13. Composition, pH, Testing, and Light Fading Stability of Mount Boards and Other Paper Products Used with Photographs

By Carol Brower and Henry Wilhelm

Mount boards, paper envelopes, and interleaving sheets used with black-and-white and color photographs should meet the following three basic requirements:

1. **Mount boards and paper materials should not cause staining or fading of prints and should not accelerate the rates of deterioration inherent with a given type of color or black-and-white photograph.** The composition, pH, and other characteristics of mount boards and paper products should be determined primarily by what is best for the stability of the particular type of photograph being mounted or stored. For example, with the exceptions of recent Fujicolor and Fujichrome papers, prints made with Kodak Ektacolor Portra II, Ektacolor Supra, Ektacolor Professional, and most other chromogenic papers gradually develop an objectionable overall yellowish stain during normal dark storage at room temperature, and there is evidence that this type of stain formation is accelerated by an alkaline environment. With some of these papers, the dark storage fading rate of the cyan image dye also is accelerated by an alkaline environment (see Chapter 5). Consequently, it is advisable to avoid high-pH, alkaline-buffered, "acid-free" boards and papers with these and similar chromogenic color prints.

   While there is ample evidence that alkaline buffering will enhance the longevity of mount boards and most other paper products, the pH level and the addition of calcium carbonate or magnesium carbonate buffering should be determined not by what is best for the board or paper, but rather by what will maximize the life of the photograph. Pending further study, high-quality mount boards, enclosure papers, and interleaving papers that have a near-neutral pH *without* the presence of buffering agents are recommended for both color and black-and-white photographs. High-quality alkaline-buffered boards and papers *are* believed suitable for platinum and palladium prints.[1]

2. **The long-term physical stability of the mount board or other paper product should be at least equal to that of the photograph used with it.** Since some types of photographs are inherently far more stable and longer-lasting than others, the stability requirements for boards and papers will vary correspondingly. With color materials, both the type of print and whether or not it will be subjected to light fading during prolonged display will determine the stability requirements of the mount board. With Ilford Ilfochrome prints (called Cibachrome prints, 1963–1991), Kodak Dye Transfer prints, and Fuji Dyecolor prints — which should remain in excellent condition for many hundreds of years when stored in the dark, but which will have a much shorter life if displayed — the intended use of a print will strongly influence the stability requirements of the board chosen to mount it. On the other hand, UltraStable Permanent Color prints (introduced in 1991) and Polaroid Permanent-Color prints (introduced in 1989), both of which are made with extremely stable color pigments instead of the far less stable organic dyes used with other types of color photographs, and properly processed fiber-base black-and-white prints that have been treated with Kodak Rapid Selenium Toner or a sulfiding toner, can be expected to have an exceedingly long life either if exposed to light on display *or* if kept in the dark. Only the most stable boards and other materials should be chosen to mount these prints.

   Physical stability requirements include the following: a mount board must maintain sufficient strength and stiffness to properly support and protect a print throughout its expected life; an interleaving paper must retain its smoothness and flexibility; and a storage envelope must have great folding endurance to withstand repeated opening and closing without breaking.

3. **The brightness and color or tone of a mount board should not change an objectionable amount during its co-existence with a photograph.** The amount of visual change that can be tolerated in a mount board depends on the particular application, and on how critical were the visual criteria for the board when it was originally selected.

   For example, with a fiber-base black-and-white print that has been treated with Kodak Rapid Selenium Toner and that may be displayed for many hundreds of years in a museum collection, the mount board should obviously have much better visual stability characteristics than a board for matting a comparatively short-lived Ektacolor print for display in an office or an Ektacolor family portrait displayed in a home. Even subtle differ-

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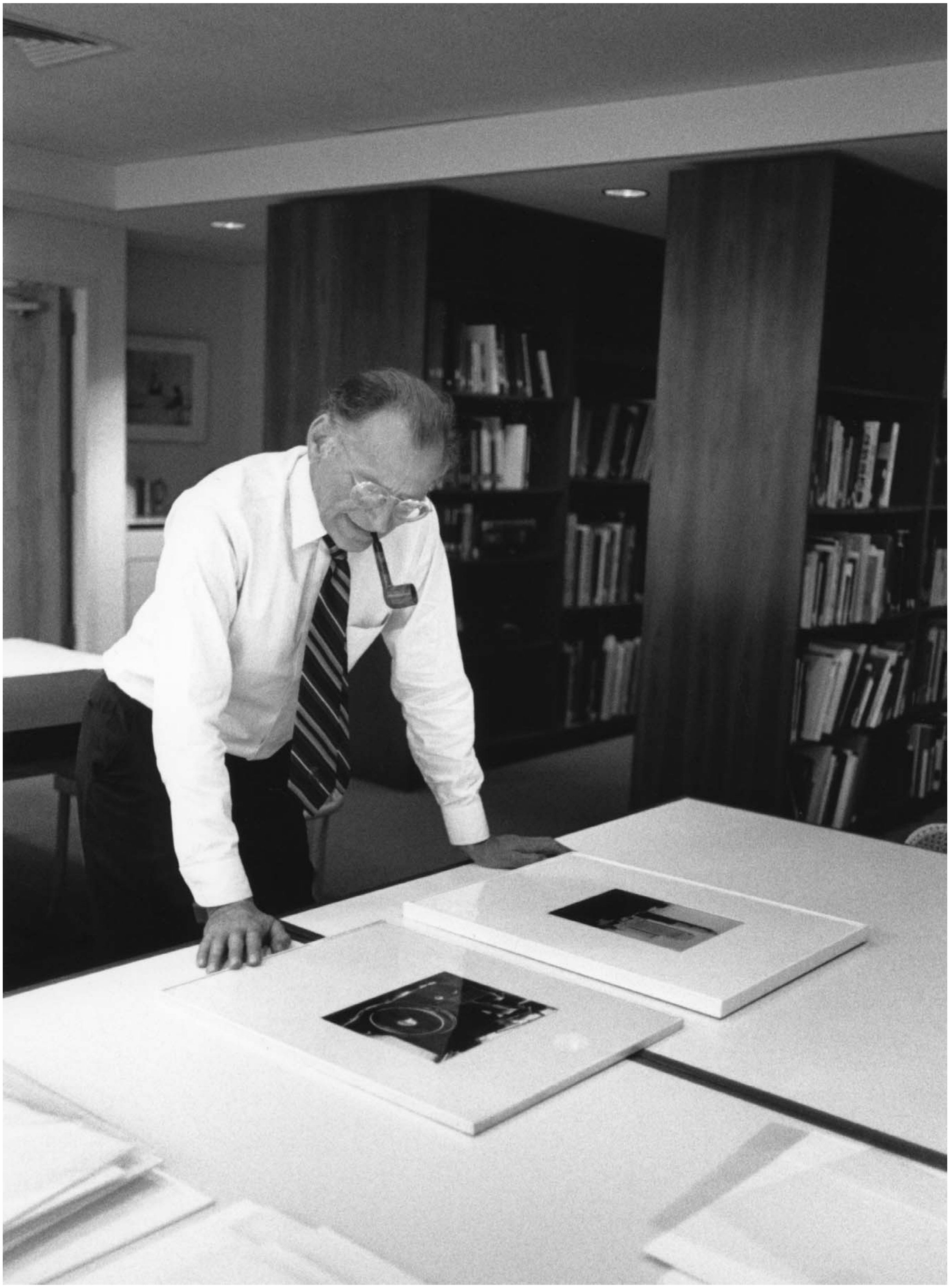

Carol Brower – July 1987

John Szarkowski, director emeritus of the Department of Photography at the Museum of Modern Art in New York City, studies two photographs by Alfred Stieglitz, both taken in 1935. The print in the foreground remains affixed to the original mount in the original frame that Stieglitz prepared. The print at Szarkowski's left has been remounted, matted, and framed with contemporary materials.

Recommendations

- **Requirements Vary:** Some types of photographs are far more stable than others (e.g., a carefully processed fiber-base black-and-white print versus a Kodak Ektacolor print), so mount boards and paper products used for storing photographs should be selected accordingly. For the most stable and valuable photographs, the following mount boards and paper are recommended:
- **Nonbuffered 100% Cotton Fiber Mount Boards:**
  Atlantis 100% Cotton Museum Board (TG Offwhite)
  Parsons Photographic Museum Board (White)
  Rising Photomount Museum Board (White)
- **Colored 100% Cotton Fiber Mount Boards:** When colored or tinted 100% cotton fiber boards are desired, the following are recommended because their colorants have superior light fading stability (see **Table 13.1**) and because the manufacturers are clearly identified on the packaging. These boards are alkaline buffered (refer to text in this chapter and Chapter 12 for precautions):
  James River Museum Board (Ivory)
  Strathmore Museum Board (Brown)
  Strathmore Museum Board (Creme)
  Strathmore Museum Board (Gray)
  Strathmore Museum Board (Green)
  Strathmore Museum Board (Natural)
  When a black board is required, there should be absolutely no direct contact between the board and the photograph (see Chapter 12). Only one black board on the market is recommended — with reservations — by the authors:
  Strathmore Museum Board (Black)
- **Envelope or Interleaving Paper:**
  Atlantis Silversafe Photostore
- **Truth in Labeling:** Until adequate information about the composition and manufacturer is provided with the products and in promotional literature, the authors cannot recommend other high-quality boards and papers on the market. For example, a number of products sold by Light Impressions Corporation and the Archivart Division of Heller & Usdan, Inc. would probably be recommended were it not for the fact that the name of the actual manufacturer of each product is unavailable to the consumer.
- **Test Methods:** For testing the suitability of paper products used with color and black-and-white photographs, the "interim test" for nonsilver photographic materials described under Sec. 5.1 of **American National Standard IT9.2-1991** is recommended. The test should be modified to have greatly extended test times and be performed at a more moderate relative humidity than the 86% RH called for in the Standard. In addition, the Sec. 5.1 Photographic Activity Test for black-and-white (silver-gelatin) materials in **ANSI IT9.2-1991** should also be employed. The best method of evaluation is to use the complex, multi-temperature Arrhenius test described in **ANSI IT9.9-1990**, with materials in contact with the particular types of black-and-white or color photographic material of interest. The light fading stability of mount boards should be evaluated with the temperature- and humidity-controlled 6.0 klux fluorescent lamp test specified in Sec. 5.7 of **ANSI IT9.9-1990.**

ences in board tones can be important in the the mats of fine art prints; therefore, in museum or fine art collections, mount boards should always have the maximum color and brightness stability possible. Mount boards should not, however, contain fluorescent brighteners.

In addition, mount boards should have an even greater resistance to yellowing or other discoloration than the photograph's support material. All black-and-white and most color print materials have a layer containing a white pigment (barium sulfate or titanium dioxide) coated between the emulsion and the support or, in the case of RC papers, as a top coating of the base paper itself; this layer can effectively hide yellowing or loss of brightness of the underlying paper support. Because mount boards do not have such coatings, or "anti-yellowing" ingredients, any change in them will be clearly noticeable.

The visual stability of a board may or may not be related to a board's physical stability. These characteristics must be evaluated separately. As shown in **Table 13.1**, many available high-quality colored mount boards have poor light fading stability; some actually fade far more rapidly than Ektacolor and similar chromogenic color prints.

The Choice of Mount Board Is Only One of Many Factors Affecting the Useful Life of a Photograph

In any discussion of mount boards, it is important to keep in perspective the various intrinsic factors that can limit the useful life of a photograph even before it is mounted. For example, whether or not a black-and-white print has been treated with Kodak Rapid Selenium Toner or other protective toner will probably have much more impact on its life than will the selection of mount board. When a black-and-white print is intended for long-term display, being made on fiber-base paper — instead of RC paper — is of *crucial* importance to insure the maximum longevity of the image. Concern about a safe mount board, therefore, must not overshadow the need to make prints with inherently stable materials and to be certain that they are properly processed.

Of the total number of photographs that are mounted in the United States each year, the majority are Ektacolor, Fujicolor, and similar chromogenic prints supplied by professional portrait and wedding photographers, many of which have been retouched and lacquered; most will be framed and displayed. For these prints, which have a limited useful life on display, the choice of mount board will probably make little or no difference. Light fading, lacquer-associated discoloration and fading, and other forms of deterioration will proceed at essentially the same rates regardless of whether the print is mounted on inexpensive "illustration board," made with a high-lignin-content chipboard base, or with the best 100% cotton fiber museum board. Of course, no harm is done to unstable prints by selecting very high-quality mounting materials. It is better, however, to spend that money to make prints on more stable materials in the first place. The focus of attention should always be on the "weakest link" among the many factors

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A visitor to the Museum of Modern Art looks at photographs taken by Alfred Stieglitz in 1935 and 1936. The Museum mounted, matted, and framed the prints with contemporary materials to better protect them during prolonged display. (It was necessary to replace Stieglitz's original frames because they were not sturdy or deep enough to support the weight and thickness of the new glazing, two 4-ply museum boards, and backing.) Although Stieglitz personally overmatted some of his photographs with thin paper mats, the majority of his exhibition prints were mounted in his lifetime on unstable wood-pulp boards without overmats. It was not until the 1970's that high-quality museum boards became widely available and conservation matting came to be viewed as necessary and desirable.

that determine and affect the longevity of a photograph.

In the museum and fine art field, where prints may be kept for hundreds or thousands of years, long-lasting mounting and enclosure materials are critical. Like the original copy of the Declaration of Independence of the United States displayed in the National Archives in Washington, D.C., which will be safeguarded forever despite the fact that it has faded so much during the past 200 years that it is now virtually unreadable, valuable photographs in museums will probably be retained indefinitely regardless of how much their images might deteriorate. It is important, therefore, that mount boards, envelopes, and interleaving papers for such photographs be of the highest quality and stability available.

Potential Problems with Mount Boards and Other Paper Products

Photographic enclosures and mounting materials have received a steadily increasing amount of attention during the past decade. Commenting on the potentially harmful effects of improper storage materials on black-and-white photographs, photographic chemist George Eaton said:

> Many of the materials used for enclosing or "housing" photographic artifacts must be carefully selected. These are primarily paper products. . . . Included are mount boards, envelopes, folders, boxes and cartons, interleaves, file cards, aperture cards. Accessories such as mounting tissues, adhesives, tapes, and adhesive tissues are all suspect.
>
> It is perhaps difficult to believe that many of the materials mentioned above can really cause any deterioration of photographic artifacts. Remember first that the photographic artifact itself has been thoroughly investigated and designed from the viewpoint of image stability from manufacture to processing. Then, it is only reasonable to be equally conscientious in archives to enclose and store under the best possible conditions. A very minute amount of an oxidizing agent released from any material can initiate the image oxidation reaction. It may not be apparent, and it may take months or years before the action of the oxidant becomes obvious.

> One example of an image-oxidation-controlled experiment will indicate the insidious nature of the problem. Carefully measured amounts of hydrogen peroxide (H_2O_2) were used in an experimental chamber in which the effect on silver could be measured. It was indicated that only one part of H_2O_2 in 30 million was required to initiate silver oxidation.[2]

Acknowledging the difficulty of accurately determining the cause of deterioration in many older mounted prints, Eastman Kodak said:

> During the nineteenth century and well into the twentieth century, mount boards did not meet the quality standards of present day products. Because much of the photographic processing done during this time was inferior and left damaging chemicals in the photographs, the degrading effects of these chemicals overshadowed most changes [caused by] the mount board."[3]

Examination of historical photographic collections clearly indicates that mounting and storage materials frequently cause or contribute to fading, staining, and other deterioration. Even today, however, with the widespread availability of information relating to papermaking technology and paper stability, it is difficult to know which materials, from among the many products on the market, to choose for use with photographs. That a mount board or other paper product is well made according to the highest standards of the paper industry does not automatically qualify it for safeguarding photographs. A number of tests have been suggested for determining which mounting and storage materials are safe with photographs; however, these tests have not often been applied outside of the photographic industry, and no study has yet been published which gives specific brand-name recommendations based on the results of such tests.

The need for information on the suitability of specific paper products was emphasized by the findings of a 1984 research project conducted by James M. Reilly at the Rochester Institute of Technology under a grant from the National Museum Act. Using the Photographic Activity Test that was specified in *ANSI PH1.53-1984, American National Standard for Photography (Processing) – Processed Films, Plates, and Papers – Filing Enclosures and Containers for Storage*[4] to study interactions between albumen prints and mount boards, paper, and plastic enclosure materials, Reilly reported that 5 of the 29 "archival" 100% cotton fiber boards and 4 of the 16 "archival" purified wood cellulose boards in the study caused unacceptably high levels of fading and/or staining of the albumen test prints.

