Canadian Conservation Institute
Institut canadien de conservation

CCI Notes 16/5

Care of Colour Photographic Materials

Introduction

Colour photography as we know it today, using the process of chromogenic development, began with the appearance of Eastman Kodak Company's Kodachrome film in 1935 and of Agfa Company's Agfacolor film in 1936. Its popularity has grown steadily since then, increasing so rapidly that black-and-white prints became both rare and more expensive than colour prints. This Note describes the major types of colour photographic materials and their properties, discusses ways to evaluate their permanence, and makes recommendations for their long-term preservation.

Colour Photographic Processes

Before 1935, colour photographs — mostly in the form of lantern slides — were made by additive processes of colour formation. They were characterized by the presence of a silver gelatin layer and a layer consisting of blue, green, and red filter elements that contained organic dyes. While some of these photographs dating from the 1920s and 1930s were on plastic films, the majority were on glass plates, including Lumière Autochrome Transparency Plates; Agfa Colour Plates; Finlay Colour Plates; Dufay Colour Plates; and Duplex, Thames, and Paget Colour Plates. Little is known about the permanence of these materials. Because of the importance of the Lumière Autochrome Plate, which was first marketed in 1904 and pioneered colour photography by additive colour formation, two references are given (Lavédrine 1992, 1993) to facilitate a detailed study of this process. However, the following recommendations for other types of colour photographs may be applied to additive colour plates as well.

Most colour photographic processes introduced after 1935 made use of subtractive systems of colour formation. Colour photographs made by any of the processes described below have a complex physical structure. They have at least three distinct gelatin layers into which the subtractive yellow, cyan, and magenta dyes are embedded. Some contemporary colour films have up to 16 layers.

Chromogenic Development Process

In chromogenic development, the dyes that form the final image are chemically synthesized during development from colourless precursors that are initially present in the film layers. Currently, by far the most common and most important processes use chromogenic development. The majority of colour slides, prints, motion picture films, and all colour negatives are made by this process. The pictures, like those made by the Dye Imbibition and Silver Dye Bleach Processes, no longer contain residual silver or silver salts. Since the mid-1970s, all major manufacturers in the world have produced colour prints on a resin-coated (RC) base.

Dye Imbibition Process

In the dye imbibition process, pre-formed dyes are successively built up in a gelatin mordant layer from a printing matrix film to produce the colour prints. The only such process used in North America was Eastman Kodak's Dye Transfer Process. However, the company has now ceased the manufacture of the necessary materials. The now-abandoned Technicolour motion picture process also worked on the dye imbibition principle.

Silver Dye Bleach Process

In the silver dye bleach process, pre-formed dyes are incorporated into the emulsion during manufacture, and are catalytically destroyed to form the image during processing. The only such material manufactured currently is Ilfochrome Classic Print Material, which was made until 1991 by Ciba-Geigy in Switzerland. This material has low sensitivity, but is used for identification photographs, in colour microfilm, and for preparing colour prints and positive transparencies in colour.

Dye Diffusion Transfer Processes

Instant colour photographic processes, technically known as dye diffusion transfer processes, include Polacolor 1, SX-70, and Polacolor 2 by Polaroid; the discontinued PR-10 system by Eastman Kodak; and similar products marketed in Europe and Japan.

Pigment Processes

Colour prints have been made since the late 19th century — and are still made today — by printing processes that use pigments suspended in a gelatin binder, not unlike those found in oil paintings. Pigment prints such as tricolour carbro prints, gum bichromate prints, and Fresson Quadrichromie prints are highly stable, even upon prolonged exposure to ambient interior lighting conditions.

Digital Prints

Since 1990, colour photography has moved towards digital print processes. Digital prints have unique features and preservation issues, and are beyond the scope of this Note.

Permanence Characteristics

The inherent properties of a colour photograph determine its stability, all other conditions being equal. Nonetheless, recommendations given in this Note apply to all colour photographs. The permanence of colour photographs is a function of storage and display conditions. Qualitative changes in the stability of colour photographs vary, depending on whether they are stored under light or in darkness. The terms *dark storage* and *dark storage stability* refer to colour photographic materials. Dyes in colour photographs appear to be the only materials in a visual art medium to fade appreciably in the dark. (One possible exception is varnish layers on oil paintings, which respond differently to dark conditions and to exposure to light.) Colour photographs may also build up stains when stored in the dark; for example, a white area may change to yellow.

