

**Hazard in the handling and storage of**

**NITRATE AND SAFETY**

**MOTION PICTURE FILM**

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**Motion Picture Film Department**

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# Hazard in the Handling and Storage of Nitrate and Safety Motion Picture Film

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## INTRODUCTION

The hazardous properties of nitrate film have been well known and understood in the motion picture industry for a long time. Safe practices in the handling and storing of nitrate film have been worked out over the years by the cooperative efforts of various organizations, the National Bureau of Standards, the National Fire Protection Association, the National Board of Fire Underwriters, the Underwriters' Laboratories, the Motion Picture Association of America, and the film manufacturers. Today everyone working in the motion picture industry, whether in studios, laboratories, exchanges, theaters, or projection rooms, is made acquainted with the hazard of nitrate film and with the proper precautions required to handle it safely. As a result, film fires are now remarkably few, and the occasional ones which do occur are usually extinguished quickly with a minimum of loss from injury to personnel or damage to property.

In spite of the relatively good safety record in the industry in recent years, a less hazardous film has been a long-sought goal. Its universal use would practically eliminate the chance of a dangerous fire, and it would make possible less rigid safety regulations, less expensive construction, and lower fire insurance rates. The so-called "safety base" or acetate films available prior to 1947 did not have satisfactory physical properties for general theater use. However, now that an improved type of safety support\* (high acetyl cellulose acetate) suitable for theaters is available in quantity, the use of nitrate motion picture film in the United States is rapidly declining, and existing safety regulations may gradually be moderated.

It is the purpose of this booklet to discuss the effect of the conversion to safety film on hazard in the motion picture industry and to answer such questions as the following:

1. Will safety film burn?
2. In the event of a fire, does safety film give off gases which are poisonous or explosive?

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\*Fordyce, C. R., "Improved Safety Motion Picture Film Support," J. Soc. Mot. Pict. Eng., 51, 331-350, October 1948.

3. What precautions are required in handling and storing safety film from the point of view of hazard?
4. How can safety film and nitrate film be readily distinguished?

Concern is felt in many quarters that with the time approaching when most motion picture film will be on safety support, but with substantial quantities of nitrate film still in use or in storage, safety precautions may be relaxed too soon or a mistake in identity may be made and a disastrous fire result.

This booklet is offered to the motion picture industry in the hope that it will aid in the promotion and maintenance of safety in the handling and storage of nitrate and safety motion picture film. The information contained herein should be of particular value during this interim period when the conversion from nitrate to safety base materials is taking place. The data, recommendations, and other material contained in this booklet have been compiled with considerable care from sources which we believe to be reliable and authentic, most of which are indicated in the text or in footnotes or in the appended Bibliography. However, because of the fact that the information is derived from so many sources and because of the widely varying conditions under which the film may be handled in studios, exchanges, theaters, laboratories, etc., the statements contained herein are made without warranty of any kind.

The preservation of the photographic record, also greatly simplified by changing from nitrate to safety film, is a separate subject, a discussion of which is reserved for a second booklet.\*

### **THE HAZARDOUS PROPERTIES OF NITRATE FILM**

The hazardous properties of nitrate film have been described frequently and in detail in the past and are given only briefly here. The most dangerous aspects of nitrate film are its ease of ignition, its very high rate of combustion, and the fact that the gases given off are extremely poisonous and, under some conditions, explosive.

Nitrate film decomposes readily when heated above room temperature even below the ignition range. The decomposition is both exothermic and autocatalytic, and once it starts it goes faster and faster. The quantity of heat produced is such that, if not dissipated, it may rapidly raise the film temperature to the ignition point. Even local heating at one point can raise the temperature of the film to a dangerous level, thus initiating decomposition in the entire mass. Cellulose nitrate also contains enough oxygen within the molecule so that decomposition

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\*"The Preservation of Nitrate and Safety Motion Picture Film," now in preparation by the Eastman Kodak Company.

or combustion proceeds rapidly even in a limited air supply, and a nitrate film fire cannot be extinguished by smothering.

Nitrate film itself is not explosive and is less flammable than certain other nitrated compounds. The ignition temperature of nitrate film is generally given as about 300 F, but the exact value depends on the time of exposure, the size and purity of the film, and other factors. Figure 1

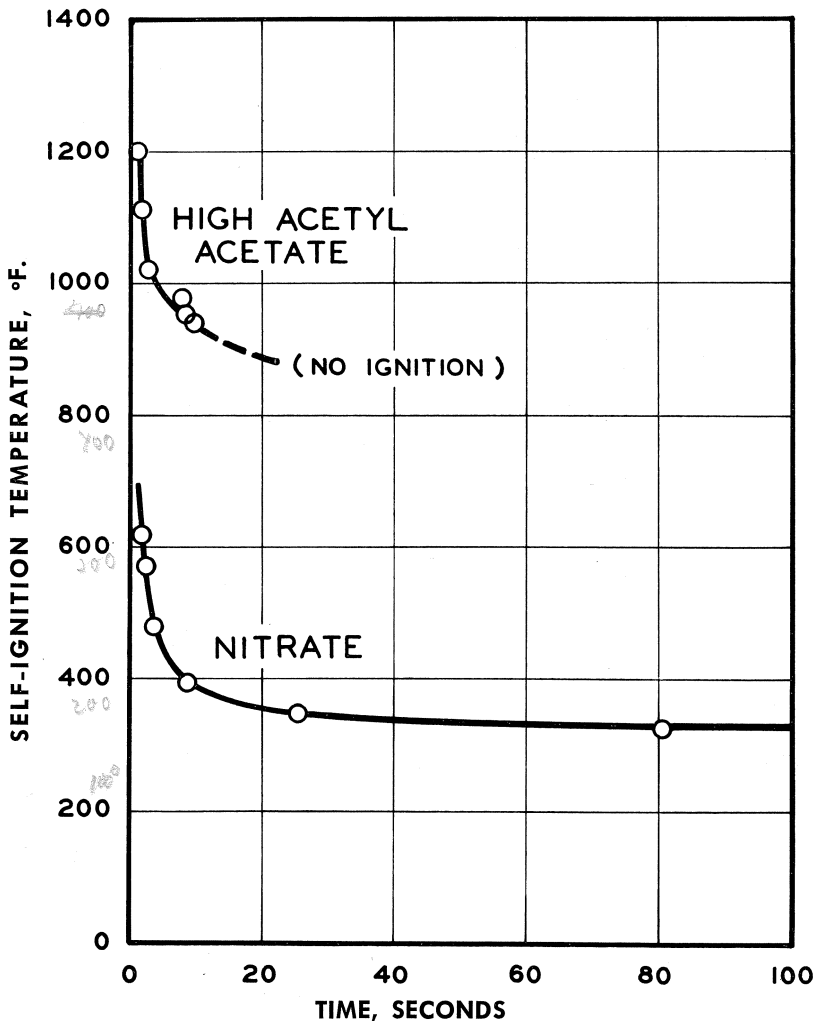


Figure 1. Self-ignition temperature in air of Eastman Nitrate and High Acetyl Acetate Motion Picture Positive Film support. American Standards Association Test method. (See Appendix A, Section 1.)

180 C.

shows that in a laboratory ignition test, a sample of fresh nitrate film base which ignited in 80 seconds in air at 325 F, ignited in 10 seconds at 400 F, and in 3 seconds at 500 F. Chemicals left from processing, dirt, and other foreign materials can lower the ignition temperature. The Chemical Warfare Service investigation following the Cleveland Clinic disaster (a nitrate X-ray film fire) in 1929 showed that temperatures of 100 C (212 F) were unsafe for nitrate film, and that exposed steam pipes, unprotected electric light bulbs, etc., were dangerous in rooms containing nitrate film. Nitrate film improperly cared for has caused fires after several hours storage at temperatures as low as 120 F. Spontaneous ignition is also believed to be responsible for a number of nitrate film fires which have occurred in storage vaults in summer following periods of 100 F weather.\* 30°

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The actual heat of combustion of nitrate film is low compared with that of some of the common fuels as indicated below:

	<i>Heat of Combustion,</i> <i>B.T.U. per Lb.</i>
Nitrate film	6,000 - 8,000
Wood	8,000 - 9,000
Alcohol, denatured	11,620
Coal, bituminous	10,000 -14,000
Gasoline	20,750

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

When a single layer of nitrate film is ignited and allowed to burn freely in an excess of air, it burns with a bright yellow flame, but the gases given off are colorless. These are chiefly nitrogen, carbon dioxide, and water vapor, none of which is poisonous or explosive. If the air supply is restricted, as is always the case in practice where film is in rolls in any quantity, the film will burn (with or without flame) and give off large quantities of thick, yellow fumes. These are extremely poisonous and may form explosive mixtures with air. The relative amounts of various gases given off by burning nitrate film in a limited air supply are shown in Table 1. Traces of the lethal hydrocyanic acid gas (HCN)

\*Cummings, J. W., Hutton, A. C., and Silfin, H., "Spontaneous Ignition of Decomposing Cellulose Nitrate Film," J. Soc. Mot. Pict. and Tel. Eng., 54, 268-274, March 1950.

have also been found but only in insignificant amounts. Complete combustion yields about 4 to 5 cubic ft. of gas per pound of nitrate film at normal temperature and pressure. The proportions of these gases will vary somewhat with the temperature, pressure, air supply, and so forth.

**TABLE I†**

**Gases Evolved in Flameless Combustion of Nitrate Film**

Volume of combustion chamber, 8 to 27 cubic ft.

Weight of film, 2 lbs. per cubic ft. of chamber.

Gases	Per cent by volume
Nitric oxide (NO)	1.4-8.2
Nitrogen dioxide and tetroxide (NO <sub>2</sub> , N <sub>2</sub> O <sub>4</sub> )	6.9-8.9
Carbon monoxide (CO)	47.7-59.1
Carbon dioxide (CO <sub>2</sub> )	21.3-24.5
Oxygen (O <sub>2</sub> )	none
Hydrogen (H <sub>2</sub> )	0.9-3.2
Methane (CH <sub>4</sub> )	1.0-2.7

†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, Ohio, on May 15, 1929." U. S. Government Printing Office, Washington, 1929.

**TABLE II\***

**Toxicity of the More Important Gases Evolved  
in Combustion of Nitrate Film**

Symptoms	Parts per Million Parts of Air		
	Nitrogen Oxides	Carbon Monoxide	Carbon Dioxide
1. Slight symptoms after several hours or maximum concentration for 8 hours exposure	30-40	100-200	5,000-30,000
2. Maximum concentration tolerated for 60 minutes without serious disturbance	50-100	450-900	33,000-60,000
3. Dangerous to life in 30 to 60 minutes	100-150	1500-2000	33,000-80,000
4. Kills most animals in short time	240-700	4000 or over	50,000-300,000

\*From Jacobs, M. B., "The Analytical Chemistry of Industrial Poisons, Hazards and Solvents," Interscience Publishers, Inc., New York, N. Y., 1941 and 1949.

The toxicity of carbon monoxide is well known, but the physiological effects of the nitrogen oxides (NO, NO<sub>2</sub>, N<sub>2</sub>O<sub>4</sub>) are even more insidious because of their greater toxicity and delayed action. Exposure to concentrations of nitrogen oxides which appear to have no serious effect at the time, frequently cause death several hours or days later. This occurred in a number of cases in the Cleveland nitrate film disaster in 1929. The simultaneous exposure to nitrogen oxides and carbon monoxide is particularly serious since these gases have an additive toxic effect, the ultimate result of which is to deprive the body of its supply of oxygen. The relative toxicity of nitrogen oxides, carbon monoxide, and carbon dioxide is shown in Table II.

### **THE COMBUSTION OF SAFETY FILM**

So far, all commercial safety motion picture film supports have been made from cellulose acetate or the mixed acetate-propionate or acetate-butyrate cellulose esters. It is sometimes thought that the term "safety film" implies that these films do not burn. Actually all of these safety films will burn slowly if held in a flame but generally cease burning soon after the flame is removed. They are called safety films because they are so very much less hazardous than nitrate film—the ignition temperature is much higher, the burning rate so much lower, and there is no danger from nitrous fumes.

Cellulose acetate film starts to decompose with evolution of fumes at about 500 F. compared with only 200 F. for nitrate film. The ignition temperature usually given for acetate film is about 800 F. compared with 300 F. for nitrate film. Our laboratory tests (Figure 1) show the high acetyl acetate film base to ignite in 9 seconds at 950 F. and in 2 seconds at 1100 F. At 930 F. the film decomposes but does not ignite in this test.

The thermal decomposition of acetate film is neither exothermic nor autocatalytic. Furthermore, the burning rate of acetate film is only about 1/20 that of nitrate film. This means that acetate film is difficult to ignite and, if ignited, is easily extinguished by water or smothering. Cellulose acetate plastics containing some of the common types of plasticizers burn about as fast as paper in the same form and quantity. However, acetate motion picture film base made by the Eastman Kodak Company contains a flame retarding plasticizer which greatly slows down the burning. Modern safety films actually burn much less easily and less rapidly than paper or wood in the same form and quantity.

The gases given off when acetate film burns (Table III) are about the same as those given off by burning wood. Of these, carbon monoxide



is the greater hazard, although the other gases may produce suffocation or even severe lung irritation if inhaled in sufficient quantity. If acetate film is burned in an excess of air, the carbon monoxide would be converted to carbon dioxide, but in a restricted air supply, some carbon monoxide would be present. In short, the hazard presented by burning acetate film is about the same as that of burning wood where the smoke is irritating but not dangerous unless confined in an unventilated space. It is not in any way comparable to the hazard of burning nitrate film.

**TABLE III†**  
**Gases Evolved in Combustion of Cellulose Acetate Film**

Gases	Physiological Effect
Carbon monoxide (CO)	Toxic
Carbon dioxide (CO <sub>2</sub> )	Suffocating
Hydrogen (H <sub>2</sub> )	
Methane (CH <sub>4</sub> )	
Acetic acid (CH <sub>3</sub> COOH)	
Aldehydes	Irritating and Suffocating
Ketones	
Alcohols	

†From Nuckolls, A. H., and Matson, A. F., "Some Hazardous Properties of Motion Picture Film," J. Soc. Mot. Pict. Eng., 27, 657-661, December 1936.

*Editor's note:* Gases present in trace amounts only are not shown in this table.

**TABLE IV**  
**Tests for Safety Motion Picture Film**  
**made by the American Standards Association Methods**  
**(See ASA Z38.3.1-1943, Appendix A)**

	ASA Limits for Safety Film	Eastman Nitrate Film, Type 1302	Eastman High Acetyl Acetate Film, Type 5302
1. Ignition time at 300 C., minutes	over 10	0.04	Infinity (Does not ignite)
2. Burning time, seconds	45 (minimum)	9	Infinity (Self-extinguishing)
3. Nitrogen content, per cent	0.36 (maximum)	10.8*	0.02-0.05

\*The nitrogen content of the unplasticized cellulose nitrate is approximately 12.0%.

## THE ASA AND UNDERWRITERS' TESTS FOR SAFETY FILM

Since all films other than nitrate might not be sufficiently free of hazard, the American Standards Association has drawn up laboratory test methods and specifications for safety photographic film designated, ASA Z38.3.1-1943. According to the ASA definition, photographic films are classified as safety films if they are, (1) difficult to ignite, (2) slow burning, and (3) low in nitrogen content. The ASA test method for each of these requirements is given in the standard which is reproduced in Appendix A. Results of tests made on nitrate and safety Eastman Motion Picture Positive Films by the ASA procedures are given in Table IV and show the wide differences between the two types of film.

The Underwriters' Laboratories describe approved slow-burning photographic films as follows: "Hazards in use and storage are small, being somewhat less than those presented by common newsprint paper in the same form and quantity."\* The Underwriters' Laboratories test procedures for classifying films as slow-burning (Appendix B)\*\* differ in some respects from those of the American Standards Association. For

**TABLE V**  
**Burning Tests on Motion Picture Film**  
**made by the Underwriters' Laboratories Method**  
(See Appendix B)

	Underwriters' Laboratories Limits for Approved Slow-Burning Film	Eastman Nitrate Film, Type 1302	Eastman High Acetyl Acetate Film, Type 5302	Newsprint Paper	White Ledger Paper
Thickness, inches		0.006	0.006	0.002	0.005
Burning time, sec.	65 sec. (minimum)	5	105	11	21
Flame height, inches		50	10	20	17
No. of times re-ignited		0	2	0	0

\*"List of Inspected Gas, Oil, and Miscellaneous Appliances," Underwriters' Laboratories, Inc., Chicago, Ill., November 1947.

\*\* See also Appendix D.

example, the Underwriters burning test is made on a strip of film held vertically instead of horizontally as in the ASA procedure, which is a more severe test. The Underwriters' Laboratories also measure the ignition temperature rather than the ignition time.

In Table V are the results of burning tests made by the Underwriters' Laboratories method on both nitrate and acetate Eastman Motion Picture Positive Film and on two types of paper. It may be seen that acetate film burns very slowly compared with nitrate and must be re-ignited several times. Acetate film is also much slower burning than either newspaper or ledger paper (which is closer to the film in thickness). Note that paper does not meet the rigid requirements of the Underwriters' Laboratories for approved slow-burning photographic film.

### **PRECAUTIONS IN THE HANDLING AND STORAGE OF NITRATE FILM**

A number of serious film fires in the early days of the motion picture industry culminating in the Ferguson Building film exchange fire in Pittsburgh in 1909 led to the promulgation of regulations by the National Board of Fire Underwriters for the handling and storage of nitrate film first issued in 1910. These were revised in 1919 as a result of further tests and are essentially the same today. Extensive investigations of film fire prevention methods were also made by the Eastman Kodak Company during the same period. As a result, a series of booklets was published between 1916 and 1919 and other educational measures undertaken. Since then much thought has been given to the problem of film fire prevention and much experience has been gained.

The most important contribution of the early studies in film fire prevention was the discovery that proper automatic sprinkler installations could control a nitrate film fire, and that no other method was as satisfactory. The great advantage of automatic sprinklers is that a fire can be deluged immediately with water before it is discovered so that it never gets out of control. The water cools the surrounding film down below its ignition point and retards the spreading of the fire. It has the additional advantage of dissolving any nitrous fumes produced and thus removing the most toxic gases from the air.

For detailed instructions on safe practices in handling and storing nitrate film the National Board of Fire Underwriters' regulations\* should

\*"Standards of the National Board of Fire Underwriters for Nitrocellulose Motion Picture Film as Recommended by the National Fire Protection Association," N.B.F.U. Pamphlet No. 40, July 1939 (Reprinted 1949). Copies may be obtained from the National Board of Fire Underwriters, 85 John Street, New York 7, N. Y.

be consulted. These are based on the following fundamental considerations as stated by Fowler and Newell.\*

- (a) "The elimination, as far as practicable, of all possible means of starting a fire.
- (b) "The provision of adequate features for the control of and protection against the spread of fire, should it occur.
- (c) "The segregation of large quantities of film into small protected units and minimizing the quantity of film exposed, or otherwise subject to fire, in all rooms where persons are working.
- (d) "Ample provisions for life safety, through the above mentioned protective measures and by adequate accessible means of egress."

The Underwriters' regulations describe the approved type of building construction, fire doors, exits, vents, automatic sprinklers, etc., for studios, laboratories, exchanges, theaters, and vaults. Only approved types of shielded lighting fixtures, explosion-proof motors, etc., are permitted where nitrate film is present. Heating equipment is restricted to hot water or steam up to a maximum of 15 pounds pressure and all pipes and radiators must be protected by guards. In vaults the steam pressure is limited to 10 pounds maximum and must be automatically controlled so that the room is not heated above 70 F. Vaults are limited to 750 cubic feet and must have vents with an area of 140 square inches per 1000 pounds of film capacity, and not less than 1400 square inches of vent surface for a 750 cubic foot vault. Automatic sprinklers are of the utmost importance in nitrate film vaults. Film cabinets must also be vented and sprinklered and the amount of nitrate film limited.

Fowler and Newell of the National Board of Fire Underwriters stated in 1931 that, "Of the many film fires which have occurred, some of serious consequences, never has a single one—as far as the writers have been able to determine—ever demonstrated the need for departure from these standards, nor have any fires ever reached uncontrolled proportions in storages protected in compliance therewith."

The Underwriters' regulations do not specify any temperature or humidity control for film storage vaults beyond the requirement that vaults should not be heated above 70 F. This does not prevent ambient temperature of 100 F. or higher in some localities in summer. To reduce the chance of spontaneous ignition of nitrate films—even those which are not of special value—we recommend that storage vaults be air conditioned where necessary to prevent temperatures in excess of

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\*Fowler, E. W., and Newell, L. B., "Storage and Handling of Motion Picture Film," *J. Soc. Mot. Pict. Eng.*, 16, 773-786, June 1931.

70 F. and relative humidities in excess of 60%. All air ducts should have approved automatic fire control dampers. The films should be stored in individual unsealed cans on metal shelves. A 1/4-inch asbestos insulating board placed between adjacent cans of film will help prevent the spread of fire in the event that one roll ignites spontaneously.

In fairness it should be pointed out that the Underwriters' regulations are not primarily concerned with safeguarding the film, but rather with the prevention of injury to personnel and damage to buildings. In the event of a fire even in an approved nitrate film vault, a large portion of the contents may be destroyed, even though serious damage to the building from explosion, or spread of the fire to other vaults is prevented. Where priceless or irreplaceable films are stored, additional precautions are required to safeguard the films.\*

### **DETECTION AND DISPOSAL OF UNSTABLE NITRATE FILM**

New nitrate film is as stable as it is possible to make it, and some nitrate films 30 or 40 years old still appear to be in reasonably good condition. However, all nitrate film deteriorates with age and this process is speeded up by chemical contamination and improper storage conditions. Nitrate films which have undergone appreciable deterioration are less stable, will ignite at lower temperatures, and are more likely to undergo spontaneous combustion than new films. Very old films are more likely to be unstable although there have been a number of cases where films less than five years old have apparently ignited spontaneously.

It is necessary to distinguish clearly between the hazard to personnel and property resulting from the spontaneous combustion of nitrate films stored under unsafe conditions, as compared with possible loss of valuable films stored under conditions where there is very little danger to other property or to personnel. It is only the first of these possibilities with which this booklet is concerned. As long as an Underwriters' approved storage vault is used, the hazard involved in the spontaneous combustion of unstable nitrate films is definitely limited, although films worth thousands of dollars may be destroyed.

All nitrate films which are to be saved should be examined carefully throughout their length before being placed in the storage vault and re-examined at regular intervals. The intervals between examinations will depend on the temperature and humidity at which the films are stored. For moderate storage temperatures and where both temperature and humidity are controlled, inspections should be made at least once

\*A companion booklet "The Preservation of Nitrate and Safety Motion Picture Film" is now in preparation. See also the bibliography, page 26.



**Figure 2**

**Top:** Nitrate film in which the image has disappeared and in which the emulsion has become sticky along the edges as a result of decomposition.

**Center:** Nitrate film in which the image has disappeared and in which the emulsion has become sticky near the center of the roll as a result of decomposition.

**Lower left:** Nitrate film with a hard "froth" on the side of the roll as a result of severe decomposition.

**Lower right:** Nitrate film, part of which has decomposed to the stage that only a fine brown powder remains.

per year. Where the conditions are not controlled, even in temperate climates, examinations should be made more often, say every six months. For tropical conditions of storage, the examination should be made every two or three months. Those films already in storage should also be withdrawn and examined. Any films showing yellow discoloration, fading of the image, undue brittleness, stickiness of the emulsion, or any other signs of incipient deterioration, and any films in cans corroded on the inside should be copied on safety base film and then discarded. Examples of nitrate film in various stages of deterioration are shown in Figure 2.

The disposal of unstable or deteriorated nitrate films presents a problem. They should not be mixed with regular nitrate scrap film or thrown in rubbish containers. Such films should be kept *under water* in a suitable steel drum until disposal can be arranged. Deteriorated nitrate films should be burned, but this involves a hazard and can be done safely only by a qualified person out of doors. A large area removed from any building or combustible material should be selected, and only a few rolls should be burned at a time. Where this is not possible, safe disposal should be arranged with the proper city or fire prevention authorities. It must be realized that unstable or deteriorated nitrate films present hazards similar to explosives and must be handled with the same respect.

#### **PRECAUTIONS IN THE HANDLING AND STORAGE OF SAFETY FILM**

Safety motion picture film requires no special precautions in handling or storage as far as its own fire hazard is concerned. It has been noted above that the Underwriters' Laboratories describe approved acetate film as slow-burning and state that "Hazards in use and storage are small, being somewhat less than those presented by common newsprint paper in the same form and quantity." Where safety film is used exclusively, only normal fire precautions are required as in any office or building containing paper, wood, or similar combustible material. Safety films should be stored in individual cans in metal cabinets, but these need not be sprinklered or vented. Where safety and nitrate films are both being used in studios, laboratories, exchanges, theaters, or storage vaults, the same regulations and precautions must be followed as if all the film were nitrate. It is, of course, entirely feasible to segregate the work involving safety film alone in any given studio, laboratory, or exchange, so that certain areas might be operated without restrictions applying to nitrate film.

The only real hazard in acetate film is that its increased use will tend to make people careless, and proper safety precautions may be neglected

while some nitrate film is still in circulation. If this happens, a serious accident may result. A roll of film which is acetate base at the outside might contain nitrate film spliced in the interior of the roll. A print released on acetate stock may later have replacements made on nitrate stock and be run on a projector not properly maintained for nitrate film. A laboratory which has been using safety stock for release prints for a period of time may suddenly switch to nitrate stock without announcement or warning. The danger of such practices is obvious.

Even when no more nitrate film is being manufactured in the United States, foreign negatives or prints on nitrate stock may be imported. Another hazard is the quantity of nitrate negatives and prints in storage vaults, some of which may be kept for 25 years or more. Any such collection of nitrate films that is to be saved should be stored in a separate approved vault, never in the same vault with safety films.

### **THE NEW EASTMAN IDENTIFICATION SYSTEM FOR SAFETY FILM**

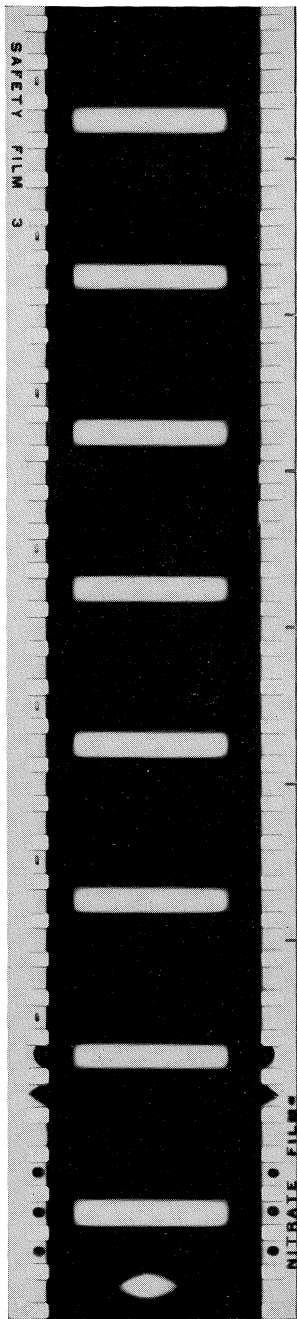
Proper identification of nitrate and safety film, of course, is of paramount importance if accidents are to be prevented. The only safe practice is to assume that all 35mm motion picture film is nitrate unless demonstrated otherwise.

A safe, simple, fool-proof method for identifying nitrate and safety film correctly is not as easy as it might seem. For many years film manufacturers have printed the word "NITRATE FILM" at frequent intervals along the edge of film made on nitrate base, and the words "SAFETY FILM" along the edge of film made on safety base. This has usually been done by a latent image exposure at the time of slitting or



**Figure 3.** A print on nitrate stock showing conflicting identifications printed through from a safety master positive and a safety duplicating negative.



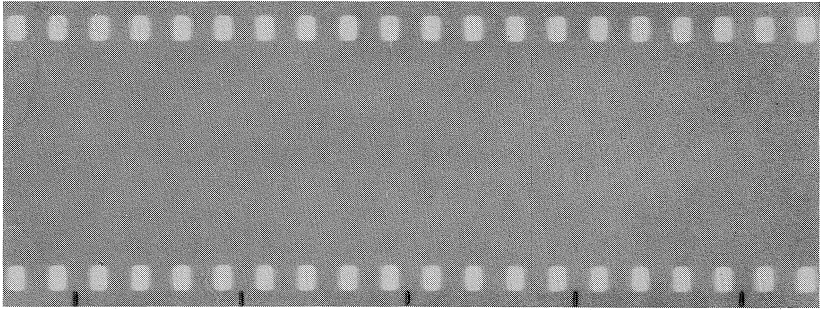


perforating and the identification is visible only after processing. This identification system was adequate as long as only nitrate film was used for professional 35mm theater productions. Now that both nitrate and safety films are in general use, there is the danger of misidentification caused by printing through from a safety negative onto a nitrate print or vice versa.

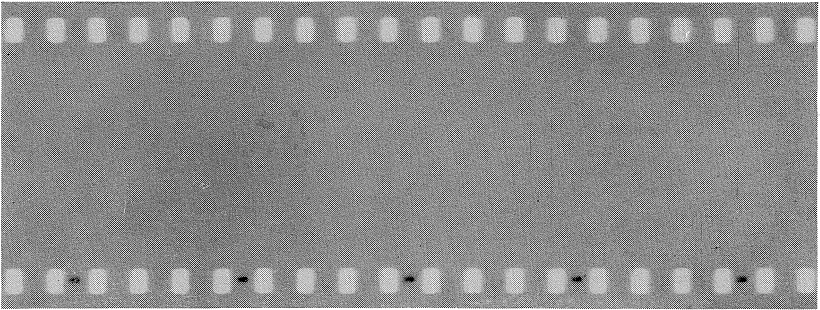
Figure 3 illustrates what can happen when a nitrate positive is printed from a safety master and a safety duplicating negative. The nitrate print carries not only its own identifying name in black but the words "SAFETY FILM" in white printed through from the safety duplicating negative, and the same in black printed through from the safety master positive. The original identifying name on a piece of film usually appears sharper than one resulting from a second generation print, but there is still a real danger of misidentification. In Figure 4 is the reproduction of a portion of a print on safety film which was found in the trade. A sample had to be burned to establish the identity of the base. Both black-and-white and color prints have also been seen frequently with a flash along the edge which virtually obliterates the nitrate or safety identification. Additional limitations to this system of film identification are the fact that it is invisible in the raw stock and that every individual spliced strip of processed film in a roll must be examined.

It is thus apparent that the existing system of nitrate and safety base identification

**Figure 4.** A portion of a print on safety film stock found in a film exchange. Note confusion of identifying names. The correct identity can be established by the presence of the safety frame-line mark. (See Figure 5.)



NITRATE FILM

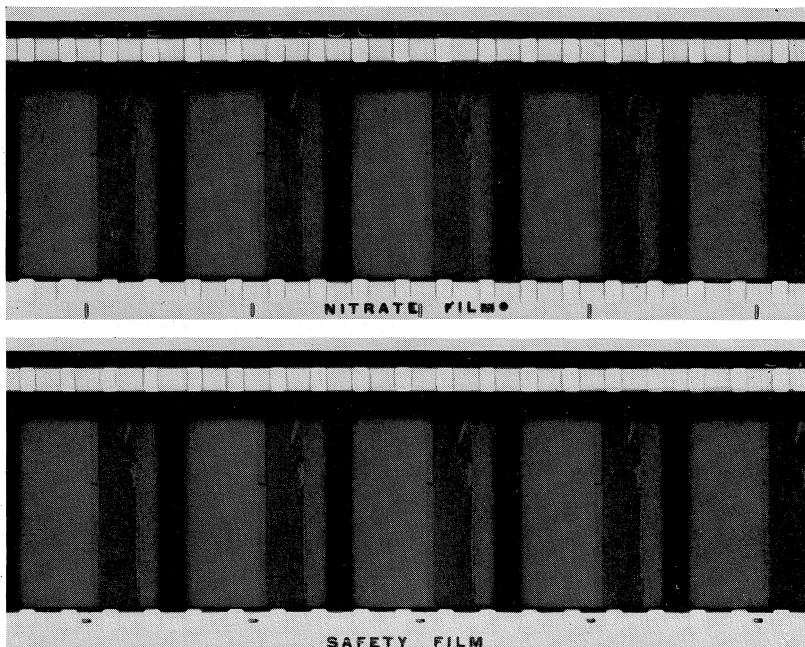


SAFETY FILM

**Figure 5.** The new Eastman visible frame-line mark on safety raw stock compared with nitrate.

is entirely inadequate. The Eastman Kodak Company has given a great deal of thought to this problem in recent years because of its importance in fire prevention. Many ideas have been suggested and it has finally been concluded that two separate identification systems for safety film are necessary. Two such systems are now being put in practice as follows:

**1. Distinctive Visible Frame-line Printing.** A scheme has been devised by which identification of the base can be combined with visible frame-line printing as shown in Figures 5 and 6. Eastman Nitrate Motion Picture Positive, Sound Recording, and Duplicating films carry a widthwise frame-line mark after every fourth perforation printed along the extreme edge of the film. Eastman 35mm black-and-white Safety Motion Picture Positive Film now carries a lengthwise frame-line mark after every fourth perforation located exactly between the perforations instead of at the extreme edge of the film. This is the only area on the film which is ordinarily not exposed in printing. This new safety frame-line mark when used on safety negative film will not print through on positive film, provided that care is taken to see that printers



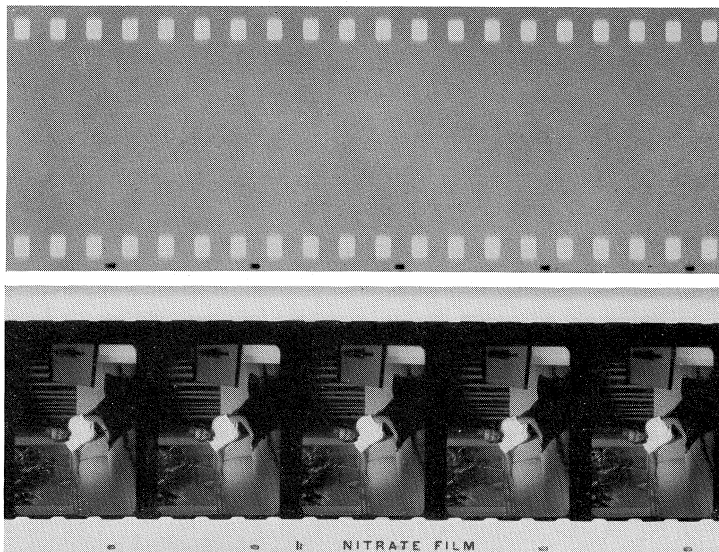
**Figure 6.** The new Eastman visible frame-line mark on processed safety film compared with nitrate.

never expose the area exactly between successive perforations. A more positive identification is thus obtained—whenever the new safety frame-line mark is found, one can be reasonably certain that the film is on safety base regardless of nitrate frame-lines or nitrate edge printing which may have been printed through from the negative. If the safety frame-line printing is not present, the film is either on nitrate base or on safety base made prior to the use of the new frame-line.

Both the nitrate and safety types of visible frame-line printing are applied to the back of the film by means of black ink instead of by latent image exposure and, therefore, are visible on the raw film (Figure 5) as well as on the developed film (Figure 6). The ink used will withstand processing solutions and normal handling wear. Even if the film is flashed before development the ink is visible by reflected light, although not by transmitted light.

The new safety frame-line mark has been used on 35mm black-and-white Eastman Safety Motion Picture Positive Film since early in 1949. It will appear on all 35mm Eastman safety motion picture films (both negative and positive types in black and white) as soon as the necessary

equipment changes can be made—it is hoped, sometime during 1951. (All color films manufactured by the Eastman Kodak Company are made on safety base but may not carry this new frame-line mark.) Of course, some Eastman safety film is already in circulation which does not have this new safety frame-line printing, but as time passes, this method of identification should prove of increasing value.\*



**Figure 7.** The visible frame-line mark on raw and processed nitrate film manufactured by Canadian Kodak.

Attention is drawn to the fact that nitrate film formerly manufactured by Canadian Kodak carried a visible frame-line mark running lengthwise of the film instead of widthwise, as in the case of Eastman nitrate film manufactured in the United States (Figure 7). The Canadian Kodak nitrate frame-line mark was located at the extreme edge of the film. It may therefore be distinguished from the new Eastman safety frame-line mark located between the perforations. Thus both the direction and the location of the frame-line mark must be checked to establish the identification of the base.

**2. A Fluorescent Edge for Safety Film.** The new visible frame-line printing described above is a useful and necessary method for identifying safety film, but it also has its limitations. In a spliced roll, every separate strip would have to be examined to make sure that the entire

\*A distinctive type of frame-line mark for safety base motion picture materials manufactured in foreign countries is also being instituted.

roll including leader and trailer was safety film. Correct identification of the whole roll is especially important for sorting films going into storage vaults where a small piece of nitrate film might damage other films. It is also important in sorting film for scrap recovery. In such cases, individual examination of every spliced strip would be very laborious and costly. It was felt that some rapid method of determining whether or not a roll of film is all safety is necessary.

The method which has been adopted by the Eastman Kodak Com-

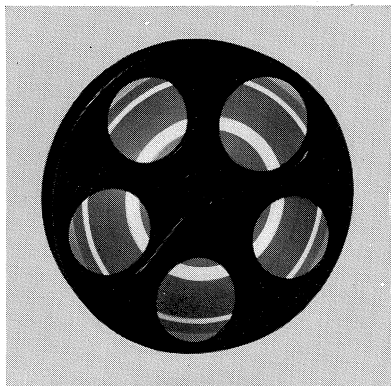


Figure 8



Figure 9

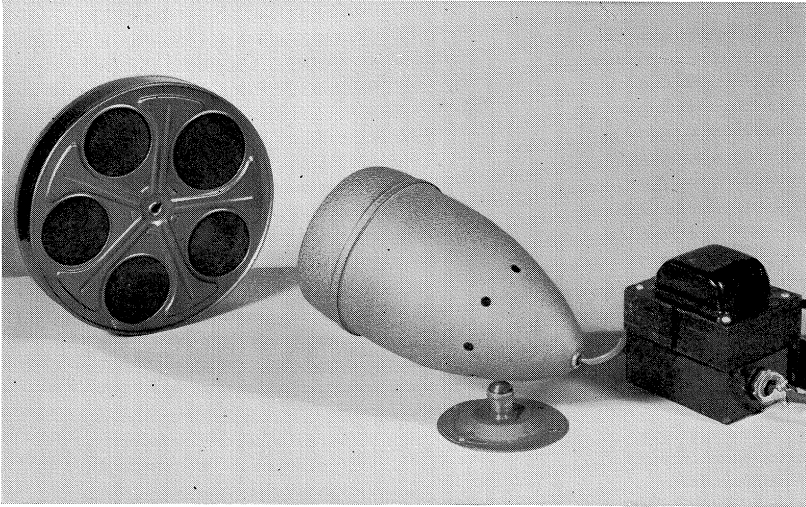
In Figure 8 is shown a mixed roll of fluorescent-treated safety film (white) and untreated nitrate film (dark) on an exchange reel. (Photographed with ultraviolet light.) The edge of the treated safety film is actually colored purple and the nitrate film black in ultraviolet light. Figure 9 shows the same roll as in Figure 8 but on a plastic core.

pany is to apply a very small amount of a fluorescent chemical on safety film base used for 35mm motion picture film. When a 35mm roll of film so treated is viewed on edge under a suitable ultraviolet lamp in a partially darkened room a vivid purple fluorescence is visible, whereas untreated film viewed in the same way appears black. In white light fluorescent-treated and untreated films look exactly the same. Extensive tests in both the laboratory and the trade indicate that the fluorescent treatment of the base has no detrimental effect on the film before or after development.

This simple and effective method of rapidly distinguishing nitrate and safety film in bulk form is illustrated in Figure 8 which shows a composite nitrate and safety film roll on an exchange reel. The same roll wound on a core is shown in Figure 9. The nitrate film appears black and the fluorescent-treated safety film appears white in these

reproductions. The contrast between the two films is much more striking in actual practice or in a color photograph where the edge of the safety film appears purple. The exchange reel does not permit as complete an examination as in the case of a roll on a core, but it is still possible to tell quickly whether most of the roll is nitrate or safety.

A suitable inexpensive ultraviolet lamp in various table, overhead, portable, spot, or flood-light models may be purchased from several manufacturers complete with transformer and filter ready for use.\* A



**Figure 10.** An ultraviolet lamp used for examining a roll of film to determine whether it is on fluorescent-treated safety base. (Photographed with white light.)

100-watt bulb is recommended for general use but smaller or larger ones may be obtained if desired. The ultraviolet bulbs and other parts may also be purchased separately from electrical supply stores and assembled in standard fixtures. Figure 10 illustrates how easily film may be examined by just passing it in front of an ultraviolet lamp of this type.

The ultraviolet lamp should be equipped with a hood or reflector and care should be taken not to expose the eyes for long periods to direct ultraviolet radiation from these lamps. Provided such care is taken, ultraviolet lamps present no personnel hazard. They are in constant use in various other industries, for example, for identifying markings on clothing in laundries. **CAUTION:** A word of warning is in order in the case of laboratories using sensitized photographic materials because ultraviolet lamp bulbs contain mercury. If broken, care must be taken

\*For example, Switzer Brothers, Inc., 1220 Huron Road, Cleveland 15, Ohio, Black Light Model 103.

not to carry or track mercury into rooms where undeveloped film is stored or handled. Even slight traces of mercury produce sensitized spots on film which become black when developed.

It should also be pointed out that the above method of examination is intended for processed film only and that if used in the inspection of raw stock, fogging of the latter will result.

Fluorescent treated film base is now being used for 35mm Eastman Safety Motion Picture Positive stock (type 5302) and will be used for all 35mm Eastman safety motion picture film without exception as soon as possible—it is hoped, in the early part of 1951.

## LABORATORY TESTS FOR IDENTIFYING NITRATE AND ACETATE FILM

Motion picture films manufactured prior to the adoption of the new support identification system described in the previous section may sometimes be difficult or impossible to identify directly as nitrate or safety. In such cases a simple test is needed and the following may be used:

**1. A Float Test.** A simple, reasonably fool-proof test to distinguish nitrate and any cellulose ester safety film is to punch a  $\frac{1}{4}$ -inch sample from the film and place it in a test tube or a small bottle of trichlorethylene.\* The liquid should be shaken to make sure that the film punching is completely immersed. If the punching sinks it is nitrate film; if it floats to the surface it is safety film. This is because trichlorethylene has a specific gravity between that of nitrate film and cellulose ester safety films as indicated below:

	<i>Specific Gravity at 25° C.</i>
Cellulose nitrate film base	1.50-1.53
Trichlorethylene	1.477
Cellulose acetate (high acetyl) film base	1.26-1.29
Cellulose acetate propionate film base	1.25-1.27
Cellulose acetate butyrate film base	1.22-1.24

No cellulose ester safety film base has a specific gravity above or even near that of trichlorethylene. The emulsion coated film has a somewhat higher specific gravity than the base itself depending on the amount of silver present. However, we have not found any safety films which do not float in trichlorethylene either raw or flashed and developed,

\* Trichlorethylene may be purchased from the Eastman Kodak Company, Rochester 4, N. Y. (Eastman Organic Chemical Catalog No. 1300) and also from various organic chemical supply houses.

including Duplitzed products having emulsion on both sides. One precaution should be heeded in making the float test—it should not be made on nitrate film still wet from processing because it does not sink in trichlorethylene as it does when dry.

Trichlorethylene is non-inflammable but its vapor should not be breathed, its toxicity being about half that of carbon tetrachloride (a somewhat hazardous solvent sometimes used for cleaning film).

**2. A Burning Test.** The final and conclusive test for a nitrate or a safety film, of course, is a burning test which can be made safely if certain precautions are taken. **THE BURNING TEST MUST NEVER BE MADE ON FILM IN A ROLL OR EVEN ON A LONG PIECE OF FILM.** A small sample should be cut from the roll and taken into another room where no film or other hazardous material is present. If a long piece of film is ignited and it turns out to be nitrate a serious burn or a bad fire may result.

The burning test must be made in a carefully prescribed manner or an inexperienced person may still confuse nitrate and safety film, particularly since only a small sample can be burned safely. For example, Duplitzed nitrate film with emulsion on both sides does not always burn as fiercely as one expects, and sometimes small pieces of safety film held in a match flame burn more rapidly than expected. The burning tests specified by the American Standards Association (Appendix A) or the Underwriters' Laboratories (Appendix B) may be used for identifying safety film, but these require a certain amount of apparatus and more film and time than is necessary merely for identification purposes.

A simple, reliable procedure is to take a piece of film no larger than a single 35mm frame ( $\frac{3}{4}$ -inch), hold it vertically with a pair of metal tongs or pliers, and ignite it with a match at the *top* edge. (*Warning: Do not hold the film in the fingers; if it is nitrate film a burn will result.*) The reason the sample should be ignited from above rather than from below is that the distinction between nitrate and safety film is much clearer when the test is made in this way. If the film is nitrate it will burn rapidly and vigorously downward with a bright yellow flame until the entire sample is consumed; if it is safety it will ignite only with difficulty and go out shortly after the match flame is removed. If ignited from below the safety film sample may burn completely.

Another method of making a burning test on a small film sample for identification purposes is that prescribed as a field test in "British Standard Definition of Cinematograph 'Safety' Film," No. 850-1939, the details of which are given in Appendix C. Only a  $\frac{1}{4}$ -inch punching from the film is required.



**3. A Chemical Test.** There is a standard chemical test known as the Diphenylamine Test for the nitrate molecular group which is present in cellulose nitrate film base. The details of this test are not given here because it should not be used for testing film by anyone other than a trained analyst. It is so sensitive that it will give a positive reaction on safety film containing a mere trace of cellulose nitrate in the sub layer (between the emulsion and the support) unless the sub is first removed.

### **CONCLUSION**

The gradual change from nitrate to safety base for professional 35mm motion picture film which is now taking place, should eventually eliminate the great fire hazard which has existed throughout the motion picture industry from the time of its inception. It has been the purpose of this booklet to emphasize that the hazard of nitrate film will persist as long as any remains in circulation or in storage and to point out the dangers of misidentification. It is hoped that the precautions recommended here will help prevent accidents during the transition years while some nitrate film still remains.

## BIBLIOGRAPHY

### Stability of Nitrate and Safety Film

1. Hill, J. R. and Weber, C. G., "Stability of Motion Picture Films as Determined by Accelerated Aging," *J. Soc. Mot. Pict. Eng.*, 27, 677-690, December 1936.
2. Gibson, J. E., and Weber, C. G., "The Evaluation of Motion Picture Films by Semimicro Testing," *J. Soc. Mot. Pict. Eng.*, 32, 105-109, January 1939.
3. Scribner, B. W., "Summary Report of Research at the National Bureau of Standards on the Stability and Preservation of Records on Photographic Film," *Nat. Bureau of Standards Misc. Publication M162*, May 1939.
4. Fordyce, C. R., "Improved Safety Motion Picture Film Support," *J. Soc. Mot. Pict. Eng.*, 51, 331-350, October 1948.

### Hazardous Properties of Nitrate Film

5. "Proceedings of a Board of the Chemical Warfare Service appointed for the purpose of investigating the disaster at the Cleveland Hospital Clinic, Cleveland, Ohio, on May 15, 1929," U.S. Government Printing Office, Washington, 1929.
6. Nuckolls, A. H. and Matson, A. F., "Some Hazardous Properties of Motion Picture Film," *J. Soc. Mot. Pict. Eng.*, 27, 657-661, December 1936.
7. Keene, K. W., "Safekeeping the Picture Industry," *J. Soc. Mot. Pict. Eng.*, 33, 533-537, November 1939.
8. Cummings, J. W., Hutton, A. C., and Silfin, H., "Spontaneous Ignition of Decomposing Cellulose Nitrate Film," *J. Soc. Mot. Pict. and Tel. Eng.*, 54, 268-274, March 1950.

### Fire Precautions in the Motion Picture Industry

9. Fowler, E. W. and Newell, L. B., "Storage and Handling of Motion Picture Film," *J. Soc. Mot. Pict. Eng.*, 16, 773-786, June 1931.
10. Anderson, H., "Fire Prevention in the Motion Picture Industry," *J. Soc. Mot. Pict. Eng.*, 27, 662-676, December 1936.
11. "Fox Film Storage Fire," *National Fire Protection Assoc. Quarterly*, 31, 2, 136-142, October 1937.
12. "Standards of the National Board of Fire Underwriters for Nitrocellulose Motion Picture Film as Recommended by the National

- Fire Protection Association," N.B.F.U. Pamphlet No. 40, July 1939. (Reprint 1949) (Obtainable from National Board of Fire Underwriters, 85 John Street, New York 7, N. Y.) Also J. Soc. Mot. Pict. Eng., 34, 311-333, March 1940.
13. Sulzer, A. F., "The Epoch of Progress in Film Fire Prevention," J. Soc. Mot. Pict. Eng., 34, 398-408, April 1940.
  14. "Storage of Cellulose Acetate Motion Picture Film," National Board of Fire Underwriters Special Interest Bulletin No. 283, September 25, 1950. (Obtainable from National Board of Fire Underwriters, 85 John Street, New York 7, N. Y.) (See Appendix D)

### **Film Storage and Preservation**

15. Crabtree, J. I., and Ives, C. E., "The Storage of Valuable Motion Picture Film," J. Soc. Mot. Pict. Eng., 15, 289-305, September 1930.
16. Weber, C. G., and Hill, J. R., "Care of Slide-Films and Motion Picture Films in Libraries," J. Soc. Mot. Pict. Eng., 27, 691-702, December 1936.
17. Bradley, J. G., "Changing Aspects of the Film-Storage Problem," J. Soc. Mot. Pict. Eng., 30, 303-317, March 1938.
18. Report of the Committee on Preservation of Film, J. Soc. Motion Pict. Eng., 35, 584-606, December 1940.
19. Bradley, J. G., "Film Vaults: Construction and Use," J. Soc. Mot. Pict. Eng., 53, 193-206, August 1949.
20. Calhoun, J. M., "Air Conditioning in Storing and Handling Motion Picture Film," Heating and Ventilating, 46, 66-69, October 1949.

## American Standard

### Definition of Safety Photographic Film\*

#### O. SCOPE

Photographic films are classified as safety photographic film if they are difficult to ignite, slow burning, and low in nitrogen content.

#### 1. IGNITION TIME

**1.1 Definition.** Film supports for light-sensitive materials are classified as difficult to ignite when the ignition time is greater than ten minutes.

**1.2 Method of Measurement.** The ignition time of photographic films is measured as follows:

**1.2.1 Sample.** A sample 35mm long and 8mm wide shall be cut from the film to be tested. The sample shall be free of perforations as far as is practicable. All gelatin layers shall be removed by washing in warm water, and the sample shall then be dried for at least 12 hours by being suspended freely in air having a temperature of 18C to 22C and a relative humidity of 40 to 50 per cent.

**1.2.2 Procedure.** The test shall be made in an electric resistance oven, the interior of which shall be in the form of a vertical cylinder (preferably with a rounded bottom), having a diameter of 70mm and a mean height of 70mm. The top of the oven shall be closed by means of a closely overlapping lid, having two holes of 7mm and 15mm, respectively, the centers being at a distance of about 15mm from each other. A thermocouple shall be introduced through the smaller opening, the connecting wires having a porcelain coating fitting tightly into the hole. Alternatively, the temperature in the cylinder may be measured by means of a mercury thermometer, protected from rising heat by means of a cork disk lying a little above the lid.

**1.2.3 Temperature.** The oven shall be brought to, and maintained at, a temperature of  $300\text{C} \pm 3\text{C}$ . When this temperature is reached, the sample, attached to a thin U-shaped wire hook, shall be introduced through the larger opening. The thermocouple (or the thermometer) and the sample shall be fixed in such a way that the thermojunction (or the mercury bulb) and the center of the sample shall be at an equal depth of about 35mm.

**1.2.4 Time Interval.** The time interval from the insertion of the sample to the ignition of the sample is recorded as the ignition time.

\*Z38.3.1-1943, American Standards Association, 70 East 45th Street, New York 17, N. Y.

**1.2.5 Preparation for Tests.** Between tests, the oven shall be thoroughly aired.

## 2. BURNING TIME

**2.1 Definition.** Photographic films having a thickness equal to or greater than 0.08mm are classified as slow burning when the burning time is not less than 45 seconds. Photographic films having a thickness less than 0.08mm are classified as slow burning when the burning time is not less than 30 seconds.

**2.2 Method of Measurement.** The burning time of photographic films is measured as follows:

**2.2.1 Sample.** A sample 35cm long and 35mm wide shall be cut from the film to be tested. All gelatin layers are to be removed by washing in warm water. The sample shall then be dried for at least 12 hours by being suspended freely in air having a temperature of 18C to 22C and a relative humidity of 40 to 50 per cent.

The sample shall be marked at a point 5cm from one end. The sample shall be perforated with holes 3mm in diameter along both edges. Perforations are to be at intervals of not more than 32mm.

**2.2.2 Procedure.** A wire having a diameter of not more than 0.5mm shall be threaded through the perforations on one side so that the sample is supported at points not more than 32mm apart. With the wire stretched horizontally and the sample hanging vertically from it, the bottom corner of the marked end is to be ignited.

**2.2.3 Time Interval.** The time which elapses from the moment the flame reaches the mark until the sample is completely burned shall be recorded as the burning time. If the sample does not ignite or if it does not completely burn, the burning time is recorded as infinity.

**2.2.4 Test Conditions.** The test shall be made in a room free from draughts and immediately after the period of drying. At least three tests shall be made.

## 3. NITROGEN CONTENT

**3.1 Definition.** Photographic films having a nitrogen content less than 0.36 per cent by weight are classified as having a low nitrogen content.

**3.2 Method of Measurement.** The nitrogen content of photographic films is measured as follows:

**3.2.1 Sample.** After the emulsion is removed, 2.5 grams of support are cut into small pieces and placed in an 800-cc Kjeldahl flask. To this are added 90cc of 30-per cent sodium hydroxide and 10cc of ethyl alco-

hol. (Note 1) The sample may be conveniently held overnight at this point.

**3.2.2 Procedure.** The sample is heated on the steam bath, and 25cc of 30 per cent hydrogen peroxide are added slowly, followed by agitation with a stirring rod. When the first portion of hydrogen peroxide is boiled out, another 20-cc portion is added; this is usually sufficient to dissolve the support completely. When the reaction has ceased, the stirring rod is removed and washed down with distilled water. The contents of the flask will now be approximately 200cc.

**3.2.3 Temperature.** The solution is evaporated over a flame to 75-100cc volume to remove the last traces of ammonia, diluted to a total of 350cc with distilled water, cooled, and immediately before connecting the flask to the Kjeldahl apparatus, 2.5 grams of DeVarda's alloy are added quickly. After the flask is connected, about 200cc of distillate are collected in a 500-cc Erlenmeyer flask containing 50cc of standard tenth-normal sulfuric acid. The excess acid is back titrated with tenth-normal alkali. (Note 2)

**3.2.4 Method of Calculation.** A blank determination is made on the reagents, using the same quantities that are used in the actual determination. The per cent nitrate nitrogen in the sample is calculated as follows:

$$\frac{[(\text{cc acid in blank}) - (\text{cc acid in sample})] \times 0.1 \times 0.014 \times 100}{2.5} = \text{per cent nitrogen.}$$

NOTE 1. Ethyl alcohol denatured with CP methyl alcohol may be used.

NOTE 2. Three sources of error must be avoided in this test:

(a) When evaporating the solution following the peroxide digestion, mechanical loss by entrainment may occur if the solution is boiled down too far. This will give low results.

(b) When distilling the sample after addition of the DeVarda's alloy, some alkali may be carried over into the standard acid by entrainment if the distillation is carried too far, or is too vigorous. This will give high results.

(c) The total volume of the sample at the time of addition of the DeVarda's alloy must be closely controlled. Too much or too little water added changes the alkali concentration so that the rate of reaction with the alloy and the corresponding reduction of the sodium nitrate present will be erratic.

## The Underwriters' Laboratory Tests for Safety Photographic Film\*

### 1. Ignition Temperature

The ignition temperature of the film (with emulsion on) is determined with an apparatus consisting essentially of a combustion chamber surrounded by a solder bath which is heated at a constant temperature during the tests by an electric furnace. The temperature of the solder bath is measured by means of a calibrated thermocouple provided with a quartz tube to protect the hot junction.

The combustion chamber consists of a glass flask of conical form with a flat bottom,  $4\frac{1}{2}$  in. (11.4cm) in height,  $2\frac{3}{8}$  in. (6.0cm) in diameter at the bottom and  $1\frac{1}{8}$  in. (2.8cm) in diameter at the top. It is of about 160 ml capacity (rated capacity 125 ml) having a ratio of surface area to volume of about 1.1.

The test consists of dropping pieces of film into the flask at each interval of  $5^{\circ}\text{C}$ . ( $9^{\circ}\text{F}$ .) and observing whether or not ignition is obtained. In some of the trials, a little additional air is introduced into the flask by means of a rubber bulb and bent delivery tube. After each trial, the gases and vapors are completely displaced by the aid of a slow stream of air. The lowest temperature at which ignition (without application of flame) can be obtained is taken as the ignition temperature.

### 2. Burning Time

A sample of the film (with emulsion on), 35 in. in length, is suspended vertically by a wire in a sheet-steel stack of square cross section 12 by 12 in. (inside) and 7 ft. high, standing on legs 1 ft. high. The stack is provided with a door containing a wired-glass window throughout its height, so that ignition, flame travel, and afterglow, if any, may be observed. A sheet of asbestos 6 in. square is mounted horizontally 6 in. below the lower end of the strip, to catch any droppings from the test sample. A gas test flame,  $\frac{3}{4}$  in. long and  $\frac{1}{4}$  in. diameter, is applied to the lower end of the vertical strip of film until ignition occurs. Observations are made for the time required for ignition, height of flame, time required for combustion, and for afterglow. If the entire strip of film does not burn upon first ignition, it is re-ignited, a record being kept of the times the film is re-ignited.

In order to classify as slow-burning under the Underwriters' listing,

\*Courtesy of the Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago 11, Illinois.

films are required to show a burning time in the above test of more than 65 sec. (where the thickness is below 0.08mm, the burning time must be more than 30 sec.).

### **3. Nitrogen Content**

The nitrogen content of the film base after removing the emulsion is determined by the DeVarda-Kjeldahl method with solution of the sample in alkaline hydrogen peroxide solution. (See also Appendix A, Test Number 3.)



## British Standard Field Test for Identifying Safety Photographic Film\*

### Method of Carrying Out the Field Test on Cinematograph Film

The field test, by which a quick indication may be obtained as to whether or not film is of the "safety" class shall be carried out as described below:

*Testing Equipment.*—The equipment used shall consist of the following items:

(a) A small hand punch by means of which a circular sample  $\frac{1}{4}$  in. in diameter may be cut from the film.

(b) A small container labelled "control samples" in which are a number of samples cut from nitro-cellulose film (i.e., inflammable film).

(c) A number of double bowled spoons, stamped out of light sheet metal. One end of the spoon shall be stamped with the letter "C," to indicate that the control sample is to be placed in the bowl at that end. The other end shall be stamped with the letter "T" to indicate that the "test sample" is to be placed in the bowl at that end.

A suitable design of spoon is shown in Fig. 1 below.

(d) A small wax candle (about  $\frac{1}{4}$  in. in diameter).

It is essential that the test be carried out in still air away from the influence of draughts.

A sample shall be taken from the film to be tested, being punched

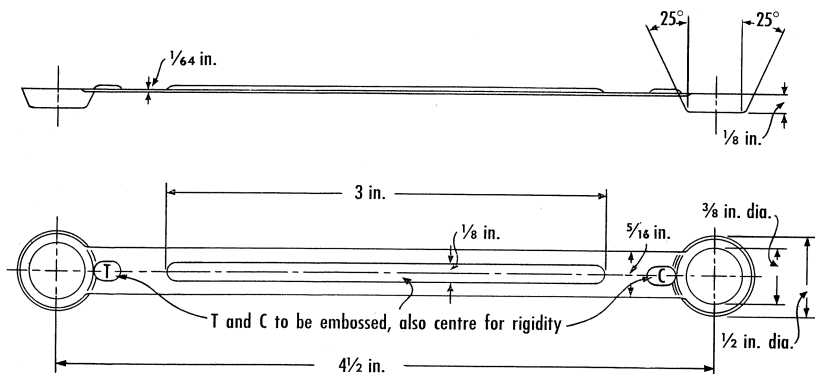


Figure 1—Details of double-ended spoon.

\*From "British Standard Definition of Cinematograph 'Safety' Film," No. 850-1939. Reproduced by permission of the British Standards Institution, 28 Victoria Street, London, S.W. 1, England.

from a position in which the perforations interfere as little as possible. Every care should be taken to cause as little damage as possible to the film from which it is cut.

One of the control samples of nitro-cellulose film shall be placed in the bowl of a new† spoon at the end marked with a "C," and the test sample (cut from the film) shall be placed in the bowl at the other end.

The small candle, fixed on a rigid support, shall then be lighted and the bowl containing the control sample shall be placed in the flame.

The behaviour of the control sample should then be closely observed. After some seconds it will be noted that it ignites with almost explosive violence, giving rise to a flame and usually accompanied by a "pop." Once commenced, combustion is completed almost immediately.

The bowl containing the test sample shall then be placed in the flame in the same manner as before and the behaviour of the test sample closely observed.

If the test sample behaves in a manner similar to the control sample the film may be adjudged not to be of the "safety" class.

If, on the other hand, it is observed that after some time the test sample melts and smoulders slowly or if it catches fire and burns quietly for a few seconds then the film may be adjudged to be of the "safety" class.

Normally a single test is sufficient to indicate whether or not the film is of the "safety" class, but if there is any uncertainty the test should be repeated.

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† It is important that a new spoon should be used every time a test is made.

## Film, Motion Picture Cellulose Acetate

[Special Interest Bulletin No. 283, Revised September 25, 1950. Issued by National Board of Fire Underwriters, 85 John Street, New York 7, N. Y.]

Following an extended investigation, acetate base film in the form of ribbon for motion pictures was listed by Underwriters' Laboratories, Inc. as slow-burning, the fire hazard being classed as somewhat less than that of common newsprint paper in the same form and quantity. Motion picture safety film having a cellulose acetate base is now being marketed for commercial and general use. It is claimed that this film has a greater projection life and is otherwise superior as compared to the older type of cellulose acetate film.

This type of film may be identified by the words "Safety Film" printed at frequent intervals along the edge. In case of doubt acetate film may be distinguished from nitrate by a burning test, using only a small piece of film, and burning it in a room where there is no film and no fire hazard. Nitrate film will burn fiercely; acetate film will burn quietly.

The ignition temperature of cellulose acetate is between 700 and 800° F., as compared to about 300° F., for cellulose nitrate. A temperature of about 500° F. is required to produce the decomposition of cellulose acetate film. In the neighborhood of this temperature the evolution of fumes in material quantity occurs. These fumes are irritating and suffocating, but not considered to be toxic under most conditions.

The decomposition of cellulose acetate film once started does not continue except under conditions where there is an external source of heat. On the contrary, in the case of cellulose nitrate film the decomposition continues when once started, even in the absence of external source of heat. This difference of decomposition is, therefore, of great importance from the fire and life hazard standpoint. Furthermore, great volumes of explosive and toxic gases are given off from decomposition of nitrate film, especially in a restricted supply of air, thus contributing to the life and fire hazard.

The rate of combustion of cellulose acetate film is relatively slow and the amount of heat evolved is of a low order, being much less than that of paper or wood.

The most important safety factor with reference to cellulose acetate film, is in its slow combustion, and any fire can be easily extinguished by the application of water or smothering, much in the same manner as fires in ordinary combustible materials.

The time will, no doubt, come when nearly all pictures will be on safety film, but there may be nitrate films in circulation for some time

and because of this every precaution should be taken to avoid any relaxation in the regulations prescribed and methods imposed for the safe handling of flammable nitrate films. The safety factor supplied by the new acetate film can be taken advantage of by arranging its storage apart from any nitrate films. By this segregation, loss possibilities will definitely be reduced and as nitrate inventories are progressively diminished their isolated confinement will tend to further control hazard possibilities. In existing film exchanges, this segregation can be readily controlled by having separate film vaults for safety and nitrate films, and marking their doors with the words Safety Film in *green*, or Nitrate Film in *red*. Similar isolation of safety films from nitrate films can also be practiced using specially identified rooms for the safety film with such measures for protection against loss as may be desired. Small amounts of safety film can be appropriately stored in ordinary steel filing cases but if they are of high value specially protected cabinets of the type designed for film storage should be given consideration.

In order to insure the degree of safety now provided by the new film it is suggested that all safety films be unmistakably identified by reel bands bearing in prominent letters the words, SAFETY FILM printed in bright green. All record cards and other control items that pertain to these films should also be printed in the same green color and bear as their main feature the words SAFETY FILM. In contrast, all flammable nitrate films should be equipped with reel bands printed in bright red with the words NITRATE FILM, with their record items correspondingly identified.

Film handling personnel working under this plan for segregating the two types of film should take special care to prevent intermixture of the two types and there should be exacting supervision of storage facilities to minimize all possible loss. By positive and intelligent management the safety factor provided by this new film base can immediately benefit all engaged in motion picture film activities. If such a plan for careful segregation is not followed, any place where both types of film are handled should follow for all film the safety precautions prescribed for nitrate film.