Albumen prints, widely made between 1850 and about 1890 and frequently found in museum collections today, have an image consisting of extremely small silver particles in an egg-albumen coating (instead of the modern gelatin emulsion coating). Even though the albumen images are normally gold-toned, these prints have proven to be very susceptible to deterioration caused by sulfur compounds and oxidants such as peroxides, especially under conditions of high relative humidity. Reporting on the results of the tests, Reilly said:

> The plastic enclosures, both non-archival and archival, did very well compared to [paper materials]. It is apparent from this study that problems with storage enclosures center on paper and board products. While there were some harmful papers, boards had the highest incidence of harmful reactions. Boards consistently produced more staining than paper products . . . .
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> In total, 9 of the 45 archival boards were harmful, 20% of the total. Of these, 4 were colored (3 black and 1 gray). Since 3 out of 3 black mat boards included in this study were harmful, it would be prudent to avoid matting photographs with black mat board until more information can be gained.
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> Two archival board products (one an off-white rag board, one a white conservation board). . . caused similar and unequalled deterioration, obliterating 5 steps of the gray scale and causing extremely heavy staining . . . . The "standard" [non-archival] mat boards included in this study proved themselves to be entirely unsuitable for photographic storage, causing heavy staining and fading.[5]

Reilly added, "Some of the archival boards seemed to have an ingredient that was really dreadful — it caused terrible staining and terrible fading of albumen prints. Just a real devastation. This was the same kind of thing observed with the binders board [an inexpensive single-ply board made from waste paper and groundwood, used for the core of hardbound book covers] samples, which was all out of proportion to the fact that they were loaded with groundwood. So something else was doing it. Maybe it is something they put in it to hold it together — a laminating adhesive or binding agent or something similar."[6]

In keeping with the Image Permanence Institute's policy of avoiding product brand name identification in comparative product evaluations, Reilly declined to identify the boards and papers included in the tests.

Modern silver-gelatin print materials may be expected to be less sensitive to peroxides and other oxidants than are albumen prints, and color prints respond altogether differently than either albumen or modern black-and-white materials. Nevertheless, Reilly's 1984 studies indicated that there is genuine cause for concern about possible adverse reactions between mount boards and other paper products and modern black-and-white photographs and, by implication, color materials.

With the aid of several grants received in 1984–85,[7] Reilly continued his research; in 1987 he and co-worker Douglas W. Nishimura proposed a new accelerated test for paper enclosure and mounting materials. This new test procedure, which has been adopted as the primary Photographic Activity Test in *ANSI IT9.2-1991, American National Standard for Imaging Media – Photographic Processed Films, Plates, and Papers – Filing Enclosures and Storage Containers,*[8] is discussed below.

Specifications and Tests for Mount Boards and Enclosure Materials

Five approaches have been suggested in attempting to assure the suitability of paper products for long-term storage of photographs:

1. **Specify paper ingredients — percentage of alpha cellulose, maximum lignin content, type of sizing, laminating adhesives, pH, alkaline reserve, etc. — that will, according to current knowledge, make the paper or board long-lasting and, therefore, by implication, safe with photographs.**

   Unfortunately, this common-sense approach does not go far enough. To be certain that a paper product such as a mount board or storage envelope is suitable for photographic applications, all of the ingredients — and contaminants — that can contribute to fading or staining of the many types of photographs must first be identified. There is currently a lack of knowledge about exactly how the many different constituents in various papers might affect different kinds of photographs; therefore, this approach has been much more successful in producing long-lasting paper products than it has been in guaranteeing that a particular product is safe during long-term contact with photographs. Although factors that affect the aging characteristics of papers have been studied for many years, almost no research on interactions between these products and modern photographic materials has been published.

2. **Test the board or paper product with one of the "silver-tarnishing tests," such as that proposed by Collings and Young;[9] test the product for reducible sulfur;[10] and, during accelerated aging, test for low-level emission of peroxides and other substances that are known to be harmful to silver images.**

   Even though these tests can provide helpful information, they may not properly indicate how an actual black-and-white photographic material will react when stored in contact with the paper product (e.g., the filamentary silver grains embedded in a gelatin emulsion coating may react quite differently than the polished silver plates in the Collings and Young test). In addition, these tests will not indicate the propensity of a paper or board to cause stains on a photographic material, and they also have other limitations, as have been discussed by Hendriks and Madeley[11] and Reilly.[12] Hendriks says: "I strongly advise anybody against the Collings and Young test."[13] These tests are probably of little significance with respect to the storage of color films and prints.

3. **Employing accelerated aging techniques, test the board or paper in contact with whatever photographic materials are of interest to determine whether the paper product causes, or contributes to, staining or fading of the photographic images.**

   While such tests cannot directly indicate *which* constituent of the paper product has caused fading or staining, they do take into account the individual sensitivities of each different type of photographic material and are applicable to both color and black-and-white photographs. Such tests can help rank various boards and other storage materials in terms of their potential harm to a particular type of photograph. The Photographic Activity Test described in Sec. 5.1 of the now-obsolete *ANSI PH1.53-1986* Standard is a simple test of this type (a modified version of this procedure is included in the current *ANSI IT9.2-1991* Standard as an "interim" test for color prints and films and other nonsilver materials). Accelerated aging tests can also provide information about the stability of a mount board or other paper product, both in and of itself and in comparison with the stability of the photographic material stored in contact with it. For color materials in particular, the more meaningful — but more complex and time-consuming — multi-temperature Arrhenius test method included in *ANSI IT9.9-1990, American National Standard for Imaging Media – Stability of Color Photographic Images – Methods for Measuring* should be undertaken for this kind of evaluation.[14,15] The Arrhenius test provides a means of estimating the number of years required for a specified amount of deterioration to take place in a given paper product, and in the photographic material in contact with it, under various storage conditions.

4. **Test storage and mounting materials intended for black-and-white photographs with the colloidal silver test strips developed by Edith Weyde of Agfa-Gevaert in 1972.[16]**

   These silver test strips are very sensitive and, placed in contact with storage or mounting materials, detect products that evolve substances that could attack the finely divided silver images of black-and-white photographs. The test strips are not applicable to color materials. The procedures published in 1972 for using the test strips called for room-temperature tests that extended over a period of months or years; high-temperature, high-humidity, accelerated tests were not described.

5. **Employ the Photographic Activity Test in *ANSI IT9.2-1991* in which Agfa-Gevaert colloidal silver test strips are used to detect boards or papers that could cause fading of the silver images of black-and-white photographs, and in which fixed and washed fiber-base photographic paper is used to indicate storage materials that could cause staining.**

   Proposed by James M. Reilly and Douglas W. Nishimura in 1987 as a replacement for the Photographic Activity Test in *ANSI PH1.53-1986,* this test can be thought of as an accelerated version of Weyde's 1972 procedure (described above) to indicate materials that could cause discoloration and fading of the silver images of black-and-white photographs.[17] The test has been adopted as the primary Photographic Activity Test in *ANSI IT9.2-1991* (replacing *ANSI PH1.53-1986*).

   Unfortunately, the new test is applicable only to black-and-white photographs and is restricted to paper storage materials; also, it is not suitable for evaluating storage and mounting materials used with color photographs, nor is it recommended for testing pressure-sensitive adhesives, non-contact storage materials, or plastic enclosure materials such as polyethylene, polypropylene, and polyester.[18] The test, which calls for an incubation period of 15 days at 158°F (70°C) and 86% RH, provides little if any information on the potential life of most mount boards or other paper products.

The ANSI IT9.2-1991 Photographic Activity Test

Approaches 2 through 5 above are more concerned with the effects that a paper product might have on a photographic material than they are with how, or with what, a paper product is made. *ANSI IT9.2-1991, American National Standard for Imaging Media – Photographic Processed Films, Plates, and Papers – Filing Enclosures and Containers for Storage* gives a set of general requirements for suitable photographic filing enclosures (see below) and requires that the enclosure or storage material pass a Photographic Activity Test.

Pointing out that the *ANSI PH1.53-1986* Photographic Activity Test "does not function well in discriminating between marginal and very good materials," and that it is not sensitive enough for other than screening out the most harmful materials, James M. Reilly and Douglas W. Nishimura of the Image Permanence Institute at the Rochester Institute of Technology in 1987 proposed a new test as a replacement for the existing test.

In a demonstration of the shortcomings of the *ANSI PH1.53-1986* Photographic Activity Test, Reilly and Nishimura obtained a 1960's cardboard microfilm box that during long-term storage had caused "redox blemishes" or microspots in the microfilm images. "The box was cut into strips and incubated (at the conditions specified in *ANSI PH1.53-1986*) in contact with processed Kodak AHU 1460 Imagecapture microfilm. After incubation, the differences between the microfilms incubated with the box and the filter paper controls were slight [Whatman Number 1 filter paper was used]. Redox blemishes were not observed on the microfilms incubated with the defective box."[19]

Reilly and Nishimura experimented with various photographic materials in search of a "detector" with sufficient sensitivity to respond in short-term accelerated tests. Kodak Studio Proof Paper, Polaroid instant slide films, fine-grain motion picture films, graphic arts films, Polaroid and conventional black-and-white prints, and other materials were tried. Among the conventional films and prints tested, Kodak Professional B/W Duplicating Film 4168 proved to be by far the most sensitive to contaminants; in this respect, 4168 film was nearly as sensitive as albumen paper. (In 1990 Kodak replaced 4168 Film with a new product, Kodak Professional B/W Duplicating Film SO-339, that is claimed by Kodak to be more stable — and much less sensitive to peroxides and other environmental contaminants.)

Also tested were Agfa-Gevaert colloidal silver test strips, which had been devised by Edith Weyde of Agfa in the late 1960's in the course of an investigation into the causes of the sudden and rapid discoloration and fading that had been discovered among films and paper prints in the government archives in Munich, Germany. At the outset it was believed that oxidizing gases such as peroxides probably caused the blemishes and discolorations, and to detect the source of the oxidants, test strips were made by coating layers of extremely finely divided colloidal silver on polyester film base (the test strips are not a light-sensitive photographic material).

With the help of the test strips, Weyde determined that the plastic index cards made of phenylene-formaldehyde were the principal source of the oxidants attacking the photographs in the Munich archives; the cards had been used in photograph files in the archives for 14 years, and the first signs of discoloration and fading had been noted after about 5 years. The plastic index cards were tested by placing them in contact with the Agfa test strips; discoloration was noted after periods varying from a few months to several years. Freshly manufactured index cards caused discoloration of the test strips much more quickly than did older index cards taken from the archive files. After observing the rates of discoloration of the test strips in situations that had caused photographs to discolor or fade over long periods of time, Weyde drew the "cautious conclusion" that the test strips would exhibit discoloration about 10 times sooner than the first visible deterioration of typical black-and-white photographs.

Since publication of the details of the colloidal silver test strips and test procedures in 1972, the test strips have often been cited as a means of testing the atmospheres of storage areas in museums and archives (in this application, the test strips are left freely hanging in the air in storage rooms — see Chapter 16 for further discussion). Along with the testing of storage materials, this use of the test strips had also been recommended by Weyde.

The Agfa-Gevaert test strips would certainly have seen wide application in museums and archives around the world following Weyde's original 1972 publication; but after the initial supply was exhausted, the strips were no longer available. Agfa did not resume manufacturing the test strips until convinced to do so by Reilly in 1986.

Reilly and Nishimura conducted further experiments with the Agfa test strips in contact with paper envelopes that were known to have caused severe fading to determine the optimum temperature, relative humidity, and test period; 15 days at 158°F (70°C) and 86% RH was selected. Reilly and Nishimura originally conducted the tests at three different relative humidities (75, 86, and 95%), and it is curious to note that at both 75 and 95% RH the filter paper control produced a *greater* density change in the Agfa test strips than did the "known to be harmful" envelope paper. Only at the 86% RH level did the envelope paper prove to be more harmful than the filter paper. Reilly and Nishimura concluded that "unsatisfactory enclosures may manifest themselves by causing significantly *less* fading than the controls, as well as more." This suggests that further evaluation of the test with a variety of materials and test conditions should be done. (It is noteworthy that at the end of the 15-day test period, the Agfa test strips exhibited a substantial drop in blue density even when in contact with inert laboratory filter paper.)

To detect paper storage and mounting materials that may cause staining (as distinct from fading or discoloration), Reilly and Nishimura suggested that samples be aged in contact with unexposed, fixed, and washed Kodak Elite fiber-base photographic paper under the same temperature and humidity conditions recommended for the Agfa test strips. As with the colloidal silver test strips, filter paper controls serve for comparison purposes. Following incubation for 15 days, the samples are evaluated in three ways: **(1)** visually, **(2)** by stain measurement, and **(3)** by fade measurement. The criteria for passing the tests are given in the ANSI Standard.

The Image Permanence Institute markets test kits consisting of the Agfa-Gevaert colloidal silver test strips, processed Kodak Elite photographic paper strips, and instructions for their use.[20]

In Reilly and Nishimura's line of reasoning, the Agfa test strips have proven to be more sensitive to harmful substances than any other "fine-grain" silver detector. Thus, they argue, if an enclosure paper or other storage material produces changes in the Agfa test strips that are no different from changes observed with inert laboratory filter paper, the storage material should not damage even the most sensitive fine-grain black-and-white photographs (e.g., albumen prints, POP prints, untoned microfilms, untoned Kodak 4168 duplicating film, and untoned black-and-white prints). In this regard the test was a major departure from the Photographic Activity Test given in the now-obsolete *ANSI PH1.53-1986* Standard, which specified that an enclosure paper or other storage material be tested in contact with *each type* of photographic material with which it will be employed. Therefore, the test was able to cover the full range of photographic materials, including color films and prints.

Only further investigation will indicate whether the test developed by Reilly and Nishimura is superior to a modified version (with lower levels of relative humidity and much longer test periods) of the previous *ANSI PH1.53-1986* Photographic Activity Test for mount boards, enclosure papers, and other materials used with modern black-and-white films and prints. The extremely small particles of colloidal silver in the Agfa test strips have a very different microstructure from the far larger and more stable filamentary silver grains of modern (developed-out) black-and-white materials. For this reason, the test strips could possibly misrank enclosure papers and mount boards in terms of how they would actually perform in long-term use under normal conditions with the types of modern black-and-white photographs that presently coonstitute the bulk of most collections.

Pending further evaluation, the authors recommend that for storage materials intended for use with black-and-white photographs, *both* types of tests be performed (the *ANSI PH1.53-1986* test should be conducted for much longer periods than the specified 30 days — see below).

The Interim ANSI Photographic Activity Test for Mount Boards and Other Paper Products Used with Color Materials

In recognition that there is a need for a photographic activity test to evaluate paper storage materials and mount boards used with color photographs, the following was included in *ANSI IT9.2-1991* as a footnote to the Photographic Activity Test (Sec. 5.1):

> This Photographic Activity Test was developed for silver photographic images. For non-silver (e.g., color, diazo) images, a satisfactory test has not yet been established. In the interim, for enclosures intended for use with non-silver photographic images, an additional third detector should be included, consisting of processed samples of the type of photograph to be stored. The general procedures of 5.1.2 and 5.1.3 should be followed, except that evaluation of image changes upon incubation should be appropriate for the detector. Image changes should be no greater than the filter paper control. The incubation conditions specified in 5.1.2 may cause high levels of staining and fading of some color images, which in turn may mask the effects of the enclosure. For chromogenic color print detectors, a suggested incubation test is 60°C, 86% relative humidity.[21]

Except for differences in test temperatures and length of the incubation period, this interim test for non-silver materials is similar to the Photographic Activity Test specified in the now-obsolete *ANSI PH1.53-1986* Standard in which a sample of the paper, mount board, or other storage material and a sample of the photographic material with which it is to be used are placed in contact and subjected to an accelerated dark-aging test for 30 days at 122°F (50°C) and 86% RH. For comparison purposes, an identical sample of the photographic material is aged in contact with a piece of pure, nonreactive laboratory filter paper (e.g., Whatman Number 1 filter paper). "At the end of this test, no visual pattern should be transferred from the enclosure material to the photographic material nor shall the image of the latter be affected. . . . The changes produced by contact with the enclosure material should be no greater than that produced by the film [or print] in contact with a filter paper control, having a pH between 7.0 and 7.7."

The Photographic Activity Test provided in old *ANSI PH1.53-1986* was criticized on a variety of grounds and a number of alternative procedures were proposed. The authors, however, believe that the basic concept of the *PH1.53* test is sound and that its only serious shortcoming is simply that the specified test time of 30 days is far too short — periods much longer than 30 days are necessary to obtain meaningful results with most photographic products. For example, the 30-day test at 122°F (50°C) provides little information about the effects of mounting and storage materials on current color films and prints. With Ektacolor Portra II chromogenic color prints, for example, so little color dye fading will take place during the 30-day test that the influence of a paper or mount board's pH on dye fading cannot be meaningfully evaluated.

