Canadian Conservation Institute
Institut canadien de conservation

CCI Notes 16/3

Care of Black-and-White Photographic Negatives on Film

Introduction

Museums and archives house black-and-white photographic negatives that were produced in the 20th century, most of which are in the form of sheet film or rolls. Unlike prints, which may be enhanced or altered, these original camera records faithfully represent the photographer's intention.

Like most photographic materials, negatives on film have a two-layer structure consisting of the support and the image-bearing layer. The image-bearing layer of black-and-white film negatives is usually composed of microscopic silver particles in a gelatin layer. A film support may consist, for the most part, of a plastic material from one of the following three categories:

(1) cellulose nitrate, the manufacture of which began in the 1880s and was discontinued by the Eastman Kodak Company in 1951
(2) cellulose acetate (1920s to present) manufactured in various modifications, such as cellulose diacetate, cellulose triacetate, or the mixed acetate-propionate and acetate-butyrate esters
(3) polyester (1950s to present)

The films in the last two categories are designated as safety films.

Cellulose nitrate materials have two undesirable properties: they are highly flammable (and have been reported in several cases to have ignited spontaneously), and they are inherently unstable. Spontaneous ignition of cellulose nitrate materials has occurred only in large-volume storage, typically in motion picture film exchanges. According to Calhoun (1953), single negative sheets kept in individual envelopes or several sheets interleaved and stored in one envelope do not constitute a fire hazard from spontaneous ignition. Cellulose nitrate film is not explosive.

Films on an acetate base can be found in many different — and sometimes surprising — conditions, which are described well by Horvath (1987). Some early types of safety film dating from the early 1930s and 1940s, which may consist of cellulose diacetate or of mixed cellulose esters, suffer from severe shrinkage due to a slow loss of solvents and plasticizer compounds.

The contraction of the film support causes the image-bearing gelatin layer to become wrinkled, making it impossible to obtain a good print from such negatives. They can be salvaged only by stripping the gelatin layer (which is a labour-intensive operation), placing it onto a new support, and duplicating the transferred negative photographically.

Another change in the stability of acetate films is caused by hydrolysis of the cellulose acetate itself, a chemical reaction that produces free acetic acid. Since common vinegar is a solution of approximately 5% acetic acid in water, this reaction has been dubbed vinegar syndrome. The smell of vinegar near aging acetate films is an indication of the beginning of chemical decomposition. The mechanism of this reaction, which is catalysed by free acetic acid, has been studied extensively in recent years by several groups. For more information, see the papers by Adelstein et al. in the *Journal of the Society of Motion Picture and Television Engineers*, as well as the work by Ram et al. (1994) on the use of molecular sieves placed in film containers to counteract the acid-catalysed hydrolysis of cellulose acetate through selective absorption of free acetic acid and excess moisture.

The life expectancy of polyester films has been determined by several research groups to be between 500 and 2000 years. Since it is by far the most stable of all film bases, its use is highly recommended in cases where long-term stability is essential, for example in microfilming brittle paper records.

Preservation and Storage

All processed photographic materials are sensitive to high relative humidity (RH) and to fluctuations in the RH level. Typically, film negatives curl up in a dry environment and flatten again in an environment of high RH. Properly processed negatives on safety

film are essentially stable in dry heat. However, a combination of high temperature and high RH accelerates the deterioration of black-and-white safety film negatives because such conditions facilitate reactions of the image silver with oxidizing chemicals.

The RH level affects the long-term stability of photographic materials. The International Organization for Standardization recommends an RH between 20% and 50% for storing processed safety photographic film. RH must never exceed 60%. Recent evidence suggests that a level of 30–35% is optimum. Avoid fluctuating RH.