When exposed to light, dyes in colour photographs can fade in the same way that dyes in textiles, watercolours, and printing inks fade. In addition, stains can build up in other components of the photograph. Consequently, the photographic industry monitors the stability of its products under light-fading conditions as well as under dark storage conditions. Dark storage stability is assessed under the influence of heat and high relative humidity (RH) alone. Light-fading and staining, however, are monitored under constant temperature and RH while the product is exposed to light sources of known intensity and spectral distribution. For experimental purposes, the longevity of a colour photograph is defined as the time elapsed before the limiting dye (i.e. the weakest dye) has lost 10% of its dye density.[1] Destruction of organic dyes through chemical reactions, such as oxidation or hydrolysis, is irreversible. It is thought to be impossible to chemically restore faded colour photographs. Therefore, it is essential to prevent dye fading.

Preservation and Storage

Colour photographic materials are more sensitive to high RH and high temperature than are black-and-white photographs. Recommendations published by the International Organization for Standards (ISO) advise maintaining an RH of 25 ± 5%. RH must never exceed 60%, and fluctuating RH must be avoided. Temperatures below 21°C are recommended for safety film in general. However, it is better to store colour film at 2°C. Cold storage is currently recognized as the most effective preservation measure for large collections of colour photographic materials. Storing colour films and prints at temperatures below the freezing point of water (0°C) will extend their longevity considerably if the RH is kept at 25 ± 5%, as is recommended by photographic manufacturers.

Keep the storage environment free of harmful chemicals, notably peroxides, sulphur dioxide, nitrogen oxides, and ozone.

Colour negatives on film are not intended for display. They are usually kept in dark storage in envelopes, boxes, or drawers. Negatives are meant to be printed, either by contact exposure or in an enlarger. Exposure to light during the copying process has not been found to cause damage to negatives. However, prolonged exposure to strong sunlight or to artificial light sources is not recommended, because these factors may cause embrittlement of the gelatin layer in addition to significant dye fading.

Use filing enclosures made of chemically inert plastics, such as uncoated polyethylene and polyester (polyethylene terephthalate). It is imperative that these plastics be uncoated. Do not use chlorinated or nitrated plastic sheeting such as polyvinyl chloride (PVC).

For optimum protection and long-term storage, place colour prints and colour negatives in the form of sheet film first in an uncoated polyester sleeve (e.g. made of polyethylene terephthalate such as Melinex 516) and then in a paper envelope. Write all necessary documentation on the paper envelope before inserting

the print or negative. Ensure that the paper enclosures meet ISO standards. Roll films can be left in rolls, cut into single frames, or cut into strips of several images. Place the films in uncoated polyester sleeves made of Melinex 516.

Unfortunately, there are no simple rules for storing 35 mm colour slides. Make duplicates of valuable slides, and use the duplicates for research or projection. Seal the originals in specially designed storage envelopes and place them in cold storage. Storage methods and equipment fall into one of three categories:

(1) an individual enclosure for each slide; store these enclosures as groups in binders, files, or cabinets
(2) open storage on display racks inside cabinets; lights and viewing areas are often supplied for sorting
(3) bulk storage of unenclosed slides grouped in boxes, trays, or cabinets

Each method has advantages and disadvantages.

Individual enclosures must be made of suitable materials because there is usually physical contact between the slide and the enclosure. Do not use enclosures made of PVC. To prevent the slides from being stained or scratched, also avoid coated, highly plasticized, textured, and abrasive materials. This system has the advantage of enclosing, and thus protecting, each slide from damage during handling. It is commonly used for storing personal collections in 3-ring binders.

Because the open storage method does not enclose slides, they are vulnerable during handling. This disadvantage is minimized by design features that allow relatively large numbers of slides to be viewed at one time without actually being touched. Such a system occupies a great deal of space. It may be most useful where fairly large numbers of slides must be viewed and sorted regularly.

The bulk storage system is similar in concept to a 3" x 5" index card file. It is the most compact system, and involves the least contact between the slide and the storage material. Its main disadvantage is that it is inconvenient to view many slides at once. It is also very dependent on a good cataloguing system, although some cataloguing is required for all systems. It is mainly used for storing large numbers of infrequently used slides. An arrangement where a viewing cabinet sits on or adjacent to a storage cabinet constitutes a practical and convenient system.

Treating Water-soaked Materials

It is best to air-dry colour photographic negatives and prints that have been soaked in water (e.g. during a flood or as a result of attempts to extinguish a fire). They can also be frozen safely as a conservation measure, and can be kept frozen until they can be thawed and air-dried. Alternatively, they can be freeze-dried in a vacuum chamber. However, a treatment cycle consisting of freezing, thawing, and vacuum-drying is not recommended because gelatin layers may block and stick.

Because of their complex layer structure, colour photographs are more sensitive to damage after soaking, freezing, and drying than are black-and-white photographs. This is true of colour negatives, slides, and prints made by the subtractive colour formation process. No data are available with respect to freezing and freeze-drying pre-1935 additive colour transparencies. Therefore, these early colour photographs must be protected against water damage from any source.

Handling

Colour photographs — negatives, transparencies, and prints — are often used heavily for study and research. Always wear lintless nylon or cotton gloves when handling any of these materials. Colour negatives are susceptible to damage from fingerprints or scratches, so place them in transparent sleeves before they are handled. Sleeve or matt prints to prevent damage to their corners and edges. Do not bend, fold, roll up, leave unprotected, or staple colour negatives or prints, and do not attach them to other documents with paper clips.

The appearance and integrity of the surface of a photographic print are major factors in its aesthetic value. Surface properties are described in such terms as *gloss*, *matte*, *lustre*, and *texture*. They, in combination with the image tone, are inherent characteristics of a photographic print. Disturbing or destroying these delicate surface qualities will change the aesthetic value of the print.

Inscriptions written in ink on colour prints are liable to fade when photographs are on display, and will invariably bleed and become illegible if they are accidentally immersed in water. If identifying information must be written on a photograph, write it on the back, as close to the edge as possible, using an HB pencil.

Minimal Cleaning

A soft brush is effective for removing most accumulated surface dirt. If the print surface appears to be intact, dry clean it using a special cleaning pad or damp cotton swabs. Do not wash photographs in water unless the stability of the gelatin layer has been confirmed. Never attempt chemical treatments in aqueous solutions on colour photographs.

Display

Physically support valuable prints by hinging them to a museum-quality board and matting them with a window mat, in much the same way as treating works of art on paper. The window mat acts as a spacer to prevent the print surface from coming into direct contact with the cover glass. Without the window mat, moisture could cause the print and the glass to stick together. For details of this and other techniques for mounting works of art on paper, refer to CCI Notes 11/5 *Matting Works on Paper*.

Many fine-art photographers have dry-mounted their prints in the past and continue to do so. There is no evidence that dry-mounting photographic prints causes the colour image to degrade. However, although it produces well-mounted, perfectly flat prints, dry-mounting has the disadvantage of being, practically speaking, irreversible. Manufacturers claim that dry-mounted prints can be dismounted by reheating them in a press, but this procedure is not safe for prints.

There is much published evidence that prolonged exposure to light will cause the dyes in colour photographs to change. Many factors influence such changes, including the nature of the dye present in a particular type of photograph, the intensity of the light source, the light's spectral distribution, and the amount of time the photograph is exposed to light. Avoid exposing colour prints to the ultraviolet radiation present in fluorescent lamps. Above all, prevent exposure to direct sunlight.

Use tungsten light sources to illuminate colour prints on display. Maintain light intensity below 50 lux when displaying valuable vintage colour prints, and limit display time to 6–8 weeks. Dramatic improvements in the light stability of colour prints made by all manufacturers since 1985 allow very modern prints to be displayed at 300 lux for several periods of 6–8 weeks each.

Do not display valuable, original, historically significant colour pictures. Instead, use copy prints for display purposes. If copies cannot be made, use innovative display methods to limit exposure to light. For example, drape a black felt cloth over a photograph on display; the viewer must lift the cloth to see the picture. Alternatively, design an exhibition case fitted with a hinged cover so that when the viewer opens the cover a light above the case switches on automatically.

Monitor densities of colour prints by measuring highlight areas, mid-tones, and shadow regions. Compare density readings of photographic prints before and after an exhibition period. This is particularly useful when prints are loaned to other institutions. Complete condition reports, including such density measurements, are the only sure way to determine whether or not the image has changed.

Endnotes

1. Density is a number on a logarithmic scale that expresses the degree of colour intensity of a colour photograph. For positive prints, this is known as the "reflection density," and is measured by a reflection densitometer. Negatives and slides have "transmission density," which is measured using a transmission densitometer. Density measurements can be performed easily and quickly, and do not harm the photograph.

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, special cleaning pads
(e.g. Cleaning Pads for Draftsmen and Artists from Faber-Castell):
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

Metal Edge, Inc.
6340 Bandini Avenue
Commerce CA 90040
USA
tel.: 1-800-862-2228
fax: 1-888-822-6937
www.metaledgeinc.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

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revised by Joe Iraci

Originally published 1986
Revised 1996, 2007

Copies are also available in French.
Texte également publié en version française.

© Minister of Public Works and Government Services Canada, 2007
Cat. No. NM95-57/16-5-2007E
ISSN 0714-6221

Printed in Canada