With black-and-white photographs, the 30-day test period is probably useless for detecting all but the most harmful materials. With the *PH1.53* test, the authors tentatively recommend a *minimum* test period of 240 days, with longer times for the more stable photographic materials. To properly assess the effects of a board or paper on a highly stable material such as a black-and-white print treated with Kodak Rapid Selenium Toner, the test should be continued until at least *some* visible change is observed in the filter-paper control sample, however long that might require.

In a high-temperature test such as this, many color materials will give anomalous test results at relative humidities as high as 86%; a lower humidity, 60% for example, would be a better choice in such cases. A lower humidity is also necessary when testing plastic materials (at 122°F [50°C] and 86% RH, gelatin is above its glass-transition temperature and emulsions will soften and stick to most plastic materials).[22]

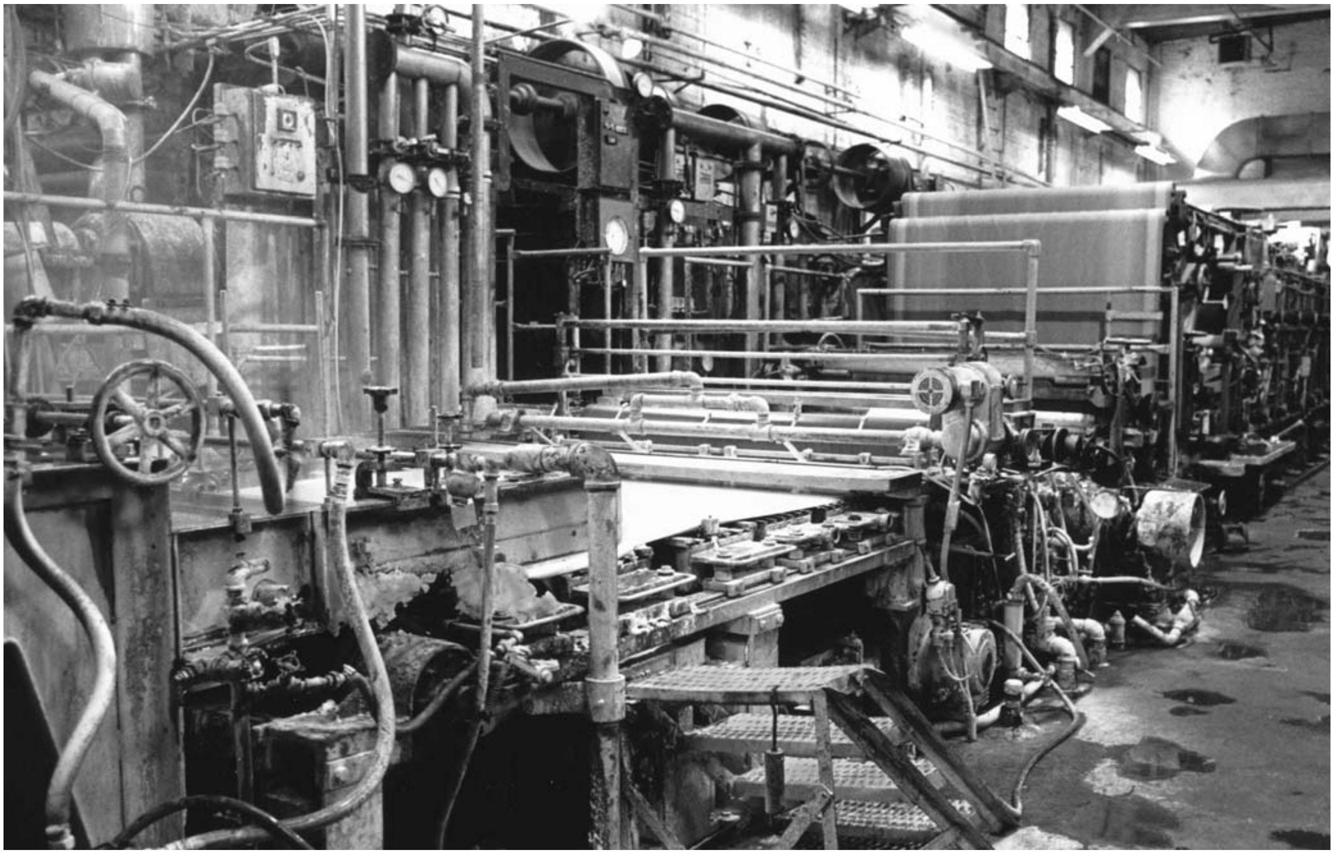
An especially appealing aspect of the obsolete *ANSI PH1.53-1986* Photographic Activity Test is that *each* different type of color and black-and-white film or print material must be tested individually with *each* enclosure material (such as mount board or interleaving paper); adhesives must also be tested. If a particular material passes the test with a certain black-and-white fiber-base paper, this does not mean that the material is suitable for color materials or, for that matter, a chromogenic black-and-white negative. At the very least, a mount board or enclosure material should be tested with a representative black-and-white fiber-base paper such as Ilford Multigrade FB Paper; a black-and-white RC paper such as Kodak Polycontrast III RC Paper; chromogenic color print materials such as Fujicolor Professional Paper SFA3 Type C and Kodak Ektacolor Portra II Paper; and a representative fine-grain microfilm.

With suitable modification, the authors believe that the *ANSI PH1.53-1986* Photographic Activity Test is the best available "simple" procedure for evaluating mount boards, paper for interleaves and envelopes, and plastic storage products used with the wide range of color and black-and-white photographic materials currently on the market and found in historical collections. Ideally, of course, the multi-temperature Arrhenius procedure described in *ANSI IT9.9-1990* should be applied to the *PH1.53* Photographic Activity Test. Carried on long enough, Arrhenius testing not only will provide valuable information about how a mount board or storage material can affect a particular type of photograph, but also will give an indication of the inherent aging characteristics of the mount board or paper material itself.

Paper and Mount Board Evaluation Using the IT9.2 Photographic Activity Test

In a practical application of the *ANSI IT9.2* Photographic Activity Test (PAT), in 1988 Douglas W. Nishimura, James M. Reilly, and Peter Z. Adelstein at the Image Permanence Institute used the test to evaluate 90 different mount board, enclosure, and interleaving papers:[23]

> This included 66 commercially available materials that could be considered "archival," not by any strict scientific definition, but because they were sold by suppliers specializing in this line of products. The 66 archival materials included 36 rag [cotton fiber] boards, 9 non-rag boards, and 21 papers, numbering among them were interleaving tissues, Japanese repair tissues, barrier papers, envelope papers, glassines, and slip sheets. These materials were obtained from a number of manufacturers and distributors, and are representative of the kinds of products that might be used in archival collections in contact with photographs. Also included were a number of known good and bad "benchmark" materials to put the performance of the archival products in perspective.
>
> . . . Overall, 29 (44%) of the archival products passed the PAT [*ANSI IT9.2* Photographic Activity Test]. The most common cause of products failing the PAT was mottling (uneven blotchy fading of the colloidal silver detector). Most of these failed products were 2- or 4-ply boards. In all, 25 products (38%) failed the mottling criteria. Mottling represents the presence of local "hot spots" of fading and generally indicates inhomogeneity in an enclosure product.
>
> . . . The results of this evaluation of 66 commercially available archival products have an important lesson for archive managers: not all enclosures offered in the marketplace are safe to use with photographs. Vague descriptors, such as "acid free" (most of the failed products were so described), do not guarantee inertness toward photographs. In some cases, the high prices paid for "archival" enclosures are actually buying materials more harmful than grocery bags or newsprint.
>
> . . . The performance of the 66 archival products can be put into perspective by comparing them with the behavior of some of the known good and bad "benchmark" materials also included in this test. This data illustrates that, by and large, photographic [paper enclosure, mounting, and storage] materials have come a long way from the truly dreadful materials that were so common in the past. For example, two 1930s portrait studio folders (one gray and the other dark green) were tested. The prints inside these folders showed fading and mirroring where they had been in contact with the overmat part of the folder. Both failed all three PAT criteria by large margins. The fading they caused was among the worst of all 90 materials. Their staining was about seven times the maximum acceptable limit, and they were heavily mottled. But it is also important to note that the fourth worst fading performance of all 90 materials was given by an "archival" product, a 2-ply white rag board. Two out of the three Japanese repair tissues tested failed the fading criterion. There appeared to be no difference in product performance related to the presence or absence of carbonate buffering. The interactions between photographic materials and enclosures are obviously more complex and varied than the commonly used archival descriptors, such as "acid free," allow for. An empirical evaluation, such as the PAT, is a vital check for unforeseen harmful effects.



Carol Brower – October 1987

1. Strathmore Paper Company has been manufacturing fine artists' papers for nearly a century. The company currently operates four paper mills in Massachusetts, one of which produces museum board. The above photograph and those that follow show white museum board being made at Strathmore's Woronoco Mill No. 1 in October 1987. The Fourdrinier machine pictured on the left — the wet end is in the foreground — is nearly 100 years old and continues to make papers and boards of outstanding quality.

ANSI Removes the "Archival" Designation from ANSI Standards

In 1990 ANSI decided to remove the "archival" designation from all of the ANSI photographic standards. The rationale for this is explained in the Foreword to *ANSI IT9.11-1991*:[24]

> The term "archival" is no longer specified in American National Standards documents since it has been interpreted to have many meanings, ranging from preserving information "forever" to the jargon meaning [especially in the computer and electronic data storage fields], temporary storage of actively used information. It is therefore recommended that the term "archival" not be used in standards for stability of recording materials and systems.

Processed photographic films are now classified according to the life expectancy or "LE designation," when stored under specified conditions. Terms such as archival processing, archival record film, and archival storage materials, all of which have been widely used in the photography conservation field, are no longer used or endorsed by ANSI.

ANSI Requirements for Paper Products Used with Photographs

While as yet there is not an ANSI standard that specifically addresses mount boards, the requirements for enclosure papers given in Sec. 3.2 of *ANSI IT9.2-1991* would generally apply:[25]

> Paper that is in direct contact with *black-and-white* photographic material shall be made from high alpha cellulose [e.g., cotton fiber], bleached sulfite, or bleached kraft pulp with an alkali resistance expressed as R_{18} value greater than 87% as determined by the method given in ISO 699:1982. It shall be free from such highly lignified fibers as groundwood, as determined by microscopic analysis and the phloroglucinol spot test. The pH should be between 7.2 and 9.5, as determined by the method given in TAPPI T509su-77. The alkali reserve shall be the molar equivalent to at least 2% $CaCO_3$, as determined by the alkali reserve test described in 5.2. This alkali reserve should be accomplished by the incorporation of an alkaline earth car-

(continued on page 466)

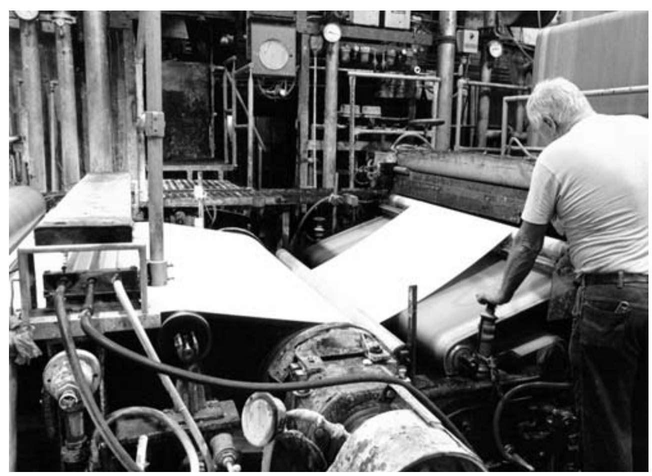
2. Dry sheets of 100% cotton linters pulp are stored in large bales at the mill, ready for making paper and museum board. Pulp operator Joe Stebbins is separating bales with a forklift truck to move them to the pulper.

3. The bales are placed on a slowly moving conveyer belt which drops the pulp into the pulper.

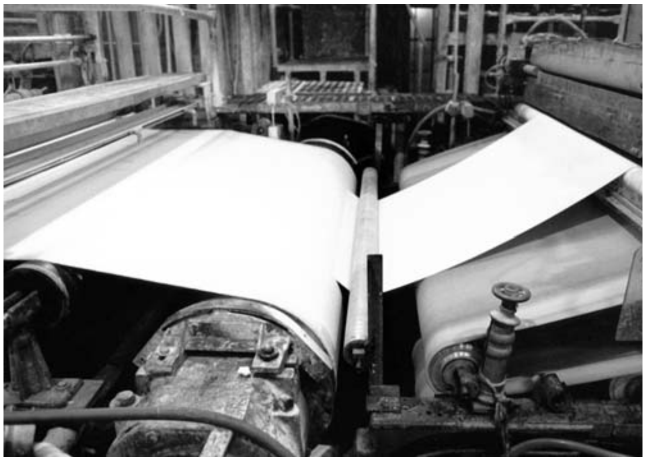
4. In this close-up, the pulper (approximately 10 feet in diameter) beats the pulp (furnish) into slurry. Most of the chemical ingredients, such as internal sizing agents, colorants, and alkaline buffers, are added to the pulp at this stage.

Carol Brower (5) – October 1987

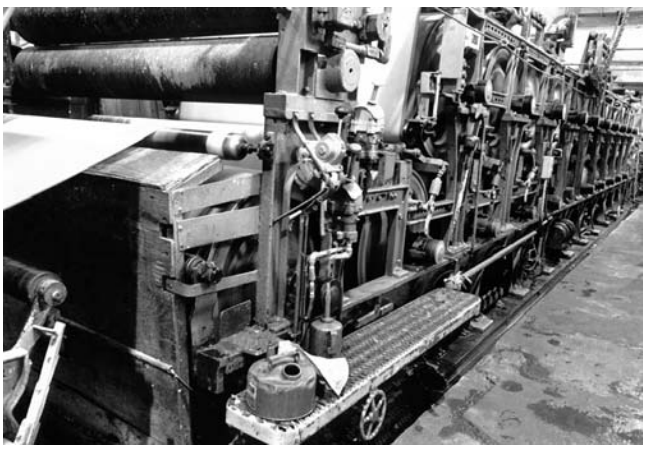
5. Machine tender Bob Hungerford looks over the wire (the wet end of the machine). A continuous belt made of fine fiber screen vibrates constantly as it moves forward so that the pulp fibers will mesh together and the water will drain away. It is during this stage that the grain direction is formed as the fibers line up in the direction of the flow.



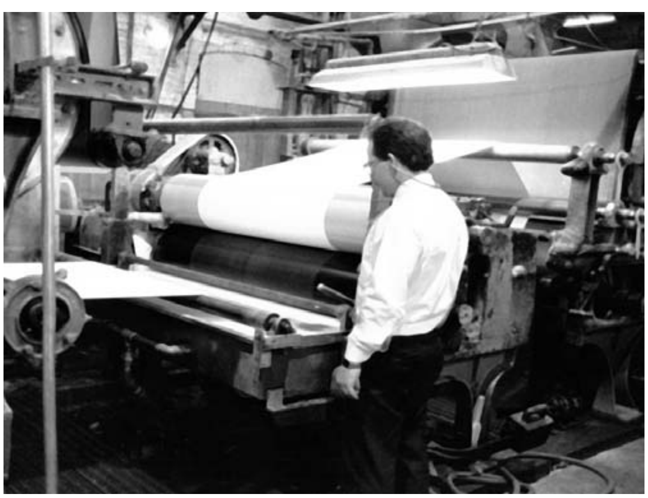
6. Hungerford inspects the machine and the stock as the newly formed wet sheet of paper is “lifted” off the screen and transferred to a continuously moving felt belt for drying.



7. This close-up view shows the point at which the stock becomes paper.



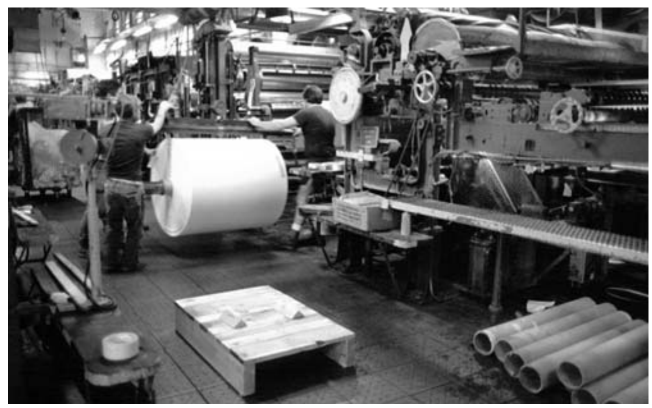
8. The wet sheet of paper (later to become museum board) enters the first set of drying drums.



Carol Brower (6) – October 1987

9. Marketing and sales manager Thomas Richards looks over the paper as it comes out of the first set of dryers and enters a bath containing surface sizing chemicals. The paper then enters a second set of dryers (right).