Maintain temperature below 24°C, and ideally below 21°C. Temperature must never exceed 32°C. Storing processed photographic film at low temperatures, even below 0°C, is not harmful to its stability, and will, in fact, extend its life. Keep the storage environment free of harmful chemicals, notably peroxides, hydrogen sulphide, sulphur dioxide, and ozone. Generally speaking, black-and-white films and prints require the presence of aggressive chemicals to react with the image silver and so cause discoloration. This is in contrast to colour photographs whose permanence is strongly temperature-dependent: heat will accelerate the breakdown of the image-forming dyes; conversely, storage at low temperature prolongs their life. Recent research on the life expectancy of acetate films at varying levels of temperature and RH has resulted in new recommendations for optimum storage conditions. See Reilly (1996) for details.

Degrading cellulose acetate negatives should be segregated from the rest of the collection to prevent the potential initiation of degradation in other films. Negatives on a cellulose nitrate film base could also be separated and stored in a different location to remove any potential fire hazard — although if each negative is put into an individual envelope, spontaneous ignition is not likely to occur. However, aging and deteriorating cellulose nitrate film can release chemically aggressive gases, which pose a danger to the preservation of adjacent negatives or prints. Carroll and Calhoun (1955) vividly describe the chemical attack of such gases on negatives of safety film. The best solution may be to seal cellulose nitrate film negatives in suitable moisture-resistant packaging (see Bigelow 2004) and keep them in cold storage. This treatment is also recommended for early cellulose diacetate films.

Photographic negatives on film are not intended to be displayed. They are usually kept in dark storage envelopes, boxes, or drawers. Negatives are meant to be copied, either by contact exposure or in an enlarger. Exposure to light during the copying process does not damage negatives. However, prolonged exposure to direct sunlight or to artificial light sources is not recommended because these factors may embrittle the gelatin layer.

Use suitable filing enclosures made of chemically inert plastics such as uncoated polyethylene or polyester (polyethylene terephthalate, e.g. Melinex 516) to store photographic negatives that are in sheet film form. Plastic materials with antistatic or lubricant applied coatings are unsuitable. Also avoid chlorinated or nitrated plastic sheeting such as polyvinyl chloride (PVC).

For optimum protection and long-term storage, place negatives in uncoated polyester sleeves and then in paper envelopes on which all necessary documentation has been written. Roll films can be either left in rolls, cut into single frames, or cut into strips that contain several images. For example, 35 mm films can be cut into convenient strips of six images and placed in uncoated polyester sleeves (Melinex 516).

While negatives must be stored carefully, they are of cultural or historical value only if they are used to make positive prints. A simple way to evaluate the quality and condition of a negative is to make a contact print. If a negative is used frequently for printing to satisfy client demand, make a duplicate negative. If done correctly, this will yield positive prints equivalent in every respect to those made from the original negative.

Cellulose nitrate negatives in apparently good condition may start to disintegrate badly at any time. Because of their inherent instability and the unpredictability of their deterioration, it is imperative to make faithful duplicates of cellulose nitrate-base negatives. Cellulose acetate negatives can also be unstable and duplication might also be considered for older negatives. Duplicating negatives requires special expertise and should be carried out by a professional photographer. Digitization may be an alternative to traditional photographic duplication in the future, but it currently does not work well beyond a medium-sized format (6 x 6 cm).

It is best to air-dry black-and-white silver gelatin film negatives that have been immersed in water (for example, during a flood or as a result of efforts to extinguish a fire). They can also be frozen safely as a conservation measure and can be kept frozen for some time until they can be dried. The best option is to thaw and air-dry these negatives. Alternatively, they can be freeze-dried in a vacuum chamber. However, a drying cycle consisting of freezing, thawing, and vacuum-drying at a temperature above 0°C is not recommended because the gelatin layers may block and stick.

Handling

Negatives are susceptible to physical damage through fingerprints or scratches. Unsleeved negatives should be handled only with protective lintless cotton or nylon gloves. They should not be folded or left unprotected. Large-format negatives (e.g. panoramic negatives) should not be rolled.

Minimal Cleaning

Removing dust and surface dirt with a soft brush is all most negatives require to prepare them for study or printing. Use dry ethyl alcohol or acetone to remove accretions of surface dirt. These solvents do not penetrate the gelatin layer, and therefore will not affect the image silver.

