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CARE OF FILMSLIDES AND MOTION-PICTURE FILMS IN LIBRARIES[1]

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ABSTRACT

The stability of cellulose acetate film used as filmslides is being studied to determine its suitability for preserving records in libraries. Cellulose nitrate motion-picture films are being tested to find the best conditions for preserving this type of film. The control of moisture content is essential to prevent brittleness in acetate films, and scratching of the emulsion appears to be a problem involved in the use of filmslides in reading projectors. Frequent cleaning is important. Nitrate motion-picture films are not permanent because the cellulose nitrate is unstable. They can be best preserved by storing in a dry atmosphere, at low temperature, in such manner that products of decomposition are permitted to escape freely. The storage of nitrate films requires very exacting fire-prevention measures.

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I. INTRODUCTION

Progress made in the use of photographic film for copying, in miniature, important reference records, and the apparent certainty of widespread expansion in the use of films for many classes of library records, make the care and preservation of films a problem of immediate importance to librarians. The term filmslide is applied to films used for projecting enlarged still pictures on a screen for comfortable reading. They can be either in roll or card form. Two kinds of film are available for this purpose: first, cellulose nitrate, which is very inflammable and chemically unstable and, second, cellulose acetate ("safety film"), which is slow-burning and chemically

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stable. Both kinds have been used for copying documents in miniature, but at present only safety film is in general use for this purpose. Acetate film presents no greater fire hazard than ordinary paper, and although the safety film now used is a comparatively new material, it has been found in tests at the National Bureau of Standards [3] to be very stable, if properly made and processed. However, the preservation of acetate film requires control of moisture content.

Cellulose nitrate is in general use in the motion-picture industry chiefly because cellulose acetate is more brittle when dry, curls more in service, and is slightly plastic when wet, consequently, it is not entirely satisfactory for continuous machine development. The samples tested were furnished by the three principal domestic manufacturers of motion-picture films, and were said to be representative of current commercial products. No materials of foreign manufacture were tested.

The National Archives and other depositories interested in the storage of valuable motion-picture films have special problems due to the highly inflammable character of the base. The base of this type of film is a mixture of cellulose nitrate and camphor. It is chemically unstable and highly combustible.

II. EFFECTS OF ATMOSPHERIC VARIATIONS ON FILMS

The effects of variations in relative humidity of the surrounding air were determined by studying the properties of film over a wide range of relative humidities at constant temperature. The properties tested were: Moisture content, and its effect on flexibility as determined by the Pfund [4] type of folding-endurance tester; and dimensional changes. Inasmuch as the experience of film users has indicated that acetate film is much more susceptible to atmospheric changes than nitrate film, the relative behavior of these two types is significant. The films were conditioned for 24 hours in all instances, because both types of film were found to reach practically constant weight within that time. The tests were made on films secured from three domestic manufacturers who stated that the films were representative commercial products.

1. MOISTURE CONTENT

The moisture contents of cellulose acetate and cellulose nitrate film, in common with other hygroscopic substances, tend to follow the relative humidity of the surrounding atmosphere. With films, changes of moisture content affect the flexibility and cause dimensional changes. Hence, the relationship between relative humidity and moisture content is of interest in that it gives the basis for explanation of the physical reactions of the films to moisture changes. This relationship is shown graphically in figure 1. The data on moisture content of films are based on oven-dry weights. Oven-dry weight was obtained by heating for 1 hour at 100° C, with a slight correction for permanent loss in weight which was due to loss of volatile material.

[3] Detailed information on the stability of films will be contained in a separate article now in preparation

[4] This type of folding tester developed by A. H. Pfund, Johns Hopkins University, for the DuPont Film Corporation, was used in the study at the Bureau after it was found to give more reproducible results than did folding testers used for paper.