10. The paper leaves the dryers and passes through an idle calender stack (which, when operating, produces a very smooth surface on such products as writing papers). A new roll is started the moment the previous roll is finished. The machines do not slow down during this operation, so the back tenders must quickly coordinate the transfer of the continuously running sheet of paper onto another cylinder. Here the crew members observe the next roll as it begins to wind.



11. The completed roll of 1-ply museum board, weighing approximately 1,000 pounds, is moved aside during the roll-change operation to make room for the next roll. The machines normally produce one roll every 45 to 50 minutes.

12. At the start of a new roll, the machine tender examines a sample of the 1-ply board before it is sent to the laboratory for specification tests (caliper or thickness, basis weight, color, consistency, strength, etc.). Requiring the attention of three separate shifts of workers, the machines run 24 hours a day, 7 days a week producing museum board and numerous other fine papers. The finished roll of 1-ply museum board is pictured on the left.

13. When the entire run is completed, the rolls are taken by semitrailers across the Woronoco River to Strathmore's Woronoco Mill No. 2 (above), where they will be pasted together to make 2- or 4-ply board. The semitrailers are pictured on the left.

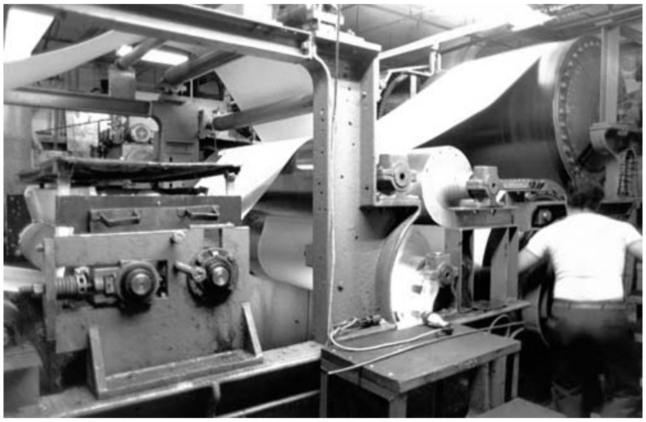
14. David Climo, assistant manager of Woronoco finishing operations, talks with forklift operator Gerald Fillion. This roll of 1-ply museum board is on its way to the pasting machine.

15. Pasting operator Kurt Bodendorf removes several outside layers before the rolls are hoisted onto the pasting machine.

16. To make 2-ply board, one roll of 1-ply board is suspended above another roll. They unroll together at a rate of about 450 feet per minute. Bodendorf supervises the operation as the lower roll passes through the pasting applicator (lower right).

Carol Brower (5) – February 1988

17. Carlos Cruz mixes the sacks of dry starch-based adhesive with water to produce the proper consistency before the adhesive enters the pasting applicator. Starch paste is preferable to animal glues or synthetic adhesives for laminating high-quality boards because it is more stable chemically, does not discolor, and does not contain residual chemicals and acids, which break down the paper fibers.



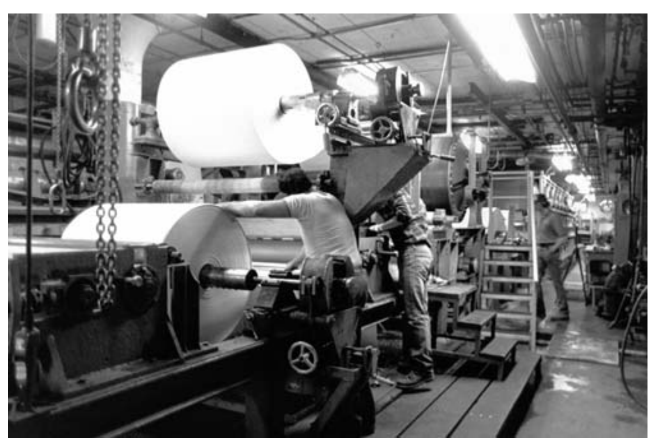
18. The board leaves the applicator (with paste on its surface) and meets the roll above as they enter a series of high-pressure stainless steel rollers (center right), which permanently join the two sheets. The damp 2-ply board is then rolled up again before it is dried.

19. Close-up view of the stainless steel rollers. The two sheets of 2-ply board can be seen coming together for the first time on the large roller on the left.

20. Kurt Bodendorf (right) and intern Rick Bergstrom splice the beginning of a recently pasted roll of 2-ply board to the end of the previous roll, which is stalled during its passage through the long row of 19 drying drums (center right).

21. When the 2-ply board will be made into 4-ply board, the board passes through the idle cutting machine (left) and is rolled up once again. Back tender Peter McLaughlin starts a new roll by quickly attaching the 2-ply board to its core.

22. McLaughlin moves the previous roll aside to join other rolls until they can be laminated again. Moisture content must be carefully controlled during each stage of manufacturing, storing, pasting, rolling, drying, re-rolling, and cutting. When the ambient relative humidity is 35 to 50%, the moisture content of the final sheet is approximately 6%.



23. Hours later, another shift of workers makes 4-ply board by guiding the rolls of 2-ply board through the same pasting machine.

Carol Brower (6) – February 1988

24. Pasting operator Mark Miller checks a roll of 4-ply board as it enters the dryers. Another recently pasted roll (left) will follow. Four-ply board takes about twice as long to dry as 2-ply.

25. The 4-ply board is cut into sheets immediately as it leaves the dryers. Here the sheets are slightly larger than the standard size of 32 x 40 inches (by about ½ inch) to allow for trimming before packaging. The sheets land on a raised skid, which is gradually lowered to floor level by a hydraulic lift until the stack is full.

26. Back tender Ron Laporte spot-checks one of the sheets.

Carol Brower (4) – February 1988

27. Forklift operator Francis Hansen takes the museum board to be weighed. This stack weighs about 1,250 pounds. Afterward, the board will be trimmed to 32 x 40 inches, sorted by hand to remove sheets with surface defects, arranged into groups of 10 or 25 sheets, wrapped in water-resistant paper, and packaged in corrugated cartons for storage in the warehouse before it is sent to distributors.

Carol Brower – October 1987

28. Warehouseman Dave Galbert, group leader Dave Christian, and marketing and sales manager Thomas Richards check the inventory of finished products in the Strathmore warehouse. Richards says, "Our paper is inspected every step of the way, from the bales of pulp to the cartons in the warehouse."

bonate or the equivalent. ($MgCO_3$ and ZnO are also being used, which in molar equivalencies correspond to approximately 1.6% reserve.) A minimum of sizing chemicals shall be used, the amount being dictated by the requirements of the end use (enclosures, overwraps, interleaving, etc.). If sizing is used, neutral or alkaline sizing chemicals shall be employed. The material shall essentially be free from particles of metal. Surface fibers that might offset onto photographic layers should not be present. The paper shall not contain waxes, plasticizers, or other ingredients that may transfer to the photographic material during storage. Glassine envelopes shall not be used. The paper shall meet the physical tests required for the particular application. [These include stability (see TAPPI T453su-70), folding endurance (see ASTM D2176-69 [1982] and TAPPI T511su-69), and tear resistance (see TAPPI T414om-82).]

Paper that is in direct contact with processed diazo or *color* photographic materials shall have similar composition to that used for black-and-white material except that the pH shall be between 7.0 and 7.5, and the 2% alkaline reserve requirement shall *not* apply.

To conduct all of the paper quality tests called for in the ANSI Standard is a complex, expensive, and time-consuming task requiring experienced personnel and a well-equipped laboratory. To the authors' knowledge, the only time the complete series of tests has been done on paper enclosure materials was in 1978 when, at the request of Klaus B. Hendriks of the National Archives of Canada (then called the Public Archives of Canada), the Ontario Research Foundation tested seven paper and glassine photographic enclosure materials under a contract with the Public Archives. The report has not been published and Hendriks has declined to identify the products included in the tests, but he has indicated that *none* of the products (which included an alkaline-buffered paper envelope popular in museums and archives) satisfied all of the ANSI requirements.[26] Mount boards were not included in the tests.

Commenting in 1984 on efforts to better formulate specifications and test procedures for mount boards and other paper products, James Reilly said:

> I think this is an evolutionary situation where more testing will be done and maybe a narrower definition of requirements will emerge. If there is one bad sizing or laminating adhesive it will be identified sooner or later. The worst types of things that might be in a board

or paper will be identified and a set of specs that are more comfortable for the paper mills will emerge.

But I think generally — in spite of a few really bad products — the overall level of board and enclosure paper quality has improved dramatically over what was common practice just a few years ago, when people, even in museums, would use practically anything. In general, we are just vastly better off now.[27]

Glassine Paper — Not Recommended

Glassine paper is a thin, very smooth translucent paper used extensively for negative enclosures and sometimes for interleaving purposes. Glassine is made from wood pulps that have been mechanically beaten to have a high degree of hydration, a process which degrades the fibers. Ethylene glycol or other substances are usually added to glassine paper to increase its translucency and flexibility.

In 1967 Eugene Ostroff of the Smithsonian Institution in Washington, D.C. advised against storing photographs in contact with glassine paper, citing its poor stability and additives that "can have a detrimental effect on image stability of adjacent photographs."[28] Based in part on Ostroff's observations, *ANSI IT9.2-1991* specifically warns against glassine envelopes. Eastman Kodak also advises that glassine be avoided, stating in 1985: "With age and dry storage this material tends to become brittle and during subsequent handling may even shatter; conversely in the presence of high temperature and high relative humidity (90°F [32.2°C] and 90% relative humidity), the transparentizers may exude, and on coming in contact with the negative surface, cause ferrotyping."[29]

So-called "archival" or "acid-free" glassine papers likewise are *not* recommended for storing photographs.

Paper Chemistry: Some Considerations with Regard to Photographic Materials

Many chemicals and additives used during the papermaking process may be deliberately present in the final product, or may exist as residual contaminants. Some of these substances can interact with photographs, causing fading and/or staining of the image and possibly deterioration of the support. For instance, boards and papers may contain acid or alkaline dyes (in addition to bright colors, board tones such as off-white, cream, ivory, antique, etc. are often obtained with dyes), pigments, retention aids, fillers, aluminum sulfate fixative (papermaker's "alum"), internal sizing agents, beater adhesives, bleaches, surface sizing agents, and waxes, as well as metal particles or other contaminants.

Boards colored with dyes commonly contain mordants that affix the dyes to the paper fibers and that help prevent color fading and color migration. Boards colored with pigments, such as Bainbridge Alphamat, have fixatives to hold the pigment particles in place and prevent bleeding. As will be discussed in more detail later, alkaline-buffered boards and papers contain calcium carbonate or magnesium carbonate to neutralize acids that may occur from internal or external sources.

Laminating and Sizing

Unlike most papers, which are manufactured as single sheets, mount boards usually consist of several layers or "plies" of thick paper; composite boards have thin "facing papers" laminated to the front and back. Both types of boards incorporate adhesives which constitute another possible source of harm to photographs.

Sizing agents are compounds added to paper to reduce the rate of moisture absorption by the fibers, making them somewhat water-resistant. For example, sizing is necessary in writing papers to keep inks from bleeding. Nearly all high-quality papers are sized to some extent (blotter paper is an obvious exception). Sizing can also modify and improve the surface finish of a paper, and can increase its tear-strength.

One reason that *ANSI IT9.2-1991* specifies "neutral or alkaline" sizing chemicals is to preclude the use of the common alum-rosin size, introduced to papermaking in the U.S. about 1830. Rosin is a low-cost by-product resulting from the distillation of turpentine from resinous pine trees. Rosin is essentially an organic acid, insoluble in water until treated with a caustic soda, in a process similar to soapmaking.

In papermaking, rosin size is precipitated on the paper fibers by the addition of aluminum sulfate (papermaker's alum), which has the undesirable result of increasing the acidity of the paper. Rosin in paper also gradually oxidizes and yellows, a process that is accelerated by iron particles from paper-manufacturing machinery, and sometimes from the water used in papermaking.

Lignin in Paper Products

ANSI IT9.2-1991 also states that paper products such as negative envelope papers and mount boards used for storing and mounting photographs shall be free of highly lignified fibers, such as groundwood. After cellulose, lignin is the principal component of fibrous plant materials. Lignin is the substance that binds plant fibers together and is largely responsible for the great strength of wood.

When present in paper, lignin yellows on exposure to light and is also unstable in the dark, releasing decomposition products such as peroxides and other potentially harmful substances. This is the main reason why lignin must not be present in paper products intended for the storage of photographs.

Many high-quality papers are now advertised as "lignin-free," in recognition that lignin should not be present. Lignin is more or less completely removed in sulfite-processed wood pulps (bleaching further removes lignin-containing residues), but little or none is removed from mechanically ground wood pulps. Newsprint and the gray chipboard base of many low-cost mount boards contain a high percentage of lignin. In addition to lignin, such groundwood papers usually contain a variety of other potentially harmful substances.

Lignin-containing wood-pulp papers, alum-rosin size, and fiber-degrading chlorine bleaches have all contributed to the sharp decline in the stability of most papers made during the past 150 years — a problem now plaguing libraries and archives the world over.

Cotton Fiber Versus Wood Pulp

There are two principal types of high-quality mount boards: "museum" board and "conservation" board.[30] So-called "museum" board is made from 100% cotton fiber pulp, which usually consists of cotton linters fibers but may be made from cotton rags or a combination of both. "Conservation" board is made from wood fiber pulp which has been cooked, bleached, washed, and extensively refined to remove lignin and other impurities. Cost and scarcity of cotton pulps have been important factors in the development of high-quality mount boards from refined wood pulps. The cost difference is not great, however, and refined wood pulp boards typically cost only about 20% less than 100% cotton fiber boards.[31] (Lower-quality "standard" boards, made from wood pulps that are not as highly refined as those processed for conservation boards, commonly cost less than half as much as cotton fiber boards.)

With the exception of several nonbuffered, neutral-pH mount boards intended primarily for photographic applications, most museum boards and conservation boards have, since the mid-1970's, been manufactured with the addition of alkaline buffering agents.

Mount board made from 100% cotton fiber differs physically, chemically, and visually from board made from chemically processed wood pulp. First of all, cotton is one of the purest forms of cellulose occurring in nature, being nearly 99% alpha cellulose, whereas typical hardwoods and softwoods are about 50% alpha cellulose.[32,33] The higher the alpha cellulose content in a given fiber, the greater the potential strength of the paper made with it. In addition, the chemical purity of such papers is usually potentially very high because a minimum of refining, processing, and bleaching is required, especially in the case of paper made from cotton linters.

There are two principal types of natural cotton fibers. The longer ones are known as "cotton seed-hair fibers" and the shorter as "cotton linters fibers." The longer and more costly cotton seed-hair fibers are used primarily in the textile industry. When these longer fibers do go into making paper, they are usually purchased in the form of textile cuttings (scraps) or as old rags — hence the terms "rag paper" and "rag board." However, most 100% cotton fiber papers and mount boards are currently made with the shorter cotton linters, and so the descriptive term "rag" is often inaccurate (see Chapter 12).

Cotton linters are likely to be freer of contaminants than reprocessed cotton rags because the latter require more chemical refining. Numerous chemical additives and dyestuffs used in the textile industry are often present in cotton rags and must be removed before they can be made into museum board and other high-quality papers. In addition, rags must be closely examined to guard against contaminating cotton pulp with synthetic materials. In 1967, Eugene Ostroff wrote that "manufacturers find it extremely difficult to purchase rags which do not contain traces of synthetic fibers and various additives intended to impart certain physical attributes, such as added whiteness. Chemical processing, uninjurious to the rag fibers, cannot successfully remove all such foreign matter. In the finished paperboard their long-range storage effects on photographs are unknown."[34]

All refining affects the structure of the cellulosic bond in cotton and wood fibers. For example, the more bleaching required, the weaker a fiber will become. Since both wood fibers and rags require significant refining and purification, they are more difficult to manufacture into high-quality, stable paper products than are pure cotton linters. Few paper mills still have equipment capable of purifying rags for papermaking.

In nearly every case, whether coming from linters or rags, cotton fibers make papers and boards that are physically more durable and resilient, having better strength and folding endurance than do products made from refined wood fibers. However, these qualities are not as crucial in photographic papers and mount boards (which are not normally folded or handled as much) as they are, for example, in a book paper.

It should be possible to make a satisfactory mount board from refined wood pulp which would be as stable as one made from cotton fibers.[35] Fiber-base photographic paper (as well as the paper core of polyethylene-coated RC papers) is itself now made from purified wood cellulose, although this was not always so. In the early 19th century, nearly all photographic prints were made on linen and cotton rag papers, selected from artists' and writing papers available at the time. Inexpensive papers made from groundwood pulp were introduced around 1840 but, because of their low quality, were unsuitable for making photographs.