Do not attempt to clean negatives in aqueous solutions, including refixing and rewashing, unless extensive tests have been performed to confirm that the gelatin layer will survive such treatments. Do not attempt to remove yellow, brown, or blue metallic stains in the image, despite the many supposedly effective formulae for this purpose that have been found in photographic journals throughout the history of photography. Such stains are formed when a negative comes in contact with unstable or chemically aggressive materials such as newsprint, adhesives from filing enclosures, peroxides emanating from fresh oil-based paint layers, and residual processing chemicals (e.g. fixing salt, or hypo).

Suppliers

Note: The following information is provided only to assist the reader. Inclusion of a company in this list does not in any way imply endorsement by the Canadian Conservation Institute.

Soft brushes:

local art stores

General conservation supplies and print and negative storage sleeves:

ARCHIVAL PRODUCTS.ca
Division of B.F.B. Sales Ltd.
2957 Inlake Court
Mississauga ON L5N 2A4
Canada
tel.: 905-858-7888 or 1-800-667-2632
fax: 905-858-8586 or 1-800-616-0342
www.archivalproducts.ca

Carr McLean
461 Horner Avenue
Toronto ON M8W 4X2
Canada
tel.: 416-252-3371 or 1-800-268-2123
fax: 416-252-9203 or 1-800-871-2397
www.carrmclean.ca

Conservation Resources International
5532 Port Royal Road
Springfield VA 22151
USA
tel.: 703-321-7730 or 1-800-634-6932
fax: 703-321-0629
www.conservationresources.com

Talas
20 West 20th Street, 5th Floor
New York NY 10011
USA
tel.: 212-219-0770
fax: 212-219-0735
www.talasonline.com

Woolfitt's Art Enterprises Inc.
1153 Queen Street West
Toronto ON M6J 1J4
Canada
tel.: 1-800-490-3567
www.woolfitts.com

Bibliography

Adelstein, P.Z. *IPI Media Storage Quick Reference*. Rochester, NY: Image Permanence Institute, Rochester Institute of Technology, 2004. www.imagepermanenceinstitute.org/sub_pages/8page3i.htm

Adelstein, P.Z., J.M. Reilly, D.M. Nishimura, and C.J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part I — Laboratory Testing Procedures." *Journal of the Society of Motion Picture and Television Engineers* (May 1992), pp. 336–346.

Adelstein, P.Z., J.M. Reilly, D.M. Nishimura, and C.J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part II — Practical Storage Considerations." *Journal of the Society of Motion Picture and Television Engineers* (May 1992), pp. 347–353.

Adelstein, P.Z., J.M. Reilly, D.M. Nishimura, and C.J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part III — Measurement of Film Degradation." *Journal of the Society of Motion Picture and Television Engineers* (May 1995), pp. 281–291.

Adelstein, P.Z., J.M. Reilly, D.M. Nishimura, and C.J. Erbland. "Stability of Cellulose Ester Base Photographic Film: Part IV — Behavior of Nitrate Base Film." *Journal of the Society of Motion Picture and Television Engineers* (June 1995), pp. 359–369.

Adelstein, P.Z., J.M. Reilly, D.M. Nishimura, C.J. Erbland, and J.L. Bigourdan. "Stability of Cellulose Ester Base Photographic Film: Part V — Recent Findings." *Journal of the Society of Motion Picture and Television Engineers* (July 1995), pp. 439–447.

Bigelow, S. *Cold Storage of Photographs at the City of Vancouver Archives*. A report prepared for the Canadian Council of Archives Preservation Committee, March 2004.

Calhoun, J.M. "Storage of Nitrate Amateur Still-Camera Film Negatives." *Journal of the Biological Photographic Association* 21, 3 (1953), pp. 1–13.

Carroll, J.F., and J.M. Calhoun. "Effect of Nitrogen Oxide Gases on Processed Acetate Film." *Journal of the Society of Motion Picture and Television Engineers* 64 (1955), pp. 501–507.

Coe, B., and M. Haworth-Booth. *A Guide to Early Photographic Processes*. London, UK: Victoria and Albert Museum, 1983.

Cummings, J.W., A.C. Hutton, and H. Silfin. "Spontaneous Ignition of Decomposing Cellulose Nitrate Film." *Journal of the Society of Motion Picture and Television Engineers* 54, 3 (1950), pp. 268–274, 381–383.

Eastman Kodak Company. *Copying and Duplicating in Black-and-White and Color*. Kodak Publication M-1. Rochester, NY: Eastman Kodak Company, 1984.

Eastman Kodak Company. *Conservation of Photographs*. Kodak Publication F-40. Rochester, NY: Eastman Kodak Company, 1985.

Eaton, G.T. "Preservation, Deterioration, Restoration of Photographic Images." *The Library Quarterly* 40, 1 (1970), pp. 85–99.

Hendriks, K.B. "Recovery of Photograph Collections Following a Flood." pp. 15–28 in *Sauvegarde et Conservation des Photographies, Dessins, Imprimés et Manuscrits*. Actes des Journées Internationales d'Études de l'ARSAG. Paris, 30 September to 4 October 1991. Paris: ARSAG, 1991.

Hendriks, K.B., D.R. Madeley, F. Toll, and B. Thurgood. "The Duplication of Historical Black-and-White Negatives." *Journal of Imaging Technology* 12, 4 (1986), pp. 185–199.

Hendriks, K.B., B. Thurgood, J. Iraci, B. Lesser, and G. Hill. *Fundamentals of Photograph Conservation: A Study Guide*. Toronto, ON: Lugus Publications, 1991.

Henn, R.W., and I.A. Olivares. "Tropical Storage of Processed Negatives." *Photographic Science and Engineering* 4, 4 (1960), pp. 229–233.

Heyne, W. "Die Filmfabrikation" ["The Manufacture of Photographic Film"]. pp. 248–279 in *Handbuch der wissenschaftlichen und angewandten Photographie*, vol. 4 (edited by Alfred Hay). Wien: Verlag von Julius Springer, 1930.

Horvath, D.G. *The Acetate Negative Survey*. Final Report. Louisville, KY: University of Louisville, 1987.

International Organization for Standardization. ISO 18911:2000. *Imaging Materials — Processed Photographic Films — Storage Practices*. Geneva, Switzerland: International Organization for Standardization, 2000.

International Organization for Standardization. ISO 18902:2001. *Imaging Materials — Processed Photographic Films, Plates and Papers — Filing Enclosures and Storage Containers*. Geneva, Switzerland: International Organization for Standardization, 2001.

Lavédrine, B., J.-P. Gandolfo, and S. Monod. *A Guide to the Preventive Conservation of Photograph Collections.* Los Angeles, CA: Getty Conservation Institute, 2003.

Mathey, R.G., et al. *Air Quality Criteria for Storage of Paper-Based Archival Records.* NBSIR 83-2795. Washington, DC: National Bureau of Standards, 1983.

McCormick-Goodhart, M.H. "The Allowable Temperature and Relative Humidity Range for the Safe Use and Storage of Photographic Materials." *Journal of the Society of Archivists* 17, 1 (1996), pp. 7–21.

Ram, T.A., D.F. Kopperl, R.C. Sehlin, S. Masaryk-Morris, J.L. Vincent, and P. Miller. "The Effects and Prevention of the Vinegar Syndrome." *Journal of Imaging Science and Technology* 38, 3 (May–June 1994), pp. 249–261.

Reilly, J.M. *IPI Storage Guide for Acetate Film.* Rochester, NY: Image Permanence Institute, Rochester Institute of Technology, 1996.

Ritzenthaler, M.L., G.J. Munoff, and M.S. Long. *Archives and Manuscripts: Administration of Photographic Collections*. SAA Basic Manual Series. Chicago, IL: Society of American Archivists, 1984.

Weyde, E. "A Simple Test to Identify Gases which Destroy Silver Images." *Photographic Science and Engineering* 16, 4 (1972), pp. 283–286.

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