The graph shows absorption and loss of moisture for both acetate and nitrate films with emulsion. These curves are similar in general form to adsorption-desorption curves for paper.[5] It will be noted that there are two curves for each type of film, which is because the moisture content of a hygroscopic substance varies according to the direction of approach to the hygrometric condition. Hence, we have one curve for absorption, that is, ascending from a dry initial condition, and one curve for descending values. This variation in moisture

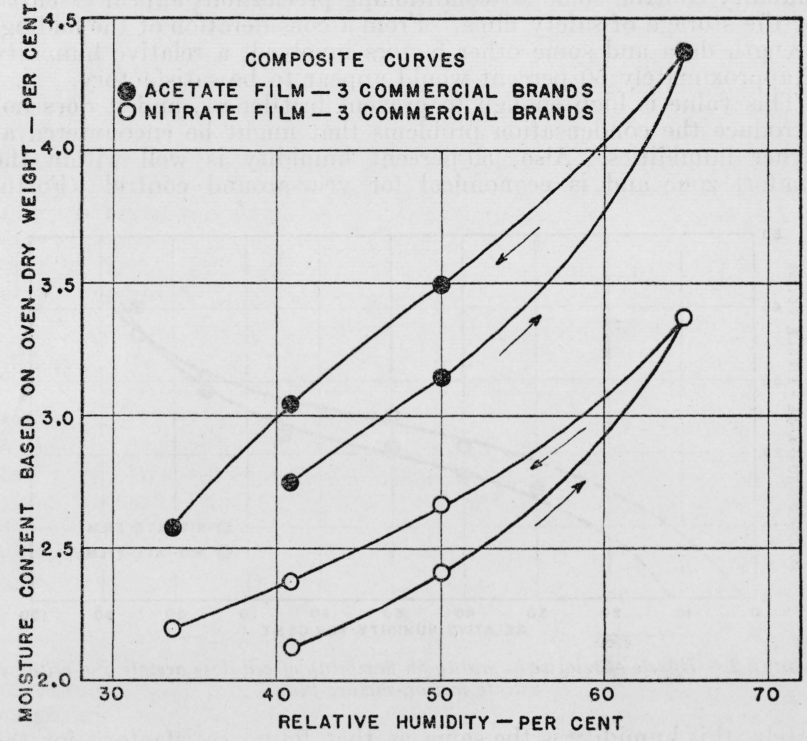

FIGURE 1.—*Relationship between relative humidity and moisture content of cellulose acetate and cellulose nitrate motion-picture film.*

content, as influenced by the history of conditioning, is known as hysteresis.

2. FLEXIBILITY

The relationship between folding endurance and relative humidity was found to be fairly regular for both acetate and nitrate film. The loss of folding strength with decreasing relative humidity was more rapid for acetate than for nitrate, which apparently explains why brittleness difficulties are more frequently encountered in the use of safety film. The relationship between the hygrometric condition and flexibility of both acetate film and nitrate film is shown in figure 2. Data were obtained for the relative-humidity range from 30 to 85 percent, as shown by the curves. Extension of the curves below 30-percent relative humidity by extrapolation is shown by the broken

[5] BS J. Research 12, 53 (1934) RP633.

lines. The only data for this region were obtained on film dried over calcium chloride in a desiccator. Neither type would withstand folding under these conditions, indicating complete loss of folding endurance before zero relative humidity was reached. The extrapolation would indicate extreme brittleness of the acetate film at about 15-percent relative humidity and below. This agrees with the experience of users Hence, since 15 percent is within the range of humidity encountered during the winter season, in heated rooms with no humidity control, some air-conditioning precautions appear essential for the storage of safety films. From a consideration of the folding-strength data and some other factors involved, a relative humidity of approximately 50 percent would appear to be satisfactory.

This value is high enough to prevent brittleness, and it does not introduce the condensation problems that might be encountered at higher humidities. Also, 50-percent humidity is well within the comfort zone and is economical for year-around control. Fortu-

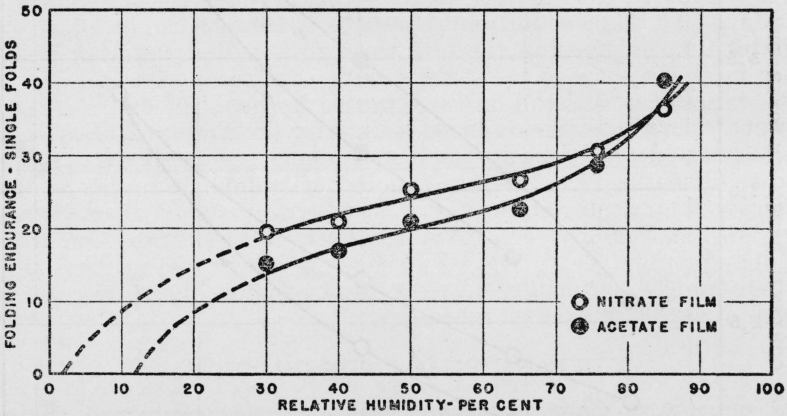

FIGURE 2.—*Effects of relative humidity on flexibility of cellulose acetate and cellulose nitrate motion-picture film.*

nately, this humidity is the same as that found satisfactory for the preservation of books in libraries;[6] therefore the use of filmslides presents no storage problems for libraries provided with air conditioning.