By 1850 at least two companies were manufacturing papers specifically for making photographs.[36] Rag papers were sized with starches, albumen, and then gelatin, which resulted in prints with improved contrast and sharper detail. However, as the science of photography advanced, the various requirements for photographic papers were not always met. Problems regarding pulp availability and contamination, unstable sizing agents, papermaking equipment, paper strength (both wet and dry), and paper permanence challenged papermakers and photographers to create better photographic printing papers. According to Kodak, "as the demand for paper of all kinds increased, the supply of suitable rags diminished . . . . Consequently, much of the rag stock that was available did not meet the purity standards required for photographic use. In an effort to solve the problem, Eastman Kodak Company instituted a program of research and development into the possibility of making pure paper from wood pulp."[37]

George Eaton explained why Kodak needed to develop a satisfactory wood cellulose paper: "George Eastman imported the finest rag papers he could obtain from Europe until 1914, when World War I prevented further importation. Eastman Kodak Company then made the highest quality rag paper using rosin sizing," although, as Eaton also noted, the company had difficulty manufacturing the paper and "experienced considerable variability in the product. It was obvious that a source of more uniform raw material was necessary, and a ten-year research program ensued with a paper company to produce a wood cellulose fiber equal in purity to new grown cotton."[38]

By 1926 Kodak was producing photographic base papers containing 50% cotton fiber and 50% purified wood pulp. In 1926–27 Kodak substituted a more stable sodium stearate binder for rosin size. In 1929 a Kodak paper made entirely from wood pulp was judged by the National Bureau of Standards to be as permanent as the best quality 100% cotton fiber paper,[39] based on the rather simplistic paper permanence tests accepted at the time. Since the 1930's, virtually all Kodak and other fiber-base photographic papers have been manufactured entirely from wood cellulose.

Cost factors undoubtedly played a major part in the decision to develop a satisfactory wood cellulose paper, since such a paper is much less expensive than 100% cotton fiber paper. Over the years, this change has saved Kodak and other manufacturers untold millions of dollars in production costs.

In addition to the general desire for long-lasting prints, the quality of fiber-base photographic paper has traditionally been consistently high because of several requirements unique to photography. The paper must be free of certain common paper contaminants, especially copper, iron, and other metal particles, since these impurities can have adverse effects on the keeping properties of an emulsion prior to processing.[40] The paper must also have good wet-strength properties in order to hold up adequately during developing, fixing, and an hour or more of washing.

With the introduction of polyethylene-coated RC papers in the late 1960's, most of these constraints — which also tended to insure a long-lasting product — no longer applied. Because of this, stability differences between various brands of RC paper appear to be far greater than is the case with fiber-base papers manufactured during the past several decades.

Research and development on all kinds of photographic papers continue in the photographic industry. For example, in 1984, in response to an expanding market for "premium" fiber-base black-and-white papers with high stability and superior image quality — and intense competition from Ilford, Oriental, and Agfa-Gevaert — Kodak introduced Kodak Elite Fine-Art Paper. Information on the stability of the many photographic papers presently on the market, as well as of the relative stability of photographic mount boards and enclosure papers, will probably become increasingly available in the future.

Fluorescent Brighteners in Prints and Mount Boards

Fluorescent brighteners, sometimes called "optical bleaches," are white or colorless compounds added to many paper products, fabrics, and so forth in order to make them appear whiter and "brighter" than they really are. (Most laundry detergents have added brighteners that mordant to fabrics during washing.) Fluorescent brighteners absorb ultraviolet (UV) radiation, causing the brighteners to fluoresce (emit light) in the visible region, especially in the blue and green portions of the spectrum. If the illumination source contains no UV radiation, fluorescent brighteners are not activated and, comparatively speaking, the paper appears "dull" or subtly lacking in brightness. It is the amount of UV radiation as a percentage of visible light that determines the perceived "brightening" produced by fluorescent brighteners in papers. Therefore, the more UV radiation present, the brighter the paper will appear.

Among common sources of illumination, indirect daylight through window glass has the highest relative UV content. Illumination from glass-filtered fluorescent lamps and glass-filtered quartz-halogen lamps has a moderate UV content. Incandescent tungsten illumination has the lowest relative UV content of any common light source, but even incandescent lamps emit sufficient UV radiation to activate fluorescent brighteners. If the light source passes through an effective UV filter such as Plexiglas UF-3, not enough UV radiation will be transmitted to affect the brightener. Thus, unfortunately, prints and mount boards with fluorescent brighteners can appear significantly different depending on the exact spectral distribution of the light source.

Because Plexiglas UF-3 absorbs virtually all UV radiation below about 400 nanometers (ordinary glass freely transmits UV radiation in the 330–400 nanometer region of the spectrum, which excites fluorescent brighteners), the yellowish tint imparted by a UF-3 sheet covering a photograph is exaggerated if the print or mount board contains a fluorescent brightener. In other words, assuming that the illumination contains sufficient UV radiation to noticeably activate a fluorescent brightener, the "yellowing" imparted by UF-3 appears to be comparatively greater than it is with a similar print or mount board made without a fluorescent brightener. When photographs covered with glass and with UF-3 are hung side-by-side, the difference in yellowness is quite noticeable.

Another drawback of fluorescent brighteners in mount boards, photographic materials, and artists' papers is that when these products are exposed to light and UV radiation over time, they gradually lose their ability to fluoresce — in effect, the fluorescent brightener "fades." Thus, the paper gradually becomes faintly yellow and less bright in appearance. These problems can be avoided simply by not adding fluorescent brighteners to the paper product in the first place.

The authors have examined most of the cotton fiber mount boards currently available in the U.S. and, fortunately, it appears that fluorescent brighteners are seldom added to them. Boards that did contain significant amounts of fluorescent brighteners were a 4-ply 100% cotton fiber board manufactured in Germany by Felix Schoeller, Jr., GmbH & Co. KG (Schoeller boards are not widely available in the U.S., although they were used during the early to mid-1970's by Ansel Adams for dry mounting his prints) and several samples of 2-ply and 4-ply 100% cotton fiber boards sold in 1982 under private label by University Products, Inc., Holyoke, Massachusetts. Unfortunately, virtually all black-and-white photographic papers now contain fluorescent brighteners. The authors advise against the use of mount boards containing fluorescent brighteners and discourage the practice of adding brighteners to photographic papers.

The Question of Paper pH

The pH of paper refers to its acidity or alkalinity, measured on a scale of 0.0 to 14.0, with pH 7.0 being neutral. A pH of less than 6.5 is considered acidic, and a pH of more than 7.5 is considered alkaline. Each whole number on the scale represents a difference in acidity or alkalinity of ten times the adjacent whole number. Common book and document papers usually have a pH value within the range of about 5.0 to 7.0, while the pH level of alkaline-buffered papers is usually about 7.5 to 9.5. Papers with a pH of 6.5 or higher are generally considered to be "acid-free."

Throughout the discussion that follows, it must not be forgotten that pH is only one factor among many which can affect the stability of a photograph. In fact, research by Glen Gray of Eastman Kodak has indicated that pH alone is not even a good indicator of paper stability, particularly with high-quality papers: "Specifications based upon extractable pH levels only cannot properly rank papers for permanence nor can useful life be estimated since several other factors are involved."[41]

The current widespread interest in paper pH was generated chiefly by William Barrow, who conducted research on the stability of paper during the 30-year period prior to his death in 1967. He and other investigators demonstrated that, other factors being equal, papers with a pH below about 5.0 are generally short-lived, while neutral or alkaline papers are more likely to have a very long life.[42] This research led to the manufacture of low-cost, relatively stable papers that are alkaline-buffered with 2% to 3% calcium carbonate or magnesium carbonate by weight and with a resulting pH of about 8.5. One function of the alkaline buffer is to help neutralize the effects of sulfur dioxide and other contaminants absorbed by the paper from acidic inks, polluted air, and other external sources.

Alkaline-buffered papers are becoming common in the publishing field. For example, this book is printed on a high-quality, long-life, alkaline-buffered, coated book paper made by the Glatfelter Paper Company and is expected to survive many hundreds of years. In 1984 the American National Standards Institute issued *ANSI Z39.48-1984, American National Standard for Information Sciences – Permanence of Paper for Printed Library Materials,* which, among other requirements, specifies a minimum pH of 7.5 and a minimum alkaline reserve equivalent to 2% calcium carbonate by weight for uncoated paper used in books and other publications intended for permanent retention (coated papers, such as that used in this book, were beyond the scope of this initial standard).[43] Alkaline buffering appears to be particularly beneficial in increasing the life of low-quality papers on which most paperback books are printed.

In recent years there has been a marked trend toward incorporating alkaline buffering agents into the manufacture of museum mount boards, boxboards, and enclosure papers. Most conservation-quality products on the market are alkaline-buffered. These products are referred to as "acid-free," a confusing term heard so frequently that many consumers have been led to believe that this is the *only* requirement for materials used in long-term contact with films, prints, and other valuable artifacts.

Among early alkaline-buffered paper products were the microfilm and print storage boxes manufactured by the Hollinger Corporation. Alkaline buffering was intended to maintain the stability of the board as it aged, thus lessening the tendency for the box to generate peroxides, which — even at very low-level concentrations — have been shown to cause discoloration and fading of silver images during long-term storage. Untoned black-and-white RC prints and the very-fine-grain images of microfilms are extremely sensitive to peroxides and other such oxidizing gases.

The first widely marketed alkaline-buffered paper was Permalife, initially produced according to Barrow's specifications by the Standard Paper Manufacturing Company of Richmond, Virginia beginning in 1960. Permalife is a moderately priced bond paper made from refined wood fibers; the trademark was acquired about 1976 by Howard Paper Mills, Inc. of Dayton, Ohio.[44]

With the introduction of Permalife in the document conservation field, archives and museums began storing negative and print collections in envelopes made of Permalife and similar papers. The Hollinger Corporation started producing envelopes of this type in the mid-1970's. Apparently neither the manufacturers nor the customers who requested Permalife envelopes tested them for possible adverse effects resulting from their long-term contact with photographs — it was simply assumed that the more stable an enclosure paper was, the better it was for storing photographs.

Some people, however, working in photographic conservation questioned the acceptance of alkaline-buffered products without testing. In 1976 Walter Clark, a former chemist at the Eastman Kodak Company and a conservation consultant at George Eastman House, wrote, "Special boxes, papers and mount boards are now made of nonacid materials, which were developed from research on permanent papers for books. It is not yet certain that the high degree of alkalinity in these materials is satisfactory in the long run for photographs, especially color pictures, but they offer the best approach at the moment."[45]

In 1978 Klaus B. Hendriks, chief conservation chemist at the Public Archives of Canada (now called the National Archives of Canada) said, "Questions are being asked concerning the most suitable pH of paper envelopes, and it may well be that different photographic records require different pH values of the respective paper enclosures in order to be kept safely."[46] Later in 1978, partially based on results of an investigation into factors influencing the dark fading stability of Ektacolor 37 RC prints, Henry Wilhelm recommended against the use of alkaline-buffered materials with photographs, pending the outcome of further research.[47]

In recent years, various advice has been given regarding pH requirements for photographic enclosures. In 1983 Polaroid Corporation said, "In general, photographs should not be subjected to acidic or highly alkaline substances. Storage envelopes, folders, papers, and so forth, should have a pH between 7.0 and 8.5 (neutral to slightly alkaline)."[48] In 1979, Eastman Kodak recommended that paper products for photographs "should be free of groundwood, alum, or alum-rosin size and have a pH of about 6.5."[49] In a 1982 publication, the company stated, "To be considered for color print mounting, a paper product should be free of ground wood, alum, or alum-rosin size and should have a pH of 7 to 7.5. (A pH of 7 to 9.5 often is considered acceptable for black-and-white print mounting.)"[50] Referring to black-and-white photographs, Kodak spokesman Henry Kaska said, "We simply haven't studied the matter in any depth. The feeling is that image stability isn't particularly affected by the [pH of the] paper that films and prints come in contact with. The question [about pH] arises from time to time, but it hasn't been subjected to the kind of study that would permit us to speak authoritatively on the matter."[51]

In the 1985 book *Conservation of Photographs,* Kodak recommended a mount board pH value “very close to 7.0 or very slightly higher.”[52] Based on an erroneous 1982 article,[53] which incorrectly cited a report by conservator Mary Kay Porter presented at a meeting of the Photographic Materials Group of the American Institute for Conservation (AIC), Kodak went on to say:

> Even though the pH may be within this range [7.0 to 9.0] an excessive amount of buffer can be harmful. One such mountboard contained 10–100 times the average concentration. Color prints stored for only a few months on this material showed considerable damage. A test for total alkalinity could have prevented the loss.[54]

Porter had actually reported on the apparent discoloration, or “staining,” of some 19th-century *albumen* black-and-white prints which had recently been overmatted with an alkaline-buffered board. *Color prints were not involved.*

Investigations reported in 1982 by conservator Sergio Burgi, at the time with the International Museum of Photography at George Eastman House, revealed that this type of apparent discoloration of overmatted albumen prints is in reality not a discoloration at all.[55] In the 19th century it was common practice to lightly “tint” the albumen layer of the paper with organic dyes to give bluish-red or yellowish-red hues to the highlights of the prints. Burgi’s research showed that these dyes characteristically have poor light fading stability, and when an overmatted albumen print is displayed for sufficient time, the dyes exposed to light in the cutout area of the overmat fade. The edges of the print protected from light by the overmat do not fade. With no record of what the print originally looked like, the unfaded dye around the edges of the print can easily be misinterpreted as a “stain.”

Porter was aware of Burgi’s findings but had been told that some of the “stained” albumen prints had never been displayed (an assertion she later came to doubt); she suspected, therefore, that alkaline buffering in the overmat might be the cause of the discoloration, but she was not certain of this. Rather, in her report to the AIC group, she emphasized that materials used by paper conservators were not necessarily satisfactory for photographs and that much more consideration should be given to how mount boards and other paper products react with the silver images of black-and-white photographs. Porter did not discuss color prints or their storage requirements in her report.

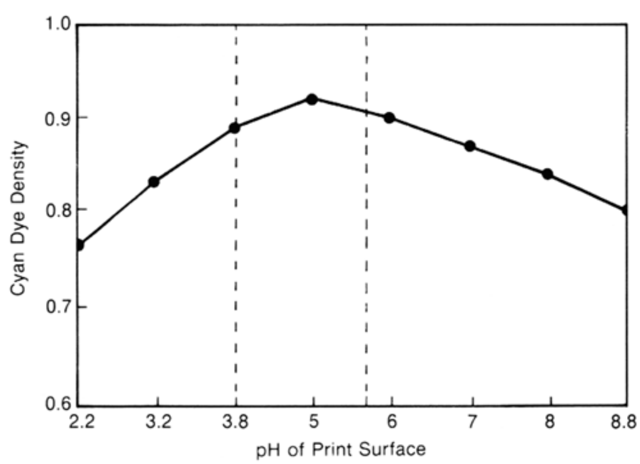


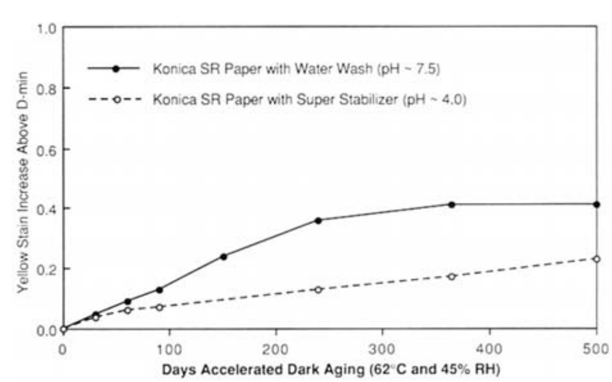
Figure 13.1 The effect of emulsion pH on the dark fading of the cyan dye in Konica Color Paper Type SR. The prints have been subjected to an accelerated dark-storage test. The optimum stability of the dye occurs in the acidic range of pH 3.8–5.5. While the pH sensitivity of dyes varies considerably among color photographic products, the behavior of this particular dye is typical of the cyan dyes in most chromogenic color photographs; this underscores the concern about storing color prints in contact with alkaline-buffered mount boards and envelopes, which generally have a pH of 8.5 or higher. (Data courtesy Konica Corporation)

Most Photographs Are Not “Acid-Free”

When contemplating the consequences and benefits of specifying pH in the manufacture of mounting and enclosure materials, it is important to consider the normal pH values of photographs. Ilford has recommended a near-neutral pH for storage materials in contact with Cibachrome prints (renamed Ilfochrome prints in 1991): “The dyes utilized in Cibachrome are at maximum stability in the near neutral range between 6.5 and 6.8 pH. Materials to be placed in contact with the surface of the photograph for long-term storage must be of neutral pH.”[56]

While the 1978 version of *ANSI PH1.53* (the predecessor of the current *ANSI IT9.2* Standard) specified buffered papers with a pH between 7.0 and 9.5 for both color and black-and-white photographs, this recommendation was changed in the 1984 and 1986 revisions of the Standard, and separate recommendations are now given in *ANSI IT9.2* for color and black-and-white photographs. For color photographs, nonbuffered paper products with a pH of 7.0 to 7.5 are specified; for black-and-white photographs, the recommendation is essentially the same as in the 1978 version.

Peter Adelstein, chairman of the ANSI subcommittee which developed the new versions of the Standard, said that “the concern was with the enclosure material lasting as long as possible. It could also be argued — though I don’t think it is a good argument — that under any adverse conditions, when cellulose acetate materials hydrolyze, they release acid, which, of course, if it were in contact with



During dark storage, high emulsion pH also contributes to yellowish stain formation with Konica Type SR paper (shown here) as well as Ektacolor and other color negative print papers. (Data from H. Wilhelm) buffered paper would be good. That is not true with the polyester materials — they don't hydrolyze as easily. However the primary concern was the stability of the enclosure paper; studies with books and documents indicated that these [alkaline-buffered] papers generally would last longer."[57]

Relative to the pH of photographs themselves, George Eaton made the following statement:

> Much has been said and will be said about the acidity or pH of photographic paper base with respect to permanence. Kodak raw stocks for black and white emulsions range in pH from 4.6 to 5.9 but after processing pH increases to a range of 5.5 to 6.6. The gelatin in the emulsion layer helps to stabilize paper acidity at these levels. This slight acidity . . . is not as important a variable to permanence as is the use of highly purified pulp, inert sizing material, and low levels of metallic impurities.[58]

As Eaton pointed out, fiber-base black-and-white prints typically have a pH in the acid range; a random selection of prints from the years 1917 to 1982 had pH levels of from 4.8 to 6.5 when tested by Henry Wilhelm.[59] Ektacolor prints from 1976 to 1982 had pH levels in the 3.5–4.5 range if the prints had been treated with Ektaprint 3 Stabilizer after washing, and about 6.5 if the acidic stabilizer had not been included, as has been the general practice in recent years. (Following the 1984 introduction of the Konica Nice Print "washless" minilab and associated Konica Super Stabilizer solution, color print stabilizers that leave the emulsion in a low-pH condition are becoming popular once again.)

Several samples of fiber-base Kodak Dye Transfer prints tested by Henry Wilhelm had a pH of about 5.0 on the emulsion side. In spite of the fact that Dye Transfer prints have a low pH, accelerated tests and experience over the last 40 years indicate that the paper support (made from highly refined wood cellulose), gelatin layers, and image dyes of the prints are extremely stable. When protected from light, Dye Transfer prints have the most stable images of any color film or print material made by Kodak. If one were to "de-acidify" a Dye Transfer print by immersion in an alkaline solution, the image dyes would bleed or even wash from the print.

The isoelectric point of the lime-processed gelatins (of which photographic emulsions are normally made) is also in the acid range, typically about pH 5.0.[60] The isoelectric point, "which is characteristic of the kind of gelatin, its method of preparation, and the impurities present, is the point at which the gelatin molecule is most tightly coiled because of the equal number of charge attractions. It is the condition of acidity or alkalinity at which the gelatin molecule is least soluble in water."[61] The significance of this, with respect to the long-term stability of photographs, is not known, but it has been suggested that gelatin may be most stable when the pH is near the isoelectric point.

There is no published information on the softening of gelatin stored at high relative humidities as a function of pH or whether the rate of penetration of airborne pollutants into gelatin (which would be most pronounced when storage humidities are high) is influenced by emulsion pH. Likewise, the long-term effects of pH in terms of gelatin cracking and brittleness are not known. There is also no published information available as to how pH of the gelatin emulsion will be altered when color and black-and-white photographs are in long-term contact with alkaline-buffered paper.

Examination of Historical Print Collections

Examination of historical print collections indicates that in general the paper supports of both albumen and silver-gelatin prints have remained in reasonably good condition, while the silver images are often significantly deteriorated as a result of poor processing, improper washing, humid storage conditions, contact with reactive storage materials, air pollutants, or fungus growths. This suggests that the focus of attention should be on preservation of the *image* and the gelatin emulsion. Assuming an otherwise high-quality paper stock, the pH should probably be selected to promote maximum stability of the silver or dye image and gelatin emulsion.

In 1982 James Reilly reported that Permalife paper promoted yellowing of freshly made albumen prints in accelerated aging tests, and he advised against storing such prints with alkaline-buffered papers.[62] Reilly's further investigation of the problem revealed that it was probably not the calcium carbonate buffering itself that produced the increased rate of yellowing, but rather it was some other, as yet unidentified, constituent of Permalife paper. Pending further research, however, Reilly said he still believed that, all other characteristics of a particular paper or board being equal, it is best to avoid alkaline-buffered products for storage of albumen prints.[63]

In general, there is apprehension about the effects of alkaline-buffered paper on all color photographs, including chromogenic prints such as Agfacolor, Ektacolor, Fujicolor, and Konica Color. There is particular concern over its adverse effects on dye-imbibition prints, including Kodak Wash-Off Relief prints, Kodak Dye Transfer prints, and Fuji Dyecolor prints.

In 1985 Konica reported findings from research on the effects of emulsion pH on the dark fading stability of Konica color paper: "It is well known that acidic pH is the best condition for keeping prints. When the pH of the print surface is between 4 and 5, the cyan dye fading is at a minimum, and yellow stain is limited."[64] As indicated in **Figure 13.1**, increasing the pH of the emulsion from 5.0 to 8.8 approximately doubles the amount of cyan dye loss under the conditions of the Konica tests. Because of interactions between an alkaline-buffered mount board or other paper product in contact with the emulsion of a color print, the pH of the emulsion may be expected to gradually rise to approximately the level of the buffered paper during long-term storage. Conditions of high humidity will accelerate the rate of change.

Accelerated dark fading tests conducted by Henry Wilhelm indicate that in addition to Konica Color Type SR and Type EX prints, the dark fading stability of Ektacolor 37 RC, Ektacolor 74 RC, Fujicolor Type 8908, and many other chromogenic papers is better (i.e., rates of cyan dye fading and/or yellow stain formation are reduced) when the prints are in a mildly acidic rather than alkaline condition. For example, with many chromogenic color papers, the rate of yellow stain formation is drastically reduced when the prints are treated with Kodak Ektaprint 3 Stabilizer, which lowers emulsion pH to less than 4.5. (In spite of the reduced stain formation and increased cyan dye stability afforded by Ektaprint 3 Stabilizer, it should not be used with current color papers — see Chapter 2 and Chapter 5.)

Pending further research the authors of this chapter, Brower and Wilhelm, discourage the use of alkaline-buffered mount boards and papers with all color products. (Boxboards are not normally in direct contact with photographic emulsions, and for this reason the authors believe that there is much less cause for concern about possible adverse effects of an alkaline buffering in such products.) As indicated above, different types of photographic materials quite likely have different "ideal" pH conditions for storage. As a practical matter, however, it would be cumbersome and costly to stock, in every size, thickness, and color, alkaline-buffered mount boards and papers for black-and-white photographs, and a separate but equally complete line of nonbuffered boards and papers for color photographs, to meet the specifications of *ANSI IT9.2-1991.* (To meet the requirements of the ANSI Standard, manufacturers of paper envelopes also would have to supply two complete lines of envelopes; at the time of this writing, no manufacturer had indicated a willingness to do so.) It is hoped that there will eventually be a *single* specification — *that takes into account all the many factors affecting both photographic and paper stability, including pH* — for boards, envelopes, and other paper products for mounting and storing all types of important photographs.

Such a specification, however, cannot be formulated in the immediate future. For example, since it is very difficult to realistically simulate the long-term effects of air pollutants on paper products and, in turn, the effects these materials may have on photographs as they both slowly deteriorate, conclusive recommendations regarding pH alone are not expected soon. Until more information is available, the authors recommend nonbuffered 100% cotton fiber boards and enclosure papers when long-term keeping is contemplated, especially for the display and storage of color prints.

Responding to these concerns, in 1982 the Museum of Fine Arts in Boston, and in 1983 the New Orleans Museum of Art, began to mount the color prints in their collections with nonbuffered 100% cotton fiber board. Since then, many other institutions and individuals have begun to do the same.[65]

Light Fading Stability of Mount Boards

Many mount boards fade or change color during prolonged display, and some are even less stable than Ektacolor and similar color prints when exposed to light. For example, some mount boards eventually lose all color and become white, white boards may turn yellow, a gray board may turn beige, a deep blue board may turn brown, or a dark green board may become light blue. This presents a difficult and often hidden problem for artists, framers, and curators who carefully select the most appropriate and complementary board when mounting a photograph and generally assume that the colors of the mount will remain unchanged.

Table 13.1 was compiled from more than 300 mount and mat boards made in the United States in 1982 and 1983. (In 1985, Rising Paper Company introduced several new "fade-resistant" colored boards to replace those previously available; the authors repeated the tests for a period of 90 days for these boards. Six tones of museum board introduced in 1985 by Crescent Paper Company were also tested and included in this table.) The boards are divided into five types and subdivided into six color-density groups; the boards are then ranked according to the stability of their original color.

The five categories of board are:

(1) 100% Cotton Fiber Boards (solid)
(2) Highly Refined Wood Pulp Boards (solid)
(3) 100% Cotton Fiber Boards (composite)
(4) Highly Refined Wood Pulp Boards (composite)
(5) Standard Wood Pulp Boards (composite)

Solid boards are consistent in color and fiber on both sides and throughout the middle. *Composite* boards are faced and backed with separate sheets of paper, usually white on the back and a toned paper on the top. The top surface papers frequently have a noticeable texture.

The six color groups are:

(A) Whites and Off-Whites	(blue density: 0.03–0.11)
(B) Ivories	(blue density: 0.12–0.20)
(C) Light Colors	(visual density: 0.10–0.33)
(D) Medium Colors	(visual density: 0.34–0.73)
(E) Dark Colors	(visual density: 0.74–1.18)
(F) Blacks	(visual density: 1.30–1.41)

The color groups are determined by the visual or blue filters on a densitometer. Two exceptions are noted in **Table 13.1** with an asterisk. (Red, green, and blue densities vary considerably outside the visual ranges; for ex-

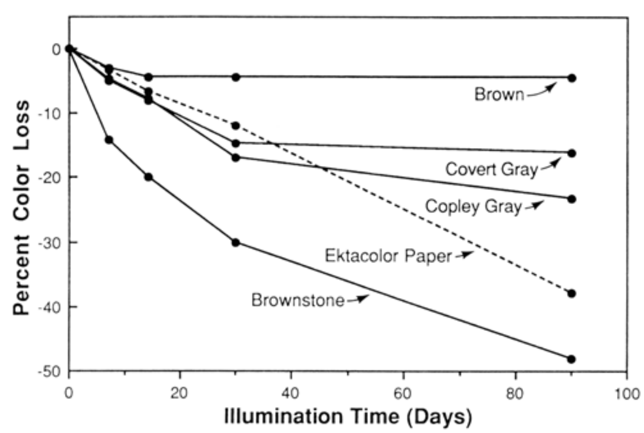


Figure 13.2 The stability of four mount boards subjected to an accelerated light fading test with 21.5 klux (2,000 fc) glass-filtered Cool White fluorescent lamps. The Rising Brownstone color falls into the authors' "extremely poor" category; Crescent Cardboard Copley Gray has "poor" stability; Crescent Cardboard Covert Gray has "fair" stability; and Strathmore Brown has "good" stability. A Kodak Ektacolor Plus print tested under the same conditions is shown for comparison.

ample, Crescent Cardboard Company's Naples Yellow board has a visual density of 0.15 and a blue density of 0.76.)

In judging the relative stabilities of the boards, the authors observed three types of changes: fading, color shift, and yellowing (darkening). Since the authors did not feel it was possible to quantitatively define acceptable amounts of such changes in this test, each board's relative stability was ranked as being good, fair, poor, or extremely poor according to the authors' visual assessment. Because of the even greater difficulty in defining these four stability categories for white and ivory boards, such boards are listed as having either good stability or poor stability; only severely changed boards (i.e., darkened or completely faded) in these two color groups are described as having extremely poor stability. White and ivory boards with very slight changes were considered to have good stability.

As a general guideline, the authors considered colored boards with less than 10% color losses (measured as losses in red, green, and/or blue density) to have good stability; a colored board with a 10–20% loss in color was considered to have fair stability; boards that lost 20–40% of their color were considered to have poor stability; and any board that lost more than 40% of its color or that actually changed color was considered extremely unstable. In general, light-colored and reddish boards achieved lower rankings with somewhat less than these percentage losses, while dark and yellow or greenish boards required greater percentage losses before they were downgraded.

When selecting a mount board, one cannot judge its color stability according to the quality of its fiber or its cost. Many museum boards made of high-quality cotton fiber have remarkably poor color stability while many of the less expensive wood pulp boards have extremely good color stability. Unfortunately, some of the most aesthetically pleasing colored museum boards, such as Crescent Cardboard Company's Rag Mat 100 Antique Tan and Archival Mist, and Rising Paper Company's Gallery Grey, proved to have extremely poor color stability.

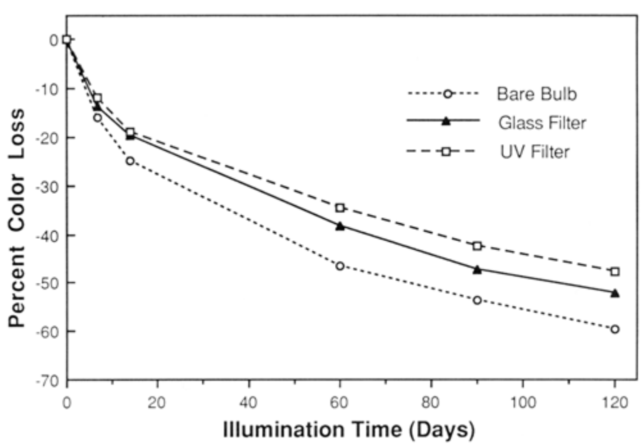


Figure 13.3 Rising Burnt Orange mount board subjected to an accelerated light fading test with 21.5 klux (2,000 fc) Cool White fluorescent lamps under three different spectral conditions. A Plexiglas UF-3 ultraviolet filter afforded only marginal improvement. In all cases the stability of the board was rated "extremely poor."

Some of the best colors for mounting photographs, such as Crescent's Neutral Gray and the various antique tones offered by most of the represented companies, performed equally poorly in these tests. Only 43% of the dyed 100% cotton fiber museum boards (Type 1) had good color stability while 49% were rated poor or extremely poor. Highly refined wood pulp boards (Type 2) fared the worst, with only 39% having good stability and 53% having poor or extremely poor stability. For whatever reasons, the solid museum and conservation boards had inferior color stability when compared with the three other types of boards. All 28 colors of Crescent Cardboard Company's Rag Mat composite boards (Type 3) had good stability. It was surprising to find that 59% of the lowest-quality, so-called standard or regular boards (Type 5) had good color stability while only 30% had poor or extremely poor color stability. Overall, 60% of all the tested boards had good stability, 7% had fair stability, 15% had poor stability, and 18% had extremely poor stability.

Manufacturers' Claims About Color Stability Are Frequently Meaningless

Manufacturers have been an unreliable source of meaningful information regarding the color stability of their boards. In the PPFA 1986 Survey on Mat/Mount Boards,[66] most companies cited various lab tests, but the results of these tests cannot be interpreted or applied by most board consumers without further information. For example, Nielsen & Bainbridge Alphamat boards were listed as being tested with the "Fade resistance Carbon Arc Fade-O-Meter (80 hr. ASTM G-25)." This fact is not meaningful to the average framer. Did Crescent Cardboard Rag Mat boards pass, did they fail, or were they simply subjected to the "80-hour fade"? Columbia Corporation provided somewhat more useful information by stating that its Museum Mounting Board 100% Rag "withstands 80 hours Fade-O-Meter exposure without fading." But how is one to know how well a particular board color will hold up compared to another?

Some of the manufacturers' advertising and promotion literature is equally uninformative, and even misleading. Miller Cardboard's specifications for the surface papers of its Ultimat boards included, "Direct dye or iron oxide to ensure bleed and fade resistance," while Rising claimed that its museum and Conservamat boards are "fade resistant." In a letter to the authors (April 25, 1986), Crescent Cardboard Company wrote, "The Crescent Rag Mat Museum Board . . . high quality surface papers are . . . completely fade resistant." While it is true that Crescent's faced "museum" boards proved to have excellent color stability, the company's Rag Mat 100 museum boards were shown to be among the least stable. In a product sample folder, both types of boards are described as "fade resistant," while the Regular Mat Board is said to have surface papers which are "highly resistant to fading."

Although only one Alphamat color (Garnet) faded more than 10% in Carol Brower's tests, Bainbridge overstated the color stability of its Alphamat Board, which it claimed "Offers complete resistance to fade, discoloration, bleeding and deterioration" (1984 Framing Colors and Textures from Bainbridge brochure). Unlike other companies, however, Bainbridge made no claims regarding the fade resis-

(continued on page 477)

Table 13.1 Comparative Light Fading Stability of Mount Boards

1. Solid 100% Cotton Fiber Boards

a. Whites and Off-Whites

Good Stability:
- LI Non Buffered (same board as Process Materials below)**
- PA Photographic (white)**
- PM Photographic (off-white)**
- RS Photomount (white)**
- ANW Lenox (white)
- ANW Gemini (off-white)
- CC White
- CC White Linen
- JR White
- LI Bright White
- LI Westminster Natural White
- MC Shell White
- N&B White
- PA Brite White
- PA Soft White
- PM Pure White
- PM Off White
- RS White
- STR White
- STR Natural

Poor Stability:
- CC Off-White
- CC Antique White
- LI Antique White
- MC Off White
- MC Warm White
- MC Ivory
- PA Antique
- PM Warm White
- RS Warm White

Extremely Poor Stability:
- MC White (d)

b. Ivories

Good Stability:
- ANW W & A
- JR Ivory
- PM Metropolitan Antique Cream
- STR Creme

Poor Stability:
- ANW Antique
- CC Antique White
- CC Antique White Linen
- CC Cream
- CC Cream Linen
- LI Ivory
- N&B Ivory

2. Solid Highly Refined Wood Pulp Boards

a. Whites and Off-Whites

Good Stability:
- ANW White
- JR Cream
- LI Gallery White
- N&B White
- RS Snowhite
- RS White

Poor Stability:
- MC Acid Free (white)
- PM Extra White

b. Ivories

Good Stability:
- PM Ivory
- PM Special Cream

Poor Stability:
- N&B Ivory
- RS Ivory

c. Light Colors

Good Stability:
- ANW Seashell

Extremely Poor Stability:
- PM Light Gray (f)
- RS Pearl Gray (f)
- RS Beige (f)
- RS Fawn (f)
- RS Light Green (fc)

d. Medium Colors

Good Stability:
- ANW Desert Tan
- ANW Gray-Grey

Fair Stability:
- ANW Blue Granite
- RS Bluestone

Extremely Poor Stability:
- RS Dark Green (f)
- RS Neutral Gray (f)
- RS Mustard* (0.20) (f)
- RS Kraft (fc)
- RS Tan (fc)

e. Dark Colors

Good Stability:
- ANW Taupe* (0.67)
- ANW Dark Gray

Fair Stability:
- RS Dark Gray

3. 100% Cotton Fiber Boards with Facing Sheets

a. Whites and Off-Whites

Good Stability:
- CC Palm Beach White

b. No Ivories Tested

c. Light Colors

Good Stability:
- CC Chamois Gold
- CC Dawn Gray
- CC French Buff
- CC India
- CC Mist
- CC Pearl
- CC Sand
- CC Sandstone

d. Medium Colors

Good Stability:
- CC Bar Harbor Gray
- CC Biscay Blue
- CC Copley Gray
- CC Las Palmas Green
- CC Oak Brown
- CC Pewter
- CC Rust
- CC Storm Blue
- CC Suntan

e. Dark Colors

Good Stability:
- CC Avocado
- CC Dark Gray
- CC Newport Blue
- CC Redwood
- CC Russet
- CC Sable
- CC Sepia
- CC Tampico Brown
- CC Williamsburg Green

f. Blacks

Good Stability:
- CC Raven Black

4. Highly Refined Wood Pulp Boards with Facing Sheets

a. Whites and Off-Whites

Good Stability:
- MC Dove
- N&B Snowflake
- N&B Photo White
- N&B Talc

b. No Ivories Tested

c. Light Colors

Good Stability:
- N&B Almond
- N&B Cashmere
- N&B Celadon
- N&B Chamois
- N&B Fairfield White
- N&B Goldenrod
- N&B Heather Mist
- N&B Khaki
- N&B Malacca
- N&B Mimosa
- N&B Moroccan Sand
- N&B Neutral Grey
- N&B Nimbus
- N&B Sea Mist
- N&B Shadow Blue
- N&B Teal Grey

Extremely Poor Stability:
- MC Balique (f)
- MC Beige (f)
- MC Blue Art (f)
- MC Pearl (f)
- MC Tawny (f)
- MC Putty (fc)
- MC Sauterne (fc)

d. Medium Colors

Good Stability:
- N&B Adobe Brown
- N&B Annapolis Blue
- N&B Antique Brass
- N&B Arabesque
- N&B Baltic Green
- N&B Brittany
- N&B Burnished Gold
- N&B Calabash
- N&B Cascade Grey
- N&B Catawba
- N&B Chelsea Blue
- N&B Cobblestone
- N&B Dijon
- N&B Emberglow
- N&B Flemish Blue
- N&B Grey Flannel
- N&B Kirkwood

5. Standard Board Made of Wood Pulp Core with Facing Sheets

a. No Whites or Off-Whites

b. No Ivories Tested

c. Light Colors

Good Stability:
- CC Antique Buff
- CC Chamois Gold
- CC Cool Gray
- CC Dawn Gray
- CC French Blue
- CC French Gray
- CC French Lilac
- CC Limestone
- CC Madagascar Pink
- CC Mist
- CC Olde Tan
- CC Paris Green
- CC Peach
- CC Pearl
- CC Sauterne

Fair Stability:
- CC Naples Yellow

Poor Stability:
- CC Cameo Rose (fc)
- CC Daffodil (f)
- CC Doeskin (f)
- CC India (f)
- CC Yellow (f)

Extremely Poor Stability:
- CC Diamond Blue (dc)
- CC Sandstone (f)

d. Medium Colors

Good Stability:
- CC Azure
- CC Bar Harbor Gray
- CC Blue Gray
- CC Bonanza Gold
- CC Camel
- CC Celery
- CC Dusk
- CC Inca Gold
- CC Las Palmas Green
- CC Mauve
- CC Mist Gray
- CC Moss Point Green
- CC Oak Brown
- CC Oriental Red
- CC Pewter
- CC Redstone
- CC Rust
- CC Saddle Tan
- CC San Fernando Gold
- CC Sand
- CC Stone Gray
- CC Suntan

PA	Ivory
RS	Antique
RS	Cream
RS	Natural
UP	Ivory

c. Light Colors

Good Stability:

PM	Graytone
PM	Ashtone

Fair Stability:

STR	Light Gray (c)

Poor Stability:

PM	Peachtone (fc)

Extremely Poor Stability:

CC	Antique Tan (fc)
CC	Archival Mist (fc)
CC	Desert Sand (fc)
CC	Neutral Gray (fc)
CC	Olde Ecru (fc)
CC	Vintage Gray (fc)
PA	Grey (f)
PA	Dark Grey (f)
PA	Tan (f)
RS	Gallery Gray (f)
RS	Fawn (f)
RS	Zinc (f)
STR	Pink (fc)

d. Medium Colors

Good Stability:

MC	Greige (same as Strathmore Gray below)
MC	Jasper (same as Strathmore Green below)
STR	Brown
STR	Gray
STR	Green

Fair Stability:

MC	Lapis (same as Strathmore Blue below)
PM	Florentine Tan
PM	French Blue
STR	Blue
STR	Tan

Poor Stability:

MC	Sable (c)

Extremely Poor Stability:

MC	Sandlewood (fc)
RS	Brownstone (f)

e. No Dark Colors Tested

f. Blacks

Good Stability:

MC	Black
PM	Black
STR	Black

Extremely Poor Stability:

PM	Ash Gray (fc)
RS	Brick Red (f)
RS	Burnt Orange (f)
RS	Chocolate (fc)
RS	Deep Blue (fc)

f. Blacks

Good Stability:

ANW	Black

Note: This table was compiled from more than 300 mount and mat boards made in the United States in 1982 and 1983 (see pages 473–478 for discussion). These products and others currently on the market may have very different light fading characteristics.

Letters follow all poor and extremely poor rankings to indicate what type of change was observed: fading (f); color change (c); yellowing or darkening (d). Boards are listed alphabetically in each column according to the manufacturer or distributor and not according to performance. Board color names (capitalized) are those of the associated company. The two colors marked with a single asterisk have a visual density reading outside the above given ranges for their assigned groups. The first four boards on the list (marked with two asterisks) are nonbuffered "photographic" boards.

Companies represented:

ANW	Andrews/Nelson/Whitehead
CC	Crescent Cardboard Company
JR	James River Corporation
LI	Light Impressions Corporation
MC	Miller Cardboard Company
N&B	Nielsen & Bainbridge
PA	Parsons Paper Company
PM	Process Materials Corporation
RS	Rising Paper Company
STR	Strathmore Paper Company
UP	University Products Corporation

N&B	Martinique
N&B	Pampas
N&B	Photo Grey
N&B	Pistache
N&B	Sonora
N&B	Spice
N&B	Sultan Sand
N&B	Weathered Oak
N&B	Windsor Tan

Extremely Poor Stability:

MC	Green Mist (f)
MC	Gulf Blue (f)
MC	Honey (f)
MC	Mica (f)
MC	Tangerine (f)
MC	Taupe (f)
MC	Moss Green (fc)

e. Dark Colors

Good Stability:

N&B	Almandine
N&B	Ash
N&B	Brianwood
N&B	Carmine
N&B	Chutney
N&B	Clove
N&B	Dover Grey
N&B	Indigo
N&B	Jasmine
N&B	Regatta
N&B	Sorrel
N&B	Tartan Green
N&B	Tuscan Brown

Fair Stability:

N&B	Garnet
MC	Charcoal

Poor Stability:

MC	Dark Blue (f)
MC	Navy (f)
MC	Ivy Green (fc)

Extremely Poor Stability:

MC	Brick (f)
MC	Russet (f)

f. Blacks

Good Stability:

N&B	Ivory Black

Poor Stability:

MC	Black (f)

Fair Stability:

CC	Bimini Blue
CC	Congo Green (c)
CC	Covert Gray
CC	Light Gray
CC	Lime

Poor Stability:

CC	Biscay Blue (f)
CC	Copley Gray (f)
CC	Cypress (f)
CC	Ex Light Gray (f)
CC	Gibraltar Gray (f)
CC	Kelly Green (fc)

Extremely Poor Stability:

CC	Burnt Orange (f)
CC	Cinnamon (f)
CC	Colonial Orange (f)
CC	Coral (f)
CC	Olive Gray (f)
CC	Persimmon (f)
CC	Pompeian Red (f)
CC	San Vincente Orange (f)

e. Dark Colors

Good Stability:

CC	Avocado
CC	Baltic Blue
CC	Dark Gray
CC	Delft Blue*
CC	Las Cruces Purple
CC	Madeira Red
CC	Marine Blue
CC	Newport Blue
CC	Nutmeg
CC	Pyro Brown
CC	Riviera Rose
CC	Russet
CC	Sable
CC	Sepia
CC	Storm Blue
CC	Volcano Blue
CC	Williamsburg Green

Fair Stability:

CC	Chinese Red
CC	Chocolate
CC	Dark Green
CC	Ivy Green

Poor Stability:

CC	Boulder Brown (f)
CC	Fudge (f)
CC	Malay (fc)
CC	Redwood (fc)
CC	Wine (f)

Extremely Poor Stability:

CC	Tampico Brown

f. Blacks

Good Stability:

CC	Raven Black

Extremely Poor Stability:

CC	Smooth Black (fc)

tance or light fastness of its Alpharag or Alphamount boards.

Vera G. Freeman, former manager of the Art Paper Department at Andrews/Nelson/Whitehead, responded to Carol Brower's inquiry on the subject of color stability in a letter dated July 14, 1982: "We do have test data on dye stability, but since it seems to vary with every making, we do not publish such findings in order not to misguide the public."

In promotional literature distributed in 1982 by Process Materials Corporation (which in 1990 became the Archivart Division of Heller & Usdan, Inc.), the company announced: "New . . . acid-free mat board in 14 compatible colors . . . that last." And in 1984: "Archivart Museum Board . . . light-fastness is assured by manufacturing specifications which yield resistance to fading at least five times that of other colored mat boards." Arno Roessler, former president of Process Materials (and currently president of Paper Technologies, Inc.), said in a panel discussion published in the November 1984 *Art Business News:*

> Producing conservation color paper is a complicated process and it depends on the manufacturer because to get it in the alkaline range you use a completely different approach, [you] are restricted, and cannot simply make every color as you please. There are different dyes you can use that lend themselves to making acid-free boards and color . . . . Most good quality colored boards are really pigmented.

Kurt R. Schaeffer, former product planner for Strathmore Paper Company, also responded to inquiry in July 1982: "We conduct a test to determine the fade resistance of our Museum Mounting Board. The test is conducted with an Enclosed Violet Carbon Arc. The industry wide standard considers a 20 hour fade test without any fade to be excellent."

As **Table 13.1** shows, stability can vary considerably within each group even among the best available products, such as Strathmore Museum Boards. It is apparent that a new, standardized test for evaluating the light fading stability of mat and mount boards is required — a test that simulates the spectral distribution of typical indoor illumination conditions. Different levels of stability need to be defined, and limits of acceptability need to be set. As a beginning, the authors recommend adoption of the 6 klux temperature- and humidity-controlled glass-filtered fluorescent light fading test specified in the new *ANSI IT9.9-1990* color stability test methods Standard.[67] Furthermore, because information supplied by the paper manufacturers and distributors is often essentially meaningless to the consumer, manufacturers are urged to provide more reliable (and comprehensible to the average consumer) information with the boards they sell.

Test Procedures

In preparing **Table 13.1**, Carol Brower exposed boards to high-intensity 21.5 klux (2,000 fc), Philips 40-watt Cool White Fluorescent Lamps (F40CW) with two lamps per fixture for a total of 120 days. The surface temperature of the samples was approximately 85°F (29.4°C) and because of the heating of the samples, the moisture content can be assumed to have been very low. The board samples were covered with window glass to absorb ultraviolet radiation below about 330 nanometers (the 313 nanometer mercury emission line radiated by the lamps, which can cause greatly increased rates of fading in some dyes used to color mount boards, is completely absorbed by the glass).

Each board was read for density changes in the visual, red, green, and blue spectrum ranges at intervals of 7, 14, 60, 90, and 120 days. A densitometer was used for this study instead of a color difference meter so that the results could be compared to fading data on color photographs. The densitometer was a Macbeth TR924 equipped with Status A filters, which were designed for use with color photographs. Zero density was calibrated on a porcelain plaque supplied by the manufacturer. The potential error of the readings was approximately ± 0.01 for any given measurement; this is of particular importance when judging the relative stability of white, ivory, and very light-colored boards as well as when calculating the changes in all low-density measurements.

Manufacturers' Efforts to Meet Photography Conservation Requirements

All manufacturers (and major distributors) of high-quality mount boards are aware of at least some of the concerns related to photographic conservation.[68] (See **Appendix 13.1** [Letter to Paper Manufacturers].) At the time of this writing, however, no paper manufacturer had performed tests to determine the effects of its products on even the most common photographic materials nor confirmed that its products meet the many requirements given in *ANSI PH1.53-1986* (essentially the same requirements are specified in the current *ANSI IT9.2-1991* Standard). Chi C. Chen, technical director at Rising Paper Company, said that many paper manufacturers do not believe they have a responsibility to conduct such tests. In Chen's opinion, people who buy the products, and particularly people working in the field of photographic conservation, bear the responsibility for testing them and for recommending specifications to the manufacturer.

Other paper companies concurred with this view. For example, Joseph B. Fiedor, general manager of Crescent Cardboard Company, made the following comment about requests for nonbuffered mount boards:

> We supply what people want. It's a question of demand. For example, our boards were once made without the addition of alkaline-buffering agents. The pH was below 7.0. But in recent years there has been great demand for buffered boards and so we began to add buffering agents. Now we strive for a pH that is above 7.5 at the time of manufacture as demanded by the market. The [future] direction we take will be based first on the research of people such as James Reilly in Rochester.[69]

Speaking for Process Materials Corporation (now the Archivart Division of Heller & Usdan, Inc.), marketing manager Robert Stiff said:

> Manufacturers have to be told what the photographic conservation field is looking for. Conservators must initiate specifications for new products — "We need a product that will do this." There has to be a consensus of opinion and then we will try to meet the stated requirements. Naturally that involves testing on our part to know that our products meet those specifications. It's wholly a matter of cooperation between the manufacturers and those in the marketplace.[70]

Nonbuffered Photographic Storage Paper and Mount Board Made by Atlantis Paper Company: An Enlightened Approach to Meeting Users' Needs

Of all the paper companies producing high-quality mount boards and papers for conservation purposes, the Atlantis Paper Company Limited, located in London, England,[71] appears to be making the greatest effort to address the specific needs of the photographic conservation field. Founded in 1978 by Stuart Welch and David Brown, who at the time were both working artists and teachers in London art schools, Atlantis initially supplied artists, printmakers, and students with papers for watercolor, printing, and drawing.

It is immediately evident from the Atlantis catalog that the company furnishes its customers with a more complete list of product specifications than is usually given by other distributors. According to Atlantis, "The idea of giving information about our products is two fold, one to supply information to the best of our knowledge about the products to assist the conservator in his or her work, and to help educate and relate information about paper, and paper conservation and preservation, to practicing artists and paper users who otherwise have little or no access to information on the materials they use."[72]

In 1983, in response to needs expressed by British paper and photograph conservators Ian and Angela Moor and others in the conservation field, Atlantis introduced Silversafe Photostore, a very smooth, white, nonbuffered 100% cotton fiber paper that is probably the first high-quality paper ever designed specifically for making photographic storage envelopes and enclosures. Available in four different weights, the paper is also intended for interleaving prints and negatives. The paper is Fourdrinier machine-made at St. Cuthbert's Paper Mill, Somerset, England. The paper is presently used as a negative enclosure and interleaving paper by a number of museums, including the J. Paul Getty Museum in Pasadena, California. Atlantis Silversafe Photostore may be ordered directly from Atlantis, or through the Archivart Division of Heller & Usdan, Inc. or Paper Technologies, Inc.[73]

Ian and Angela Moor collaborated with Atlantis in developing the specifications for the paper, which embodies all of the qualities they could identify as important for the long-term preservation of photographs. The specifications for the paper, as given in the 1991 Atlantis catalog, are:

- 100% cotton fiber from purest cotton linters
- Passes Silver Tarnish Tests
- Passes ANSI photographic activity test IT9.2
  Criterion 1: Fading of colloidal silver detector
  Criterion 2: Staining of gelatin/photographic paper detector
  Criterion 3: Mottling of colloidal silver detector
- Sized with neutral curing ketene dimer
- Reducible sulfur: less than 0.2 parts per million
- Qualitative test for chloride – negative
- Gurley test to assess porosity where airflow can be beneficial:
  40gsm (before calendering) 3.5 sec;
  (after calendering) 10 sec;
  120 gsm (before calendering) 11 sec;
  (after calendering) 55 sec.
  The higher the figure the less porous the paper expressed as sec/100ml/sq. in.
- pH: 6 by cold demineralised extract
- Ash content: 40 gsm 0.025%
  120 gsm 0.019%
- No added alkaline buffering agents
- Supplied long grain
- Smooth surface
- Available in four weights
- White colour, free from Optical Brightening Agents

Atlantis also supplies a line of 100% cotton fiber mount boards under the Atlantis 100% Cotton Museum Board name. In 1985 the company introduced Atlantis 100% Cotton Museum Board TG Offwhite (initially called Heritage Museum Board TG Offwhite) for the mounting and conservation of photographs. "In line with current opinion," according to Atlantis, the board has a pH of about 7.0 at the time of manufacture and is not buffered. Atlantis 100% Cotton Museum mount board stock is sized with the same alkyl ketene dimer sizing agent used in Silversafe Photostore; in addition, the mount boards are "lightly" surface-sized with a modified non-ionic farina starch.

The board plies are laminated with a V.A.E. polymer adhesive, which contains no plasticizer and is about pH 7.0. According to Atlantis, selection of the V.A.E. adhesive was based on the following criteria:

1. Since pH is of primary importance we considered a V.A.E. polymer better than P.V.A. [polyvinyl acetate] since they are less susceptible to hydrolysis and release of acetic acid. As a further precaution the system is neutralized by a small proportion of ½% calcium carbonate to absorb any acetic acid should it be formed, thereby maintaining the neutrality of the glue line. This should not be considered as a normal buffer as we are not looking for an alkaline product.

2. There is a small possibility that any plasticizer present could migrate and adversely affect the material in contact with the board and hence this is avoided by the omission of any plasticizers in the formulation of this adhesive.

3. Chloride and sulfur content should be as low as possible. After coating a layer of the base paper used for the Atlantis 100% Cotton Museum Board with a film of our V.A.E. adhesive, allowing it to dry and then testing directly against the adhesive for Silver Tarnish using a standard test, the results were totally satisfactory: i.e., no tarnish at all. Included in the formula of this adhesive is less than ½% of Ortho Phenyl Phenol which is included as a preservative to prevent mold growth and bug attack. This additive has the advantage that it continues to protect the adhesive from this kind of attack in its dry state after lamination. The formula for the adhesive was arrived at after lengthy discussions with both conservators and adhesive chemists.[74]

Atlantis, unfortunately, has declined to identify either the specific adhesive or its manufacturer, citing "competitive reasons." However, Stuart Welch, a director of the company, commented, "I should say that if it can be shown that a better adhesive exists we would have no hesitation using it. We try to work as closely as possible with conservators and conservation scientists and rely very much on their advice and help to produce the best possible products. All of our fine art and archival products are in a constant state of development according to the ever changing requirements of our customers, and advances in the 'State of the Art' of paper-making technology."[75]

Welch also said that Atlantis would be willing to disclose the name of the adhesive manufacturer to "institutional conservators" if they wrote to Atlantis on their official letterhead and "are able to persuade Atlantis that this information is essential in solving a problem in their work."[76]

Atlantis claims that Atlantis 100% Cotton Museum boards are "light fast," equal to or better than a Blue Wool Scale No. 5 rating. (The authors presently do not have the data necessary to compare the light fading stability of Atlantis 100% Cotton Museum boards with other available white and near-white boards; however, the fact that Atlantis publishes such information is noteworthy.)

Atlantis says that its papers and boards intended for photographic applications are tested with a silver tarnish test at St. Cuthbert's Paper Mill as part of routine quality control. All Atlantis products intended for museum and archive applications are made by St. Cuthbert's "using the pure water source of the River Axe directly as it leaves the underground complex of caves at Wookey Hole, in the Mendip Hills. The pipework throughout the mill is stainless steel ensuring no rust, oxidization or contamination of the water source or stock during the manufacturing process."[77]

Other Suppliers of High-Quality Boards and Papers

Process Materials Corporation (now the Archivart Division of Heller & Usdan, Inc.) was the first paper company to respond to reservations in the photographic conservation field regarding alkaline-buffered boards. In November 1981, as an outcome of discussions between Arno Roessler (who at the time was president of Process Materials), the authors, and others, the company introduced Archivart Photographic Board: "This board has been manufactured specifically for photographic use, for such applications where the alkaline environment of Archival Quality Matboards is considered to be undesirable. This board comes in an off-white color and is manufactured from selected 100% cotton fiber in the neutral pH range, without any alkaline reserve[78] or buffering."[79,80] According to Archivart, the pH value of Archivart Photographic Board at the time of manufacture is between 6.5 and 7.5, which may be expected to drop somewhat with time as the board is exposed to normal atmospheric conditions.

Archivart regularly publishes technical bulletins, which, along with samples of the products, are sent to anyone who requests them. The company also publishes "discussions" in its *Paper and Preservation* series, invites comments on its literature and products, and has for many years demonstrated an interest in educating and working with its customers. Unfortunately, Archivart has declined to identify the manufacturer of its mount board, and for this reason its use in long-term photographic applications cannot currently be recommended by the authors. The importance of identifying the manufacturing mill of a paper product for conservation purposes is discussed in this chapter and in Chapter 12.

In 1982 Rising Paper Company introduced a white, nonbuffered 100% cotton fiber board called Rising Museum Photomount. The company stated, "It is for use with photographic prints where excessive alkalinity should be avoided."[81] The board is made at the Rising paper mill in Housatonic, Massachusetts. Rising Museum Photomount is one of the boards tentatively recommended for photographic applications by the authors.

Parsons Paper Company introduced a line of 100% cotton fiber mount boards in mid-1983. Among them is a nonbuffered 4-ply board called Photomounting Board, which is available in two tones: white and antique. Made at the Parsons Paper Company mill in Holyoke, Massachusetts, Photomounting Board is tentatively recommended by the authors for photographic applications. A/N/W-Crestwood Paper Company in New York City and University Products, Inc. in Holyoke sell the Parsons line of museum and photographic mount boards under their own names.

Process Materials Corporation (now the Archivart Division of Heller & Usdan, Inc.) introduced Archivart Photographic Storage Paper in 1983. Made from wood cellulose, the paper has an exceptionally smooth finish without being shiny, is neutral in pH, is nonbuffered, and is claimed to be sulfur free. Also in 1983, Light Impressions Corporation introduced a nonbuffered, neutral-pH product called Renaissance paper, developed specifically for storing albumen and color prints.[82] Both papers are suitable for making mounting corners and negative envelopes, and also as interleaving papers, depending on the selected weight. However, as neither Archivart nor Light Impressions would identify the manufacturers, the papers cannot be unequivocally recommended.

Conservation Resources International, Inc. supplies a nonbuffered, sulfur-free, high-alpha-cellulose wood-pulp paper called Lig-free Photographic Enclosure Paper that is recommended by the company for “archival photographic enclosures.”[83] Conservation Resources has declined to identify the manufacturers of the company's paper and board products.

In 1985, Andrews/Nelson/Whitehead introduced a smooth-surfaced, white, nonbuffered 100% cotton fiber board called Photographic Board, available in 2-ply and 4-ply thicknesses. The company, however, declined to reveal the name of the manufacturer(s) of the board. Later that year Process Materials Archivart Photographic Board became available in white. A comprehensive list of mount board manufacturers and distributors can be found at the end of Chapter 12.

Summary of Recommendations

Museum and Archive Collections

Given the lack of unbiased information on which mount boards and papers are most suitable for photographic applications, and on what pH levels are best, the authors believe the safest course for museum and archive collections to follow at present is to choose nonbuffered 100% cotton fiber boards and enclosure papers for all types of important photographs. Until the consequences have been thoroughly investigated, it is probably unwise to subject photographs to a potentially major alteration of normal emulsion and support pH levels, which may occur as a result of prolonged contact with alkaline-buffered materials. It is particularly important to use nonbuffered, neutral-pH boards with color photographs.

Although nonbuffered 100% cotton fiber mount boards are available from a number of distributors, the authors currently recommend only Atlantis 100% Cotton Museum Board TG Offwhite, Parsons Photographic Board (Brite White and, for some applications, Antique), and Rising Photomount Museum Board (White). At present, direct contact between colored boards and photographs should be avoided if possible, and black boards should not be used.

The authors also recommend Atlantis Silversafe Photostore (available directly from Atlantis in England) for interleaving sheets, storage envelopes, and mounting corners, depending on the selected weight and application. [Archivart product manager Robert Stiff said his company supplies a high quality interleaving tissue similar to Silversafe called Archivart Photo-Tex Tissue, which is also made with 100% cotton fibers and is nonbuffered; Stiff said that this paper has passed the ANSI Photographic Activity Test.]

Photographers, conservators, and other individuals may, of course, have specific preferences in paper and board surface characteristics, tone or color, and handling characteristics that will not be met by the recommended products. The user will have to make the final decision about what is best according to his or her specific requirements in each individual circumstance.

The recommendations given here are based on a studied examination of available information (which, unfortunately, includes scant test data that would permit more conclusive evaluations) and represents the authors' best opinion about which products are most likely to be satisfactory in long-term preservation. As more information becomes available, and new papers and mount boards which meet the strict requirements of photographic conservation are marketed, the range of thicknesses, surface textures, and tones will certainly become broader.

Black-and-White Photography

When black-and-white prints have been processed correctly (treatment with Kodak Rapid Selenium Toner or other protective toner is recommended) and image permanence is an important consideration, nonbuffered 100% cotton fiber boards and papers are recommended.

It is particularly important to choose good-quality mount board if prints are to be dry mounted or otherwise permanently attached, because it is highly unlikely that the print and board will ever be separated. If museum boards are deemed too expensive, good-quality “conservation” boards may be a suitable option. Because Atlantis, Parsons, Rising, and Strathmore are the only companies to market positively identifiable boards, the authors tentatively recommend their conservation boards despite the fact that they are alkaline-buffered.

Low-cost boards with gray chipboard cores (usually with white facing paper on one side) should be avoided at all times; these and other groundwood boards with a high lignin content are not suitable for even short-term contact with black-and-white photographs. The presence of groundwood can easily be detected with the Tri-Test Spot Testing Kit for Unstable Papers,[84] available from Light Impressions Corporation, the Professional Picture Framers Association, and other suppliers.

With most low-quality mount boards, alkaline buffering is probably an advantage, both for black-and-white and color prints. The authors currently believe that the potential for harm to photographs caused by the alkaline buffer is probably more than offset by the increased life and reduction in harmful emissions from low-quality boards afforded by alkaline buffering. When colored boards are required, the most light-stable boards available should be selected (see **Table 13.1**). At present, black boards should be avoided.

Color Photography

For most Fujicolor, Ektacolor, Konica Color, and similar chromogenic color prints intended for display, such as those produced by portrait and wedding photographers, the choice of mount board is less important because the useful life of the prints will be limited by the instability of their dye images when exposed to light. The mount board should, of course, maintain adequate stiffness and freedom from warping. The “standard” mat boards supplied by Crescent Cardboard Company, Nielsen & Bainbridge, and others appear to be satisfactory. If colored mount boards are needed, however, those with poor light fading stability should be avoided (see **Table 13.1**).

When color prints are intended for long-term storage without extensive display, they should be mounted on high-stability nonbuffered boards or stored in high-quality envelopes made of nonbuffered paper or uncoated polyester (see Chapter 14).

Truth-in-Labeling Recommendations

In the case of high-quality mount boards, artists' papers, and other papers for storing or displaying photographs, the authors recommend that every manufacturer and distributor identify the particular paper mill making the product and supply relevant information about the composition and method of manufacture, including any tests done to assure its suitability for photographic applications.

By manufacturing their respective photographic boards at only one mill, Atlantis Paper Company, Parsons Paper Company, and Rising Paper Company avoid a significant source of product variability that results when distributors periodically change paper mills. With "private label" mount boards and other paper products, consumers usually have no idea of where, or by whom, they were made. As one employee at Light Impressions Corporation commented with regard to the company's products, "We jump around among a lot of suppliers — it all depends on price and availability."

Privately labeled mount boards can have two origins. A distributor may purchase a "ready-made" board from a paper mill and then affix its own label. Thus, the board may be identical to that sold by other distributors — all under different names. When a distributor changes suppliers, it usually keeps the same private label name for a different board made by a different manufacturer.

Some distributors have board manufactured according to their own specifications, but may change mills from time to time in response to price and other considerations. Depending on how detailed the specifications are — and how strictly they are adhered to — this may not be much different in practice than simply putting a private label on a "ready-made" product. In all these cases, the customer has no way of knowing which mill made the board and will, in most instances, also be unaware of significant alterations in the specifications, such as a change in laminating adhesives. Perhaps more important is that test results cannot be applied to subsequent batches. For example, when a mount board is subjected to the *ANSI IT9.2* Photographic Activity Test, results may be meaningless if the "same" board is, at one time or another, also made at another mill. The practice of private labeling is discussed at greater length in Chapter 12.

Parsons Paper Company and Rising Paper Company are themselves manufacturers of the products that bear their names. Atlantis Paper Company Limited is a distributor, not a manufacturer; however, all of the Atlantis products intended for photographic conservation are made at the St. Cuthbert's Paper Mill, according to specifications formulated by Atlantis in collaboration with St. Cuthbert's — and the products are clearly marked as such.

The practice of private labeling for the purpose of obscuring the real manufacturer — in order to create the impression that the board or paper is available from only one source — is a disservice to customers and makes meaningful independent evaluation, with the ANSI Photographic Activity Test and other recognized test methods, impossible. The authors strongly disapprove of the marketing of mount boards and papers for which the actual manufacturer, brand name, and complete specifications are not openly stated.

Information That Should Accompany Every Package of Paper and Mount Board:

1. Distributing or retailing company
2. Manufacturing company and mill location
3. Date of manufacture and manufacturer's lot number
4. Converting company
5. Fiber origin (e.g., cotton fibers, wood fibers)
6. The pH range (including maximum and minimum pH)
7. Percent (reserve) and type of alkaline buffering agent, if used
8. Level of reducible sulfur compounds
9. Tests conducted, if any, to determine photographic image reactivity with color and black-and-white photographs
10. Types and brands of internal and surface sizing agents
11. