooms or vaults that are used for the storing and handling of nitrate film.

4.3.1.1* Explosion venting shall not be required for rooms where the total quantity of film not stored in vented cabinets is less than 6100 m (20,000 ft), or 46 kg (100 lb).

Δ 4.3.2 Explosion venting shall be provided in the ratio of 0.09 m² (1 ft²) of free vent area per each 1.4 m³ (50 ft³) of room or vault volume.

4.4* Space for Workers.

4.4.1 There shall be at least 3.3 m² (35 ft²) of floor area for each worker in every inspection room.

4.4.2 Not more than 15 persons shall work at any one time in any one room where nitrate film is handled.

4.5 Tables and Racks.

4.5.1 Tables and racks that are used in connection with the handling of film (e.g., joining, inspection, and assembly tables) shall be noncombustible or of wood construction with no member less than 38 mm (1½ in.) in least dimension.

4.5.2 Tables shall not have racks or shelves beneath them.

4.5.3 Tables and racks shall be kept at least 100 mm (4 in.) away from any radiator or heating apparatus.

4.6 Electrical Equipment.

4.6.1 All electrical wiring and equipment shall comply with NFPA 70 for Class I, Group D, Division 2 locations. The temperature rating of electrical equipment shall be Class T6.

4.6.2 Motors shall be located or arranged so that film cannot come in contact with them.

4.7 Heating, Cooling, and Refrigeration Equipment.

4.7.1 Artificial heating in any building or room in which nitrate film is handled or stored, other than a vault, shall be restricted to hot water or steam not exceeding gauge pressure of 103 kPa (15 psi).

4.7.1.1 Approved electric steam radiators operating at pressures not exceeding gauge pressure of 103 kPa (15 psi) and protected with wire mesh guards shall be permitted to be used if they are of the fixed (nonportable) type.

4.7.1.2 If the radiators or heating coils of an indirect heating system that uses high-pressure steam are not located in the room or rooms being heated, then the requirements of 4.7.1 shall not be interpreted as prohibiting the installation of such a system. Heat-generating equipment shall be located in a separate room.

4.7.2 All steam pipes within 1.8 m (6 ft) of the floor and where passing through walls, partitions, or racks or near woodwork shall be protected by insulation.

4.7.3 All radiators, heating coils, pipes, and returns that are near the floor or located so as to permit contact with any combustible material, waste, or dirt shall be guarded and protected with 6.4 mm (¼ in.) mesh, galvanized steel wire cloth (hardware cloth, No. 20 B&S gauge or equivalent). The guards shall be arranged so that they can be lifted for cleaning. The tops of such guards shall be sloped so that they cannot be used as shelves. Guards shall be constructed so that no film can come within 100 mm (4 in.) of the heating surface. Guards shall be constructed with a substantial metal framework that will prevent the wire mesh from being forced against the radiator or pipes.

4.7.4* Extended term storage vaults shall be permitted to have refrigeration from air-conditioning systems installed where necessary to provide temperature and humidity control.

4.8 Duct Systems.

4.8.1 Air-conditioning, warm-air-heating, air-cooling, and ventilating systems that employ ducts shall be installed in accordance with NFPA 90A.

4.8.2 Any duct system used for air that is conditioning a film vault or room where nitrate film is handled shall be entirely independent with no duct connecting to any other vault or room.

4.8.2.1* It shall be permitted to share conditioning air systems among multiple storage vaults where fire- and pressure-rated isolation devices capable of withstanding a gauge pressure of 7 kPa (1 psi) overpressure and a temperature of 1370°C (2500°F) for 40 minutes are installed.

4.8.2.2 Isolation devices shall be located in the supply and return ductwork at the boundary of the vault to contain any incident within the vault, as well as isolate other vaults in the common system.

4.8.2.3 Isolation devices in all connected vaults shall be automatic closing on actuation of the incident detection system in any vault.

4.8.2.4 Incident detection shall be provided in accordance with 6.5.6.8.

4.8.2.5 The isolation devices shall be fully closed within 10 seconds of the actuation of the incident detection system.

4.8.3 Air shall not be recirculated between vaults.

4.8.3.1 It shall be permitted to recirculate air to a centralized conditioning air system if there is an incident detection system that closes off the recirculation by means of an isolation device as specified in 4.8.2.1.

4.8.3.2 The incident detection system shall meet the criteria stated in 6.5.6.8.

4.8.3.3 The air recirculation shall be fully closed within 10 seconds of the actuation of the incident detection system.

Chapter 5 Fire Protection

5.1* Automatic Sprinklers.

5.1.1 The purpose of this protection is to prevent fire or heat from affecting storage that is not initially involved in a fire.

5.1.2 Every room, except projection booths and rewinding rooms, where nitrate film is stored or handled in quantities greater than 23 kg (51 lb), or 3050 m (10,000 ft), shall be protected by an automatic sprinkler system that is installed in accordance with the requirements of NFPA 13 for Group II extra hazard occupancies.

5.1.3 Protection for areas other than film cabinets and vaults shall utilize automatic sprinklers. Protection for film cabinets and vaults, extended term storage or other than extended term storage, shall be permitted to utilize an automatic sprinkler system or a deluge system using fixed spray nozzles or open sprinklers.

Δ 5.1.4 In areas or rooms where nitrate film is handled, the area that is protected per sprinkler shall not exceed 6 m² (64 ft²) with sprinklers not being more than 2.4 m (8 ft) apart.

5.2 Water Supplies.

5.2.1 Water supplies that are acceptable to the authority having jurisdiction shall be provided.

5.2.2 Water supplies for automatic sprinklers shall be based on 1.26 L/sec (20 gpm) per sprinkler for 20 minutes for the total number of sprinklers in one vault plus 25 percent of the sprinklers in the communicating fire area.

5.3* Portable Fire Extinguishers. Every room in which nitrate film is stored or handled shall be provided with portable fire extinguishers in accordance with NFPA 10.

5.3.1 Film vaults shall not be required to comply with the portable fire extinguisher requirement in Section 5.3.

N 5.3.2 Portable fire extinguishers shall be inspected and maintained in accordance with NFPA 10.

Chapter 6 Storage of Nitrate Film

6.1* General. Nitrate film that is not in process or being worked on shall be stored as follows:

- (1)* Amounts exceeding 11 kg (25 lb) but not exceeding 340 kg (750 lb) shall be stored in approved cabinets or in vaults. (See Sections 6.2 and 6.3.)
- (2)* Amounts exceeding 340 kg (750 lb) shall be stored in vaults. (See Section 6.3.)
- (3) Extended term storage film shall be stored in extended term storage cabinets or extended term storage vaults, which are subject to the limitations of Section 6.1(1) and 6.1(2). (See Sections 6.4 and 6.5.)

6.2 Film Cabinets.

6.2.1 Film cabinets shall be constructed in the following manner:

- (1) The bottom, top, door, and sides of the cabinet shall be at least No. 18 U.S. gauge sheet steel and double walled with 38 mm (1½ in.) air space.
- (2) Joints shall be riveted, welded, or made tight by some equally effective means.
- (3) The door shall be provided with a three-point latch arrangement, and the door sill shall be raised at least 50 mm (2 in.) above the bottom of the cabinet to retain spilled liquid within the cabinet, as shown in Figure 6.2.1.

6.2.2 Cabinets shall have a capacity not exceeding 170 kg (375 lb), or 22,860 m (75,000 ft).

6.2.3 Shelves shall be made of noncombustible insulating material not less than 9.5 mm (⅜ in.) thick or of hardwood that is not less than 25 mm (1 in.) thick.

6.2.3.1 Shelves shall fit tightly to the back and sides of the cabinet. There shall be a clearance of at least 25 mm (1 in.) between the front of the shelf and the inside of the door.

6.2.3.2 Shelves for motion picture film storage shall be 25 mm (1 in.) wider, with a tolerance of 6.4 mm (¼ in.), than the diameter of the largest roll that is stored in the cabinet. Stops or bars shall be provided so that film cans cannot be stored with the front edge less than 19 mm (¾ in.) from the front edge of the shelf. There shall be no thumbholes or indentations in the shelves that will allow any part of the containers to project forward from the front edge of the shelf.

Δ 6.2.4* Each cabinet having a capacity of more than 23 kg (51 lb), or 3050 m (10,000 ft), of nitrate film shall be provided with a vent to the outside of the building.

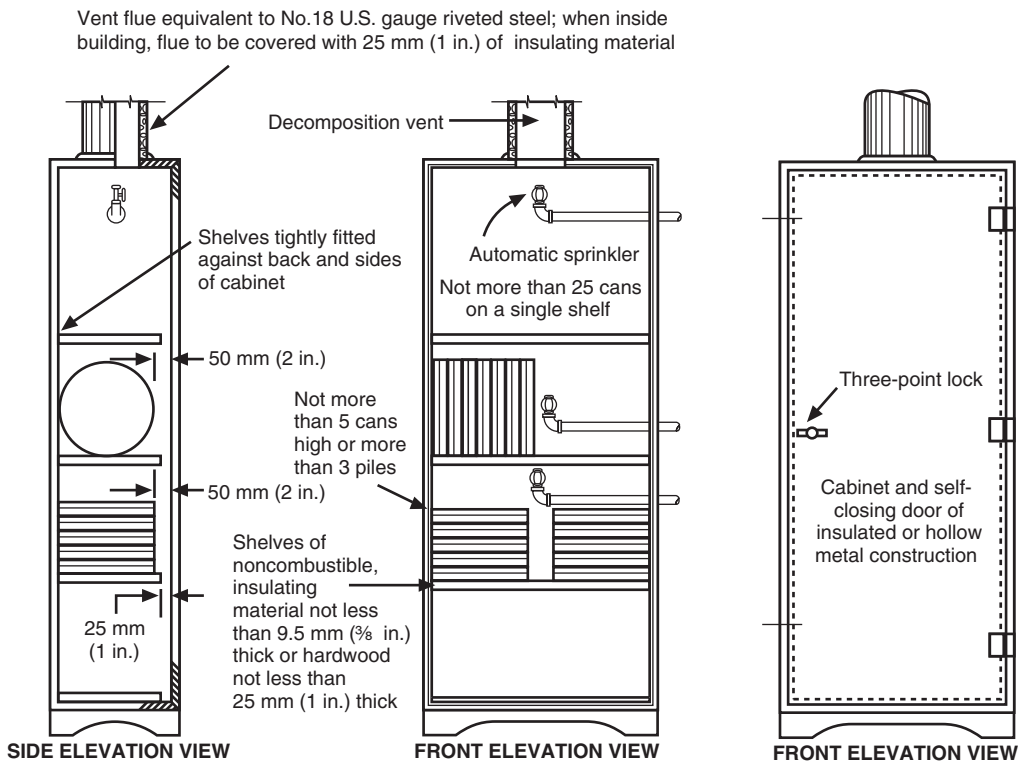


FIGURE 6.2.1 Standard Film Cabinet (for Other Than Extended Term Storage Film).

6.2.4.1 The vent required in 6.2.4 shall have a minimum effective cross-sectional area of 90 cm² per 45 kg (14 in.² per 100 lb) of film capacity.

6.2.4.2 Vent flues shall be of a construction that is equivalent to No. 18 U.S. gauge riveted sheet steel, and, where inside the building, it shall be covered with 25 mm (1 in.) of noncombustible thermal-insulating material.

6.2.5 Cabinet Protection.

6.2.5.1 Cabinets having a capacity of more than 34 kg (75 lb), or 4575 m (15,000 ft), of film shall be provided with at least one automatic sprinkler.

6.2.5.2 Where cans are stored on more than one shelf, as shown in Figure 6.2.1 and as described in 6.2.6.2 or 6.2.6.3, one sprinkler head shall be provided for each shelf.

6.2.6 Motion Picture Film. Paragraphs 6.2.6.1 through 6.2.6.3 shall apply only to motion picture film.

6.2.6.1 Film in cabinets shall be in closed metal cans or DOT-authorized containers.

6.2.6.1.1 Materials other than film shall not be stored in the same cabinet with nitrate film.

6.2.6.1.2 Where cabinets are provided with individual insulated compartments for each roll, the individual rolls shall not be required to be in cans or other containers.

6.2.6.2 Film cans, if placed on edge, shall be limited to not more than 25 cans per shelf.

6.2.6.3 Film cans, if placed flat, shall be stacked no more than five cans high with not more than three stacks per shelf.

6.3* Vaults Other Than Extended Term Storage Vaults.

6.3.1 Vaults shall be constructed in accordance with plans that have been submitted to and approved by the authority having jurisdiction.

6.3.1.1 Vaults shall not exceed 21 m³ (750 ft³) in inside volume. Where the height of the vault ceiling results in a vault having a volume greater than 21 m³ (750 ft³), a heavy wire screen of at least 50 mm (2 in.) mesh or equivalent shall be installed below the ceiling to limit the interior vault space to 21 m³ (750 ft³). (See Figure A.6.3.)

6.3.1.2* Walls and floors of vaults shall be of Type I construction and shall have not less than 4-hour fire resistance. Where masonry units have cracks or holes, the surface shall be plastered on both sides with a cement plaster to a minimum thickness of 13 mm (1/2 in.) to prevent escape of gases through wall cracks.

6.3.1.3 Where the ceiling of a vault is a bearing floor, it shall have a fire resistance of at least 4 hours.

6.3.1.4 Where the vault walls extend 0.9 m (3 ft) or more above the roof, the vault roof and ceiling shall be permitted to be constructed of noncombustible materials and shall be permitted to serve as an explosion vent.

6.3.1.5 Vaults shall be provided with drains or scuppers to carry automatic sprinkler discharge directly to the outside of the building.

6.3.1.5.1 Existing vaults shall not be required to drain directly to the outside.

6.3.2* Door openings shall be protected with automatic, self-closing fire door assemblies having a fire protection rating of 3 hours. Such doors shall be installed in accordance with NFPA 80 and, if held open, shall be arranged to close automatically upon actuation of an approved smoke detector that is located in the vault.

6.3.2.1 Existing heavy steel doors or combinations of one swinging and one sliding door, both of steel construction, shall be permitted to be accepted at the discretion of the authority having jurisdiction.

6.3.3* Vaults shall be temperature controlled to maintain temperature at 21°C (70°F) or less.

Δ 6.3.4 Each vault shall be provided with an independent decomposition vent having a minimum effective cross-sectional area of 1290 cm² per 454 kg (200 in.² per 1000 lb) of film capacity.

6.3.4.1 In vaults that are provided with explosion venting, the decomposition vent shall be permitted to be omitted.

Δ 6.3.4.2 Existing vaults shall be permitted to be provided with independent vents having an effective minimum cross-sectional area of at least 903 cm² per 454 kg (140 in.² per 1000 lb) of film capacity.

6.3.4.3* The vent area for a 21 m³ (750 ft³) new vault shall be not less than 1.3 m² (2000 in.²).

6.3.4.4* Vent flues within the building shall be of Type I construction having a fire resistance of 4 hours.

6.3.4.5 The outlet of each vent shall be above the roof, and where vents discharge horizontally, a deflector wall or other device shall be provided to deflect gases upward. Vents shall be located at least 15 m (50 ft) horizontally from any window or other opening exposed thereby and at least 7.6 m (25 ft) from any fire escape on the same or a higher level.

6.3.4.6* Vaults, especially those having a window for a vent, shall be arranged so that the nitrate film in the vault is protected against ignition from the following:

- (1) Rays of the sun, wherever the film in the vault is exposed to direct sunlight entering through the vent
- (2) Radiated heat entering through the vent opening, as from an exposure fire, wherever the vent is severely exposed by buildings or storage of combustible material or by other openings in the same wall

6.3.4.7* Each vent shall be protected against the weather by either single-thickness [4.2 mm (1/8 in.)] glass in a sash arranged to open automatically in case of fire or a hinged hollow metal or insulated vent panel, either of which shall be equipped with an approved releasing device that is placed inside the vault. The vents shall be arranged to open by either temperature or internal pressure of 24.4 kg/m² (5 lb/ft²). No pane of glass shall be smaller than 1290 cm² (200 in.²).

6.3.4.8 A light wire screen that is not coarser than 3.2 mm (1/8 in.) mesh shall be permitted to be placed in each vent. No bars or screens other than this insect screen shall be placed in vent openings.

6.3.5* Where there is a possibility of fire being transmitted from one vault to another or to another building through open

skylights, glass windows, light roof panels, or venting devices, provisions shall be made to prevent that possibility.

6.3.6 Film. Paragraphs 6.3.6.1 through 6.3.6.5 shall apply only to film.

6.3.6.1 Racks in film vaults shall be of hardwood or of noncombustible insulating material and shall consist of shelves tightly fitted to walls and vertical baffles.

6.3.6.2 Vertical barriers shall be of noncombustible insulating material that is at least 9.5 mm (3/8 in.) thick. They shall be spaced to divide the racks into sections of not more than 0.9 m (3 ft) in width.

6.3.6.3 Shelves shall be at least 25 mm (1 in.) wider than the diameter of the largest stored container.

6.3.6.4 Metal supports shall be permitted to be used to keep containers in place.

6.3.6.5 Open racks shall be used only for storage of film in standard DOT containers or in insulated boxes.

6.3.7 Fire protection in vaults shall be provided by a deluge system with directional nozzles meeting the criteria in 6.5.6.

6.3.7.1 Sprinkler systems in existing vaults that were in compliance with the provisions of this standard at the time of installation shall be permitted to be continued in use.

6.3.8 Light fixtures shall comply with the requirements of 4.6.1. All switches shall be outside the vault and provided with pilot lights to indicate whether vault lights are on or off.

6.3.9 Where heat is required to prevent freezing of the sprinkler system, it shall be provided by hot water or low-pressure steam that is limited to gauge pressure of 69 kPa (10 psi) maximum pressure. Vault temperature shall not exceed 21°C (70°F) (see 6.3.3). Radiators shall be placed at the ceiling, over aisle spaces, and with pipes. Also, radiators shall be protected by wire guards that are arranged so that film cannot be placed within 300 mm (12 in.) of them.

6.3.10 All motion picture film that is stored in vaults shall be in closed metal cans or DOT-authorized containers.

6.4* Extended Term Storage Cabinets.

Δ 6.4.1* Extended term storage cabinets shall be provided with individual drawers or compartments, each holding not more than 610 m (2000 ft) of film.

N 6.4.1.1 Individual compartments shall be separated by 9.5 mm (3/8 in.) of noncombustible insulating material.

N 6.4.1.2 Each compartment shall be provided with a hinged damper or similar device to allow release of decomposition gases into the cabinet vent.

6.4.2 Extended term storage cabinets shall be provided with automatic sprinklers when holding more than 23 kg (51 lb) of nitrate film.

Δ 6.4.3* Each extended term storage cabinet having a capacity of more than 23 kg (51 lb), or 3050 m (10,000 ft) of film shall be provided with a vent to the outside of the building.

N 6.4.3.1 The vent required in 6.4.3 shall have a minimum cross-sectional area of 90 cm² per 45 kg (14 in.² per 100 lb) of film capacity.

6.4.3.2 Decomposition vent pipes shall be of No. 18 U.S. gauge riveted steel or equivalent. Where located within the building, decomposition vent pipes shall be covered with 25 mm (1 in.) of noncombustible insulating material.

6.5* Extended Term Storage Vaults.

6.5.1 Extended term storage vaults shall not exceed 28 m³ (1000 ft³) in interior volume. Where the height of the vault ceiling results in a vault having an interior volume greater than 28 m³ (1000 ft³) or greater than the volume that is agreed upon by the authority having jurisdiction, then the interior vault space shall be permitted to be limited as described in 6.3.1.1. (See Figure A.6.5.)

6.5.1.1 Walls and floors shall be of Type I construction, having a fire resistance of 4 hours. Where masonry units have cracks or holes, the surface shall be plastered on both sides with a cement plaster to a thickness of at least 13 mm (½ in.). Equivalent construction that will provide equal fire resistance and prevent escape of gases through wall cracks shall be permitted to be used.

6.5.1.2 Extended term storage vaults shall comply with 6.3.1.3, 6.3.1.4, and 6.3.1.5.

6.5.2 Door openings in extended term storage vaults shall be protected in accordance with the requirements of 6.3.2.

6.5.3 Maximum temperature control shall be provided in accordance with 6.3.3.

6.5.4 Extended term storage vaults shall be provided with decomposition vents meeting the requirements of 6.3.4.

6.5.4.1 In vaults provided with explosion venting, the decomposition vent shall be permitted to be omitted.

6.5.4.2 The vent area for a standard 28 m³ (1000 ft³) extended term storage vault shall be not less than 1.72 m² (2670 in.²). (See Figure A.6.3.4.3.)

6.5.5* Film. Paragraphs 6.5.5.1 through 6.5.5.5 shall apply only to film.

Δ 6.5.5.1* Extended term storage vaults shall be provided with horizontal shelves and vertical barriers that are spaced so that no more than 610 m (2000 ft) of film shall be permitted to be placed in each compartment.

6.5.5.2 The spacing between shelves shall be such that the container covers can be lifted approximately 13 mm (½ in.) but cannot be lifted completely off the container.

Δ 6.5.5.3 The shelves shall be separated by vertical barriers so that no more than 610 m (2000 ft) of film can be placed between vertical barriers.

N 6.5.5.3.1 Shelves and vertical barriers shall be of noncombustible insulating material that is at least 9.5 mm (⅜ in.) thick or of hardwood construction that is at least 25 mm (1 in.) thick.

6.5.5.4 Containers shall not overhang shelves except as provided in 6.5.5.4.1.

N 6.5.5.4.1 Where more than one 122 m (400 ft) can is stored in a single cubby hole, the cans shall be permitted to overhang shelves by no more than 25 mm (1 in.).

6.5.5.5 Racks shall be designed in relation to the sprinkler system so that the open face of each rack structure shall be protected by the sprinkler system.

6.5.6 For extended term storage vaults in accordance with 6.5.5, fire protection shall be provided by a deluge system with directional nozzles installed in accordance with NFPA 15 and meeting the criteria in 6.5.6.1 through 6.5.6.9.7.

6.5.6.1 Sprinkler systems in existing extended term storage vaults that were in compliance with the provisions of this standard at the time of installation shall be permitted to be continued in use.

6.5.6.2 High-velocity open water spray nozzles each capable of providing a discharge rate of 1.26 L/sec (20 gpm) at a gauge pressure of 345 kPa (50 psi) shall be installed.

6.5.6.3 The design shall be based on a discharge density of 28 mm/min (0.68 gpm/ft²) over each face of storage racks.

6.5.6.4* The nozzles shall have a combined spray pattern capable of covering the face of the film storage racks.

6.5.6.5 The nozzles shall be installed at the top of the storage shelf array, aimed at the opposite shelf array.

6.5.6.6* Nozzles shall be installed on opposite faces of the storage shelf array in a staggered pattern such that no nozzles are directly opposite one another.

6.5.6.7 The water supply duration shall be a minimum of 20 minutes.

6.5.6.8 The deluge system shall be activated by a signal from one of the following:

- (1) An air sampling-type smoke detection system
- (2) A fixed temperature heat sensitive cable

6.5.6.9 The very early warning detection (VEWD) fast response air sampling system shall be permitted to be sensitive to CO₂ or smoke.

6.5.6.9.1 The air sampling smoke detection system shall be designed and installed in accordance with NFPA 72.

6.5.6.9.2* The air sampling smoke detection system shall activate at a point less than 0.6 percent obscuration per 0.3 m (1 ft).

6.5.6.9.3 The fixed temperature heat sensitive cable shall activate at a temperature not greater than 73.9°C (165°F).

6.5.6.9.4 It shall be permitted to set lower alarm levels for either type detection device for the purpose of providing early warning of an incident.

6.5.6.9.5 The fixed temperature heat sensitive cable shall be installed at the top of each shelf array and located so as not to be shielded from heat produced by film combustion from the shelf array.

6.5.6.9.6 Full water flow shall be discharged from the water spray nozzles within 10 seconds of reaching the set point actuation of the detection system.

6.5.6.9.7 Actuation of the detection system or the water deluge system shall transmit a signal to a constantly attended location where emergency response can be initiated.

6.5.7 Interior lighting for extended term storage vaults shall comply with 6.3.8.

6.5.8 Where heat is required to prevent freezing of the sprinkler system, the heating system shall comply with 6.3.9.

6.5.9 All film that is stored in extended term storage vaults shall be in closed metal cans or DOT-authorized containers, and the container cover shall not lift off when the container is placed properly in the rack.

Chapter 7 Handling of Nitrate Film

7.1 General Conditions. All procedures for handling nitrate film shall be conducted only with the appropriate safeguards to protect against possible hazards. Specialized operations such as printing, video transfer, sound transfer, cleaning, splicing, repairing, marking, and cataloging that are necessary for the maintenance and use of nitrate film shall be permitted to be grouped together in common work areas and shall be done in a manner that is consistent with this standard.

7.2 Containers Required.

7.2.1* Nitrate motion picture film shall be stored in closed metal cans or DOT-authorized containers.

7.2.2* Nitrate flat film shall be stored in DOT-authorized containers.

7.3 Shielding. Nitrate film shall not be placed or kept under benches, tables, or other surfaces that would shield it from sprinkler discharge.

7.4* Scrap and Discarded Film.

7.4.1 Scrap nitrate film shall be kept separate from waste paper and other rubbish. If nitrate film is intermixed with other materials, the mixture shall be treated as nitrate film.

7.4.2 Scrap nitrate film shall be collected from workrooms at least once daily and removed to a room used for no other purpose. It shall be kept under water in steel drums or metal containers with tight-fitting covers.

7.4.3 Discarded film in full or partial rolls shall be kept in containers in vaults until disposal.

7.4.4 Scrap and discarded film shall be disposed of at frequent intervals. Scrap film shall not be baled or burned.

7.5 Transportation.

7.5.1 Nitrate film shall not be transported in any vehicle, aircraft, or other public conveyance that is used for the transportation of passengers unless it complies with DOT shipping regulations and other applicable regulations.

7.5.2 Nitrate film shall not be allowed in any underground subway train or station unless under the jurisdiction of the U.S. Department of Transportation and conforming to DOT regulations.

Chapter 8 Motion Picture Projection and Special Processes

8.1 Enclosures for Motion Picture Projectors.

8.1.1* Motion picture projectors using nitrate film shall be operated or set up for operations only within an approved

enclosure not less than 3.7 m² (40 ft²) in area for each projector and 2.3 m (7½ ft) high.

8.1.1.1 The enclosure shall be temperature and humidity controlled while nitrate film is present so that the enclosure temperature does not exceed 23°C (75°F) and the enclosure relative humidity does not exceed 60 percent.

8.1.2* No more than 34 kg (75 lb) of nitrate film shall be allowed in the projection booth unless stored in an approved cabinet in accordance with Chapter 6.

8.1.3 The projection room shall have a fire resistance rating of not less than 1 hour. The interior finish shall have a flame spread index that is no greater than 25 in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*.

8.1.4* Exit doors shall be outward-swinging, self-closing, approved fire doors that have a fire protection rating of not less than 1 hour. They shall be installed according to NFPA 80. Doors shall be kept closed at all times when they are not actually in use.

8.1.5 Openings for the nitrate projectors, for the projectionists' view, and for other projectors and/or theatrical lighting machines shall comply with 8.1.3.

8.1.6 Each opening in accordance with 8.1.5 shall be provided with an approved gravity shutter with a fire resistance rating of not less than 1 hour and actuated by a fusible link.

8.1.6.1 Means shall be provided for manually closing all shutters simultaneously from the projector head and from a point within the projection enclosure near each exit door.

8.1.7 All shelves, furniture, and fixtures within the enclosure shall be constructed of noncombustible materials.

8.1.7.1 Tables shall comply with Section 4.5 instead of 8.1.7.

8.1.8 No combustible material of any sort shall be permitted in the projection enclosure other than the film, film cleaner, lubricants, and film cement.

8.1.9 Ventilation shall be provided by one or more mechanical exhaust systems that draw air from each lamp housing and from one or more points near the ceiling.

8.1.9.1 Exhaust systems shall exhaust to the outdoors either directly or through a noncombustible flue that is used for no other purpose.

8.1.9.2 Exhaust capacities shall be as follows:

- (1) Each nitrate projector equipped with carbon arc bulbs shall have an exhaust capacity neither less than 0.43 m³/min (15 ft³/min) nor more than 1.4 m³/min (50 ft³/min) for each lamp.
- (2) Each nitrate projector equipped with xenon bulbs shall have an exhaust capacity neither less than 7.1 m³/min (250 ft³/min) nor more than 22.8 m³/min (800 ft³/min).
- (3) Projection rooms shall have exhaust capacities not less than 5.7 m³/min (200 ft³/min) for the room itself.

8.1.9.3 Exhaust systems shall be controlled from within the enclosure and shall have pilot lights to indicate operation.

8.1.9.4 The exhaust system serving the projection room shall be permitted to be extended to cover rooms that are associated

with the projection enclosure, such as rewind rooms, but shall not be connected in any way with ventilating or air-conditioning systems serving other portions of the building.

8.1.9.5 No dampers shall be installed in exhaust systems associated with the projection enclosure.

8.1.9.6 Exhaust ducts shall be of noncombustible material and shall either be kept 25 mm (1 in.) from combustible material or be covered with 13 mm (½ in.) of noncombustible thermal-insulating material.

8.1.9.7 Fresh air intakes, other than those direct to the outside, shall be protected by approved fire dampers or shutters that are arranged to operate automatically with the shutters described in 8.1.6.

8.1.10 Provision shall be made so that auditorium lights can be turned on from within the projection enclosure and from at least one other convenient point in the building.

Chapter 9 Special Occupancies

9.1 Motion Picture Film Exchanges. Nitrate film shall not be stored or handled in film exchanges.

9.2 Motion Picture Film Laboratories.

9.2.1 The requirements of Chapter 4 also shall apply to nitrate motion picture film laboratories.

9.2.2 All buildings housing a nitrate motion picture film laboratory shall be protected throughout with an approved automatic sprinkler system.

9.2.3 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 12,192 m (40,000 ft), or 91 kg (200 lb), in rooms where film is prepared for printing.

9.2.4 The total quantity of nitrate film that is not in containers in all workrooms shall not exceed 610 m (2000 ft), or 5 kg (11 lb), per person handling film.

9.2.4.1 The requirement in 9.2.4 shall not apply to film that is in process on cleaning or printing machines.

9.2.4.2 A quantity of 1524 m (5000 ft), or 12 kg (26 lb), of film per cleaning or printing machine work station shall be permitted to not be in containers, provided that the total does not exceed 3050 m (10,000 ft), or 23 kg (51 lb), at any time.

9.2.5 Printing machines shall be separated from each other by noncombustible partitions unless they are spaced so that there is a 1.8 m (6 ft) distance between the film on one machine and the film on an adjacent machine.

9.2.5.1 Partitions separating one nitrate film-handling room from another shall be of Type I construction and shall have a fire resistance rating of not less than 1 hour.

Δ 9.2.5.2 In all cases, sprinklers shall be arranged so that not more than two machines are protected by any one sprinkler.

9.2.6 Cabinet-type drying machines shall be listed.

Δ 9.2.7 Waxing of film shall be done in a separate room.

N 9.2.7.1 Waxing processes that require the waxed film to be left exposed to dry shall be in a room used solely for that purpose.

N 9.2.7.2 Not more than five machines shall be located in any one room.

N 9.2.7.3 Not more than 3050 m (10,000 ft), or 23 kg (51 lb), of film shall be exposed at any one time.

9.2.8 Not more than two projectors for nitrate film shall be located in any one room.

Δ 9.2.9 The shipping room shall be separated from the rest of the building by partitions complying with 4.1.2.

N 9.2.9.1 No process other than the inspection and packing of film shall be conducted in the shipping room.

N 9.2.9.2 Not more than 30,480 m (100,000 ft), or 230 kg (500 lb), of film shall be in a shipping room at one time.

N 9.2.9.3 Of the quantity specified in 9.2.9.2, no fewer than 15,240 m (50,000 ft), or 115 kg (250 lb), shall be in shipping cases.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 Although the storage and handling of cellulose nitrate film have a good safety record, fire tests conducted prior to 1967 indicated the desirability of a modification of existing standards. The requirements of this standard, therefore, apply strictly to long-term storage of cellulose nitrate film.

A.1.1.1 Cellulose nitrate-based film includes, but is not limited to, original negative, duplicate negative, interpositive (fine grain), color separation master (YCM), successive exposure master (SEN), optical soundtrack negative or master, mattes, title bands, and release prints.

A.1.3.2 For example, any process in a studio that, in the opinion of the authority having jurisdiction, is similar to some process covered under laboratories would be covered by the requirements for that process given under laboratories.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory author-

ity. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Δ A.3.3.1 Cellulose Nitrate Film. The terms *cellulose nitrate film* and *nitrate film* are preferable to *nitrocellulose*; however, for practical purposes, the terms are synonymous. The film can be in the form of unexposed film, positive prints, negatives, or used film.

Cellulose nitrate contains chemically combined oxygen, sufficient in amount so that it can partially burn or decompose without the presence of air. The gases formed during burning or decomposition are both toxic and flammable and can be produced so rapidly as to create dangerous pressures in building structures and severe hazard to life. Free burning of the material results in the production of less toxic gases, but, due to the rapid burning, such fires are intense and still represent a serious life hazard. The actual heat of combustion of cellulose nitrate film is 13,944 kJ/kg to 18,921 kJ/kg (6000 Btu/lb to 8000 Btu/lb), compared with 16,268 kJ/kg to 18,921 kJ/kg (7000 Btu/lb to 8000 Btu/lb) for wood. However, the rate of combustion is about 15 times greater than the combustion rate of wood in similar form. (See Table B.1.)

For many years, motion picture film was manufactured with a supporting film base of cellulose nitrate, commonly called nitrocellulose. Since 1951, no cellulose nitrate film base of any kind has been manufactured in the United States. Also, the use of cellulose nitrate film in theaters has virtually ceased. However, large quantities of cellulose nitrate film still exist and will remain in storage for many years. (See Annex B for additional information.)

A.3.3.3 Extended Term Storage. *Extended term storage* is synonymous with *archival storage*.

A.3.3.6 Extended Term Storage Rack. Such racks are constructed so that individual rolls or groups of two rolls are placed in insulated compartments.

A.3.3.7 Extended Term Storage Vault. This type of vault is used for the extended term storage of cellulose nitrate motion picture film.

A.3.3.9 Vault. This type of vault is used for the storage of cellulose nitrate motion picture film in quantities not exceeding 341 kg (750 lb).

A.4.1.1 See NFPA 220.

A.4.2.3 For illuminated exit signs, see Section 7.10 of NFPA 101.

A.4.3.1 For information on the design of explosion vents, see NFPA 68.

N A.4.3.1.1 Nitrate motion picture film that is 305 m (1000 ft) long and 35 mm (1 in.) wide weighs approximately 2.3 kg (5 lb). Throughout the document, length measurements are for motion picture film that is 35 mm (1 in.) wide. Length measurements should be revised downward for wider gauge film and upward for narrower gauge film.

A.4.4 The purpose of Section 4.4 is to prevent congestion of workers in areas where large quantities of nitrate film are handled.

A.4.7.4 The following text is extracted from the Eastman Kodak publication, *Hazard in the Handling and Storage of Nitrate and Safety Motion Picture Film*: “To reduce the chance of spontaneous ignition of nitrate films — even those which are not of special concern — we [Kodak] recommend that storage vaults be air conditioned where necessary to prevent temperatures in excess of 21°C (70°F), and relative humidity in excess of 60 percent.” Provisions for refrigeration systems can be found in ASHRAE 15 (packaged with ASHRAE 34), *Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants*.

A.4.8.2.1 *Isolation devices*, in this context, do not refer to a standard smoke or flame damper built for normal service for air-handling systems or to a blast damper that might be used in combustible dust isolation service. This is a purpose built or modified device specifically tested for the service. In particular, the temperature criterion far exceeds the UL 555, *Standard for Fire Dampers*, or 555S, *Standard for Smoke Dampers*, ratings for flame and smoke dampers.

A.5.1 It is recommended that buildings used for the storage or handling of nitrate film, except for buildings that house small areas possessing no fire hazard and are so located that there is little opportunity for fire gases to enter the area, be protected completely by automatic sprinklers. Also, although this section does not require automatic sprinklers for projection rooms, fire experience indicates that they do provide desirable protection, and their use is advised.

A.5.3 The intent of this section is to provide the capability to extinguish incipient exposure fires and not cellulose nitrate film fires.

N A.6.1 Cellulose nitrate flat film can be very difficult to distinguish from cellulose acetate flat film. Cellulose acetate film might be intermingled with cellulose nitrate film in flat film collections.

Δ A.6.1(1) For reference, 11 kg (25 lb) corresponds to approximately five 305 m (1000 ft) rolls of 35 mm (1⅜ in.) motion picture film, or approximately six hundred fifty 204 × 254 mm (8 × 10 in.) negatives, or approximately thirteen hundred 127 × 178 mm (5 × 7 in.) negatives. Also, 11 kg (25 lb) corresponds to approximately 0.01 m³ (0.5 ft³) of motion picture film, or 0.04 m³ (1.5 ft³) of individually sleeved, flat film negatives.

Δ A.6.1(2) For reference, 340 kg (750 lb) corresponds to approximately one hundred fifty 305 m (1000 ft) rolls of 35 mm (1⅜ in.) motion picture film. Also, 340 kg (750 lb) corresponds to approximately 0.4 m³ (15 ft³) of motion picture film, or 1.3 m³ (45 ft³) of individually sleeved, flat film negatives.

A.6.2.4 For long lengths of vent pipe, a larger size could be necessary to overcome friction loss and turns in the pipe.

A.6.3 See Figure A.6.3. The illustration shows the location of sprinklers and the decomposition vent.

A.6.3.1.2 See NFPA 220.

A.6.3.2 Vaults can have two door openings. Such an arrangement is often a great convenience, as in laboratories, where the vault is located between rooms and is used for temporary storage of film in process. Approved, quick-operating devices for closing vault doors are recognized as having advantages over the fusible link, and their use is recommended.

A.6.3.3 The life of nitrate film retained for its historical value is maximized when it is stored in individually air-conditioned and sprinklered extended term storage vaults. Often these vaults are maintained at temperatures as low as 1.7°C (35°F) and a relative humidity of 30 percent. Air changes to minimize decomposition product accumulation can also be effective.

A.6.3.4.3 See Figure A.6.3.4.3. The figure shows the location of sprinkler heads, decomposition vents, and noncombustible flame barriers.

A.6.3.4.4 The extension of a vent outlet by means of flues that extend a considerable distance adds appreciably to the frictional resistance and greatly decreases the effectiveness of the vents. If it is necessary to construct vents longer than 7.6 m (25 ft), proper allowance should be made for frictional losses, and the cross-sectional area should be increased progressively to ensure venting. Such cases are regarded as special and are subject to the approval of the authority having jurisdiction.

A.6.3.4.6 Protection against sunlight can be obtained by painting the glass in the vent opening a dark color. One method of effecting protection from radiated heat is to use a hinged insu-

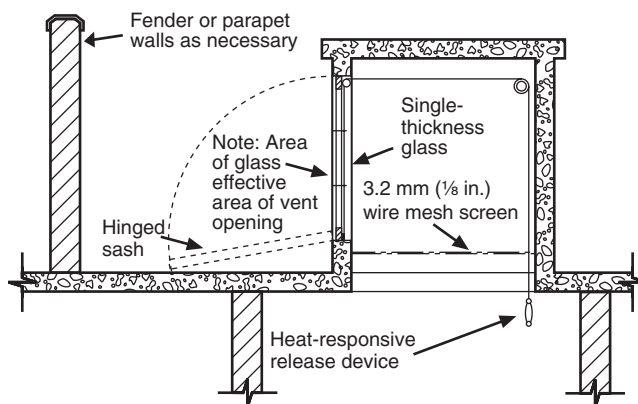


FIGURE A.6.3.4.3 Decomposition Vent.

lated or hollow metal panel as a vent. Another acceptable method uses two baffle walls inside the vault itself. The baffle wall closer to the vent extends down from the ceiling to within 0.9 m (3 ft) of the floor; the inner baffle wall extends up from the floor to within 0.9 m (3 ft) of the ceiling. These walls should be of substantial construction and spaced and arranged to afford the full required vent area from the film storage space to the outside.

A.6.3.4.7 The use of approved, quick-operating devices is recommended.

A.6.3.5 This protection can be achieved by providing roof parapets or extended wing walls between such openings.

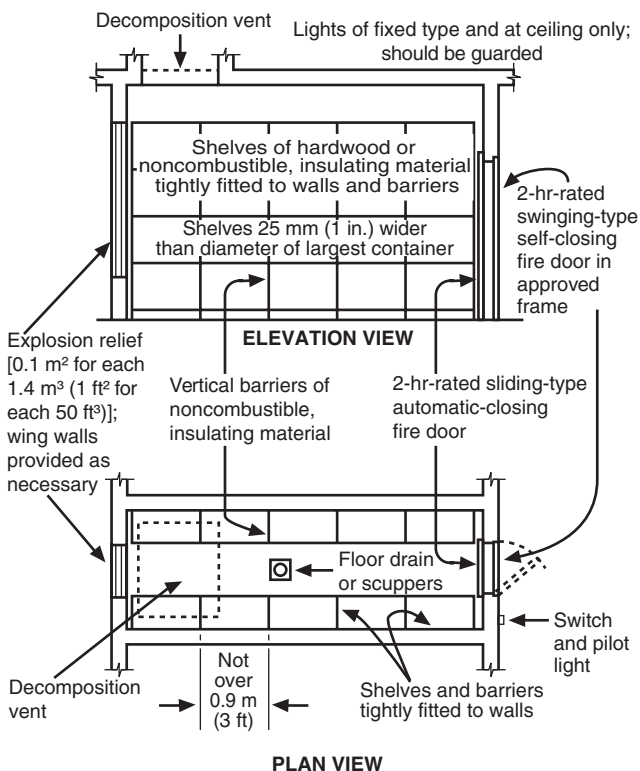
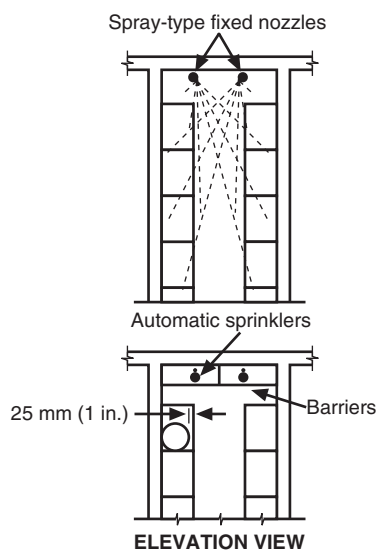


FIGURE A.6.3 Standard Film Vault (for Other Than Extended Term Storage Film).



A.6.4 Low temperatures slow nitrate decay. Freezing temperatures halt nitrate decay. Laboratory-grade refrigerators or freezers for flammable materials, complying with NFPA 45 and having a manual defrost mode, are recommended for extended term storage of amounts of cellulose nitrate film not exceeding 11 kg (25 lb).

A freezer or refrigerator complying with 6.4.1 through 6.4.3.2 is acceptable for extended term storage of cellulose nitrate film in amounts exceeding 11 kg (25 lb) but not exceeding 340 kg (750 lb).

Low or freezing temperatures are also recommended for vault storage complying with 6.5.1 through 6.5.9 for amounts exceeding 340 kg (750 lb).

N A.6.4.1 See A.6.1(1) for approximate equivalents for flat film.

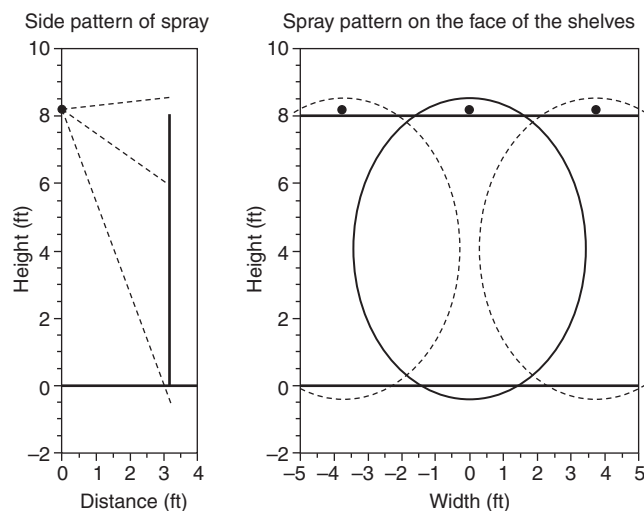
A.6.4.3 Good engineering judgment recommends that the vent lines be no longer than 3 m (10 ft). (See NFPA 68.)

A.6.5 See Figure A.6.5.

N A.6.5.5 See A.6.1(1) for approximate equivalents for flat film.

N A.6.5.5.1 Where collections contain 915 m (3000 ft) rolls originally produced as successive exposure negatives, they can be stored in specially designed shelving in extended-term storage vaults. Alternatively, a maximum of 75 rolls can be stored on open shelving in vaults other than extended-term storage vaults or in extended-term storage cabinets.

A.6.5.6.4 One acceptable nozzle spray pattern would be such that at a 2.4 m (8 ft) distance the cone is about 1.5 m (5 ft) in diameter. See Figure A.6.5.6.4.



Note: 1 ft = 0.3 m.

FIGURE A.6.5.6.4 Typical Nozzle Spray Pattern.

A.6.5.6.6 Figure A.6.5.6.6(a) shows an example of a nozzle layout consistent with the recommended arrangement for a vault design as shown in Figure A.6.5.6.6(b).

A.6.5.6.9.2 It is good practice to set notification levels lower than the actuation set point to permit emergency response at the early stage of the incident.

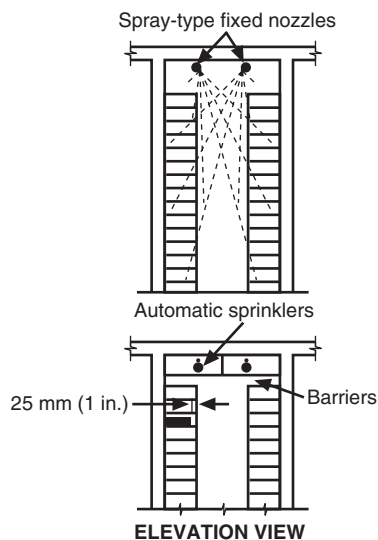
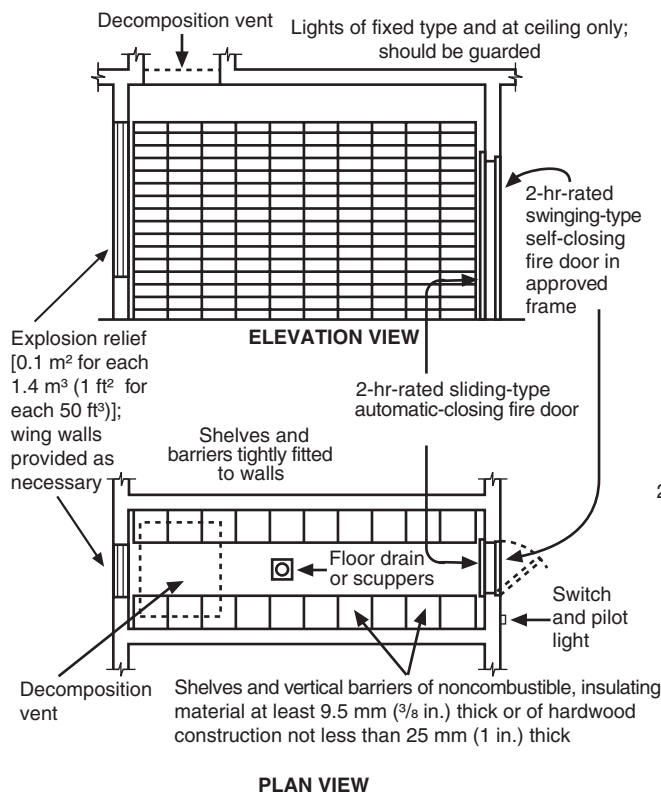


FIGURE A.6.5 Extended Term Storage Vault.

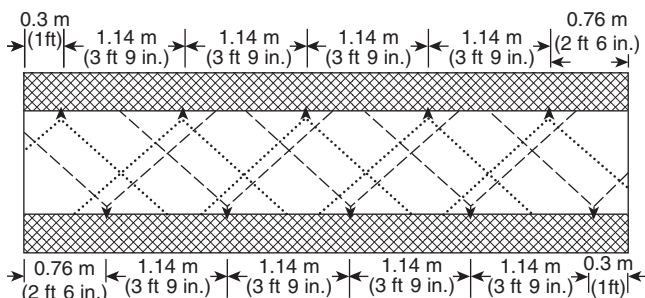


FIGURE A.6.5.6.6(a) Nozzle Layout for Typical Vault.

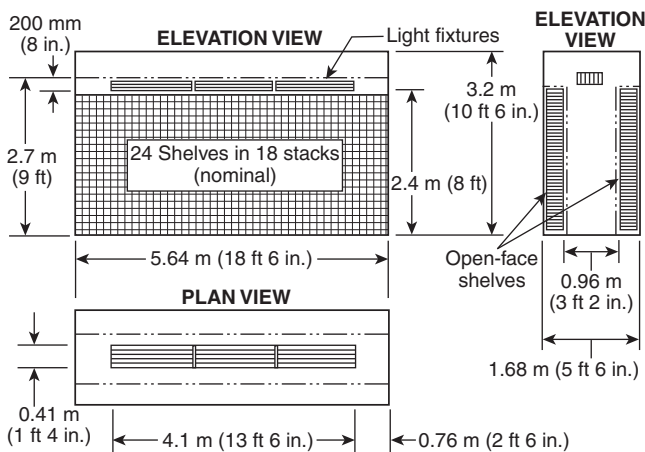


FIGURE A.6.5.6.6(b) Typical Vault Layout.

A.7.2.1 Examples of DOT-authorized containers are in 49 CFR 173.183, “Nitrocellulose Base Film.”

A.7.2.2 Flat film should be stored in individual buffered (high calcium carbonate reserve) envelopes or enclosures in DOT-authorized containers. Additional buffered enclosures and buffered supports might be used inside the DOT-authorized container if needed to preserve the film and/or content. Buffering will help neutralize the acid. Examples of DOT-authorized containers are provided in 49 CFR 173.183, “Nitrocellulose Base Film.”

A.7.4 Nitrate film in the form of clippings and short lengths is very hazardous. Safety precautions in the handling of such scraps are essential. Baling and burning of film are processes that present distinct fire hazards. Waste nitrate film should be disposed of in accordance with federal, state, and local statutes.

A.8.1.1 For new construction, an enclosure not less than 2.4 m (8 ft) wide, 3 m (10 ft) long, and 2.4 m (8 ft) high is recommended for one projection machine, and not less than 3 m (10 ft) wide, 4.3 m (14 ft) long, and 2.4 m (8 ft) high is recommended for two machines.

A.8.1.2 Thirty-four kg (75 lb) of nitrate film is approximately 4572 m (15,000 linear ft).

A.8.1.4 For new construction, it is recommended that at least two doors be provided, each not less than 76 cm (30 in.) wide and 183 cm (72 in.) high. In all cases, it is recommended that exit requirements of the authority having jurisdiction be complied with, particularly those regarding size and locations.

At least one door should be of the conventional stairway type, having a landing at the top or opening directly into a corridor.

Annex B Additional Information on Cellulose Nitrate Film

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

This material has been extracted with permission of Eastman Kodak Company from Hazard in the Handling and Storage of Nitrate and Safety Motion Picture Film.

B.1 Hazards. The most dangerous aspects of cellulose nitrate motion picture film are its ease of ignition, its very high rate of combustion, and its extremely poisonous combustion gases.

Cellulose nitrate film decomposes readily when heated to temperatures above ambient but below its ignition temperature. The decomposition is both exothermic and autocatalytic. The quantity of heat produced by decomposition is such that, if not dissipated, it can rapidly raise the temperature of the film to the ignition point. Even local heating can raise the temperature of the film to a dangerous level, initiating decomposition in the entire mass. Cellulose nitrate also contains enough oxygen within its molecule so that combustion proceeds rapidly, even in a limited air supply. A fire in cellulose nitrate film, therefore, cannot be extinguished by smothering.

Cellulose nitrate film is not itself explosive and is less flammable than certain other nitrated compounds. Its ignition temperature is given generally as about 149°C (300°F), but the exact value depends on the duration of exposure, size and purity of film, and other factors. For example, in a laboratory test a sample of fresh nitrate film base ignited in air at 163°C (325°F) within 80 seconds; at 204°C (400°F), ignition occurred in 10 seconds; and at 260°C (500°F), in only 3 seconds. Residual chemicals from processing, dirt, or foreign material can lower the ignition temperature. Investigations conducted after the Cleveland Clinic fire of 1929 showed that temperatures above 93°C (200°F) were unsafe for nitrate film and that exposed steam pipes and unprotected light bulbs were dangerous in rooms containing nitrate film.

Improperly cared-for nitrate film has caused fires after several hours storage at temperatures as low as 49°C (120°F). Also, spontaneous ignition is believed to have been responsible for a number of nitrate film fires that have occurred in storage vaults in the summer, following periods of 38°C (100°F) weather (Cummings, Hutton, and Siltan, “Spontaneous Ignition of Decomposing Cellulose Nitrate Film”).

The actual heat of combustion of cellulose nitrate film is low compared with that of more common fuels. (See Table B.1.)

However, the rate of combustion of nitrate film is about 15 times greater than the combustion rate of wood in any form so that the heat evolved per minute is initially much greater. This rate results in a rapid temperature increase and a very intense fire. A nitrate film fire burns so fiercely and spreads so quickly that it is virtually impossible to control or extinguish except by automatic sprinklers.

B.2 Products of Combustion. When a single layer of cellulose nitrate film is ignited and allowed to burn freely in excess air, it burns with a bright yellow flame. The gases given off are colorless and are chiefly nitrogen, carbon dioxide, and water vapor — none of which is poisonous or explosive. If, however, the air supply is restricted, as is always the case where the nitrate film is

Table B.1 Heat Rates of Combustion

Nitrate Film vs. Common Fuels	kJ/kg	Btu/lb
Nitrate film	13,944–18,592	6000–8000
Wood	16,268–18,592	7000–8000
Alcohol	27,005	11,620
Coal, bituminous	23,240–32,536	10,000–14,000
Gasoline	52,900	22,750

in rolls, the film burns with or without flame, producing copious quantities of thick, yellow smoke. These gases are extremely poisonous and can form explosive mixtures with air. The relative amounts of the gases given off by burning nitrate film in a limited air supply are shown in Table B.2. Traces of hydrogen cyanide have also been detected, but not in significant amounts.

Complete combustion of nitrate film yields 0.051 m³ to 0.064 m³ per kg (4 ft³ to 5 ft³ of gas per lb) of film at normal temperature and pressure. The proportions of the various gases will vary somewhat with such conditions as temperature, pressure, and air supply.

B.3 Detection and Disposal of Unstable Nitrate Film. New nitrate film was made to be as stable as possible, and many nitrate films, regardless of age, still appear to be in reasonably good condition. However, all cellulose-based film deteriorates with age, and the deterioration can be increased by chemical contamination and improper storage conditions. All nitrate films that are to be saved for future reprocessing or for extended term storage purposes should be examined carefully throughout their length prior to being stored in a vault. Further, they should be re-examined periodically.

Any films that, upon examination, show yellow discoloration, fading of the image, undue brittleness, stickiness of the emulsion, or any other signs of deterioration should be reformatted as soon as possible. Any films in cans that are corroded on the inside should be recanned. Such corrosion can indicate an imminent deterioration problem. Films that have degraded to the point of complete image loss should be disposed of.

Table B.2 Gases Evolved in Flameless Combustion of Nitrate Film

Gas	Percent by Volume
Nitric oxide	1.4–8.2
Nitrogen dioxide and tetroxide	6.9–8.9
Carbon monoxide	47.7–59.1
Carbon dioxide	21.3–24.5
Oxygen	None
Hydrogen	0.9–3.2
Methane	1.0–2.7

Notes:

1. From "Proceedings of a Board of the Chemical Warfare Service Appointed for the Purpose of Investigating Conditions Incident to the Disaster at the Cleveland Hospital Clinic, Cleveland, OH, on May 15, 1929."
2. Volume of combustion chamber: 0.23 m³ to 0.76 m³ (8 ft³ to 27 ft³)
3. Weight of film: 0.9 kg/m³ (0.056 lb/ft³)

The disposal of nitrate film should be handled as hazardous waste in accordance with local, state, and federal regulations. Nitrate film should not be mixed with ordinary rubbish.

Annex C History of Cellulose Nitrate Film Use and Storage

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Inspection and Storage of Film. Heritage nitrate film should be stored in approved vaults and should be hand-inspected periodically. Any signs of deterioration should be flagged in preservation records, and deteriorating films should be prioritized for reformatting efforts. Material that has degraded to the point of complete image loss should be destroyed. Nitrate film should be located only in areas approved for its storage, handling, or projection.

C.2 Projection Booths. The only projection booths that should be permitted to project nitrate film are those booths that are equipped specifically to project nitrate film. These booths should meet the requirements of this standard and be approved by the local authority having jurisdiction. Once approved, the booths should project nitrate film only under the direction of trained projectionists following approved procedures. It is understood that such instances are restricted to venues, usually operating in conjunction with extended term storage programs, in libraries, museums, academic institutions, motion picture studios, or laboratory screening rooms, all of which must have facilities that are approved for handling nitrate film. It is acknowledged that there might be some nitrate film in the possession of individuals, and those individuals might have private projection rooms. The hazards of nitrate film are well known to trained, professional archivists and projectionists. Under the restricted conditions of this standard, nitrate film stock can be projected only in those venues approved for the purpose.

C.3 Storage. It is presently recognized that substantial amounts of nitrate film will be retained for its historical value. It is recognized that the life of the film will be maximized when it is stored in individually air-conditioned and sprinklered extended term storage vaults.

C.4 Safety Film. Since 1951, motion picture film has been produced with a "safety" base of cellulose acetate or other slow-burning esters or polyesters. The fire hazard characteristics of all these materials are roughly similar to those of ordinary paper of similar thickness and form. Unlike cellulose nitrate, they do not produce oxides of nitrogen when they burn. Safety film is damaged by heat at a lower temperature than is needed to destroy paper records. For that reason, safety film needs special protection to prevent damage by heat from an exposing fire. (*See NFPA 232.*)

Annex D Informational References

D.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

D.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 220, *Standard on Types of Building Construction*, 2018 edition.

NFPA 232, *Standard for the Protection of Records*, 2017 edition.

D.1.2 Other Publications.

▲ **D.1.2.1 ASHRAE Publications.** ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.

ASHRAE 15 (packaged with ASHRAE 34), *Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants*, 2013.

▲ **D.1.2.2 UL Publications.** UL LLC, 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 555, *Standard for Fire Dampers*, 2006, revised 2014.

ANSI/UL 555S, *Standard for Smoke Dampers*, 2016.

D.1.2.3 U.S. Government Publications. U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Baker, Lt. Col. Walter C. "Proceedings of a Board of the Chemical Warfare Service Appointed for the Purpose of Investigating Conditions Incident to the Disaster at the Cleveland Hospital Clinic, Cleveland, OH, on May 15, 1929."

Title 49, Code of Federal Regulations, Part 173.183, "Nitrocellulose Base Film."

▲ **D.1.2.4 Other Publications.** Cummings, J. W., A. C. Hutton, and H. Sifton. "Spontaneous Ignition of Decomposing Cellulose Nitrate Film." *Journal of the Society of Motion Picture and Television Engineers*, 54 (1950): 268–274.

Hazard in the Handling and Storage of Nitrate and Safety Motion Picture Film. Rochester, NY: Eastman Kodak Company, 1951.

▲ **D.2 Informational References.** The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

Adelstein, P. Z., J. L. Bigourdan, and J. M. Reilly. "Moisture Relationships of Photographic Film." *Journal of the American Institute for Conservation* 36.3 (Autumn-Winter 1997): 193–206.

Adelstein, P. Z., J. M. Reilly, and F. G. Emmings. "Stability of Photographic Film: Part VI, Long-Term Aging Studies." *SMPTE Journal* 111.4 (April 2002): 136–143.

Adelstein, P. Z., J. M. Reilly, D. W. Nishimura, and C. J. Erbland. "Stability of Cellulose Ester Base Photographic Film:

Part I, Laboratory Testing Procedures." *SMPTE Journal* 101.5 (1992): 336–346.

Adelstein, P. Z., J. M. Reilly, D. W. Nishimura, and C. J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part II, Practical Storage Considerations." *SMPTE Journal* 101.5 (1992): 347–353.

Adelstein, P. Z., J. M. Reilly, D. W. Nishimura, and C. J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part III, Measurement of Film Degradation." *SMPTE Journal* 104.5 (1995): 281–291.

Adelstein, P. Z., J. M. Reilly, D. W. Nishimura, and C. J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part IV, Behavior of Nitrate Base Film." *SMPTE Journal* 104.6 (1995): 359–369.

Adelstein, P. Z., J. M. Reilly, D. W. Nishimura, C. J. Erbland, and J. L. Bigourdan. "Stability of Cellulose Ester Base Photographic Film: Part V, Recent Findings." *SMPTE Journal* 104.7 (1995): 439–447.

Allen, N. S., et al. "The Nature of the Degradation of Archival Cellulose-Ester Base Motion-Picture Film: the Case for Stabilization." *The Journal of Photographic Science* 36 (1988): 34–39.

Allen, N. S., et al. "The Degradation and Stabilization of Historic Cellulose Acetate/Nitrate Base Motion-Picture Film." *The Journal of Photographic Science* 36 (1988): 106.

Edge, M., et al. "Mechanisms of Deterioration in Cellulose Nitrate Base Archival Cinematographic Film." *European Polymer Journal* 26.6 (1990): 623–630.

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D.3 References for Extracts in Informational Sections. (Reserved)