In libraries without conditioned air, satisfactory conditioning of films can be accomplished by means of humidification in small closed rooms or cabinets. Small closed rooms can be humidified with simple, relatively inexpensive air-conditioning units. This method has been employed successfully at the Library of Congress for film-slide storage space. Cabinets or small vaults can be humidified by using open vessels of the proper salt solution. A saturated solution of sodium dichromate, $Na_2Cr_2O_7.2H_2O$, because it gives 52-percent relative humidity at 68° F, should prove very satisfactory for the purpose. The solution should be exposed in shallow vessels with fans blowing air across the surface to promote the circulation of air. Inasmuch as considerable water may be absorbed from the air, an excess of dichromate should always be used to ensure saturation.

[6] BS Misc. Pub. M144 (1933).

Acetate filmslides should be stored in the conditioned chamber when not in actual use. In order to ensure sufficient contact with the humidified air to permit films to regain the moisture lost during projection, they should be stored in open reels without cans. When placed in the humidity room, all tightly wound rolls should be loosened and hung exposed so that the air will have free access to all parts of the film.

Successive projections drive out the film moisture more rapidly than it can be regained while tightly wound, and film in frequently used rolls may become brittle even when stored in the humidified atmosphere between projections, unless proper precautions are taken. Acetate film that has become brittle through excessive drying will regain its flexibility without permanent damage if the moisture is restored.

Moisture penetrates a tightly wound roll of film very slowly and it will require weeks to recondition a roll of brittle film properly, if the roll is not loosened to permit the air to get between the convolutions of film. Thorough conditioning can be accomplished in 10 to 30 minutes time by passing the film through a humid chamber or by other methods such as moistening with a mixture of water and a water-miscible volatile liquid as suggested by Crabtree and Carlton.[7] However, such methods are inconvenient for the average library, and are not considered necessary for conditioning the small rolls of film used as filmslides. Nitrate film has better folding endurance at low humidity than acetate film, and is less prone to break in use when dry. Hence, humidity control is less essential for nitrate film from the standpoint of flexibility. Filmslides in card or strip form that are not subject to winding on reels do not require moisture-content control if carefully handled when dry.

3. EXPANSION AND CONTRACTION

All changes of moisture content of films are accompanied by expansion or contraction. The dimensional changes resulting are not important to users of filmslides, except as uneven dimensional changes may cause curling of the films, and that is rarely sufficiently pronounced to give serious difficulty in a well-designed projector. The relationship between moisture-content increase and expansion of films is shown in figure 3. It will be noted that there is little difference between the two types of films as regards changes of dimensions per unit of moisture change. However, the moisture-content changes accompanying atmospheric variations are greater for acetate film as shown in figure 1. Furthermore, the acetate film always tends to curl more than the nitrate. While the expansion and contraction of film is considered a serious problem in film processing it does not often give trouble in the projection of films, as standard sprockets are made to allow for a shrinkage up to 1.5 percent.

Film shrinkage not caused by loss of moisture is caused by loss of volatile material. With acetate film this is confined to the loss of some traces of solvents, and possibly some plasticizer, during the first 6 months, after which there is no further measurable permanent change. Nitrate film shrinks more or less continuously throughout

[7] Trans. Soc. Motion Picture Engrs. no. 30 (1927).

its life because of the loss of solvents and of volatile decomposition products. Thus, printing from old nitrate negative will often require pulling the film down frame by frame in step printers, because the shrinkage will cause too much creep for continuous printing.

III. SCRATCHING OF FILMSLIDES

Examination of filmslides that have been used in reading projectors over a period of time has revealed considerable scratching, particularly on the emulsion side. Figure 4 shows a section of film that had been in use in a public library for a period of less than 2 years. This photograph was taken by reflected light to show the actual extent of damage. The scratching has not in this instance reached the stage where legibility is seriously impaired. However, it apparently brings

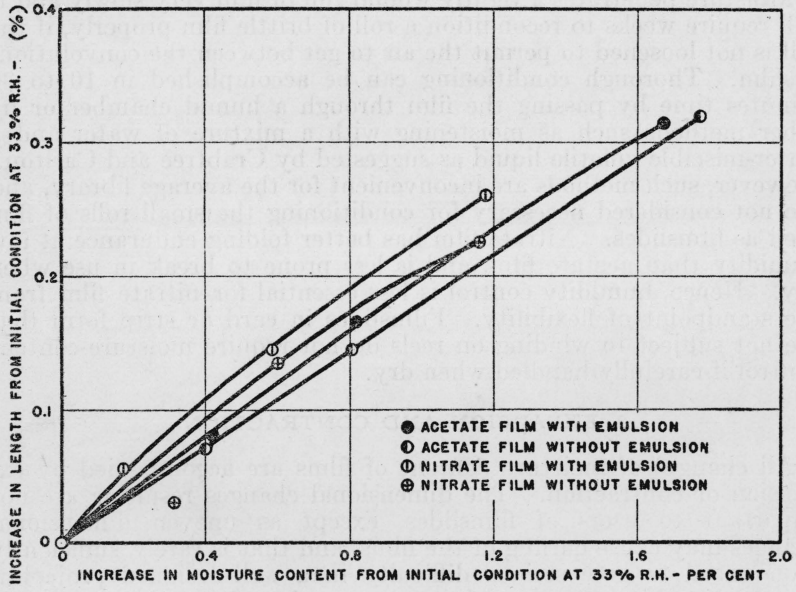

FIGURE 3.—*Relationship between moisture content and dimensions of cellulose acetate and cellulose nitrate motion-picture films.*

up a problem in connection with the care and use of filmslides. If the scratching cannot be avoided through improvements in the design of projectors and by keeping the films clean, it appears that the negative films of important records should be carefully preserved. It may be necessary to replace from time to time those positives that receive an excessive amount of use in projectors because of the accumulation of scratches. None of the commercial scratch-proofing treatments were tested for the purpose of determining their effectiveness in preventing scratching.

IV. CLEANING OF FILMS AND FILMSLIDES

It is important that film be kept clean, not only because extraneous material on the film affects legibility, but because dust particles cause scratching of the film when in use. The Bureau has found chemically

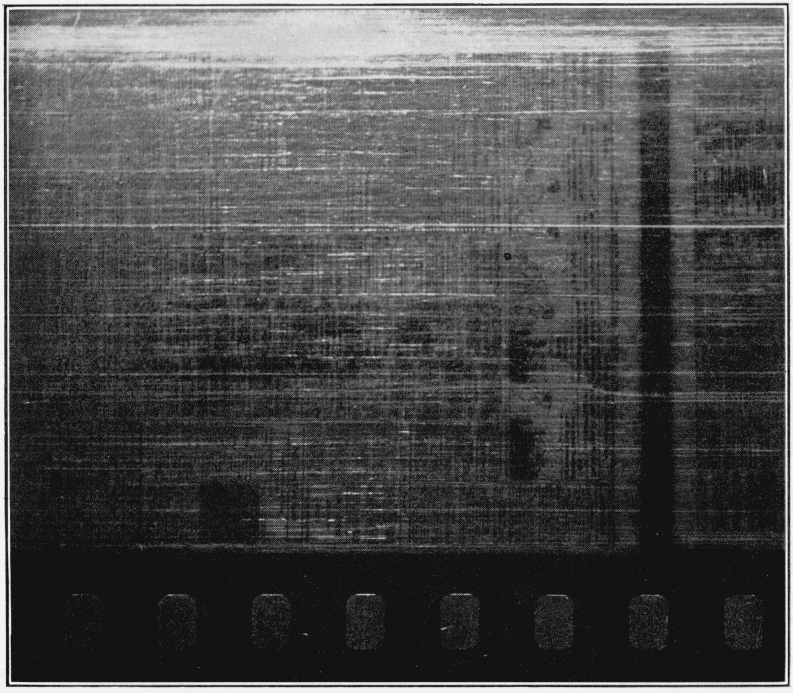

FIGURE 4.—*Scratches on cellulose acetate film resulting from normal use in projector.*

pure carbon tetrachloride to be quite satisfactory as a cleaning fluid. It is a good solvent for fats and oils, evaporates readily, is noncombustible, and does not have any measurable effect on the stability of the film. However, the fumes from this liquid are rather toxic and should not be inhaled. The use of this and other cleaning liquids is described by Crabtree and Carlton.[8] They recommend that the film be wiped gently with a silk plush moistened with the cleaning liquid. It is stated that cleaning machines suitable for roll films are available commercially, and that their use is preferable to hand cleaning. Film subject to intermittent use should be inspected at regular intervals for dust, finger marks, or traces of oil from the projectors that may make cleaning necessary to preserve the legibility and prevent scratching.

V. PROBLEMS IN THE STORAGE OF CELLULOSE NITRATE FILM

Nitrate motion-picture film presents special problems of storage and handling because of its highly combustible nature. It has a low ignition temperature combined with a high rate of combustion, and is capable of decomposition with little or no air supply, evolving poisonous, inflammable gases. Standards for the handling and storage have been established in the regulations of the National Board of Fire Underwriters.[9] However, storage from the standpoint of the preservation of valuable film requires not only the protection of the surroundings in the event of a fire within a storage vault but the proper isolation of films within the vault so that only the minimum amount of film will be destroyed in case of fire. Crabtree and Ives [10] found it possible to construct cabinets with metal-lined, insulated, individual film compartments that would prevent the complete burning of single rolls of film from igniting other film in the cabinet. Such cabinets are now available commercially, and their use inside safety vaults of suitable fireproof construction [11] [12] should afford adequate protection from fire. This system has been followed in the construction of the film-storage facilities at the National Archives.[13]

Film of the nitrate type is perishable because the cellulose nitrate base is unstable chemically. Deterioration is accelerated by increasing temperature or moisture, raising the pressure, or by contact with the products of decomposition. Hence, storage compartments and containers should be so vented as to prevent any accumulation of gases to raise the pressure as might result in sealed containers, or to injure the film by contact. Also from the standpoint of preservation, the lower the temperature and humidity the better. However, the advantages to be gained by storing at temperatures below about 50° F are probably more than offset by the added costs of air conditioning, and the tempering difficulties involved to prevent condensation when film is taken out of storage. Relative humidity above 50 percent is not recommended in any case. Even when stored under the most ideal conditions, nitrate film cannot be expected to last indefinitely, and valuable film should be inspected regularly for signs of

[8] Trans. Soc. Motion Picture Engrs. no. 30 (Aug. 1927).
[9] Regulations of the National Board of Fire Underwriters Governing the Production, Storage, and Handling of Nitrocellulose Motion-Picture Film. National Board of Fire Underwriters, New York, N. Y.
[10] J. Soc. Motion Picture Engrs. **15**, no. 3 (Sept. 1930).
[11] J. Soc. Motion Picture Engrs. **16**, no. 6 (June 1931).
[12] See foot note 9.
[13] J. Soc. Motion Picture Engrs. **26**, no. 6 (June 1936).

deterioration. Protective duplications should be made as soon as deterioration is evident, and it appears to be desirable to reproduce the negatives of permanent record value on the more stable acetate base before deterioration is evident.

VI. SUMMARY

The cellulose acetate film used as filmslides for records is hygroscopic. It adjusts its moisture content to conform to the humidity of the surrounding air, and changes in moisture content affect its properties.

The film is brittle under the conditions often encountered in rooms without air conditioning, making control of the moisture content essential. The conditions suggested for storage and use of film are those recommended for the preservation of books in libraries, namely, 50-percent relative humidity and 70 to 80° F. However, libraries without air conditioning can get satisfactory performance by storing the film slides in humidified cabinets or small rooms in which the relative humidity is not permitted to drop below 50 percent. Control of temperature is not considered essential, except that extreme variations should be avoided.

The emulsion side of film is easily scratched and despite care in handling, projecting, and cleaning to minimize abrasion, filmslides accumulate scratches. The positives in constant use may require occasional replacement; hence negative films of important records should be carefully preserved as a source of replacement.

Nitrate film is perishable and highly combustible. Storage of this type of film should be undertaken only in approved fireproof cabinets, and these should be within vaults of fireproof construction. Low temperature and low relative humidity are recommended to retard the deterioration of films in storage. Film containers for nitrate film should be vented to permit free escape of the products of decomposition (principally nitrous oxides) since their presence accelerates deterioration. It appears advisable to preserve pictures of permanent value by making negatives on acetate base, because of the perishable nature of nitrate film.

The authors are indebted to J. E. Gibson and M. Reiss for assistance in the work while assigned to the Bureau by the National Archives.

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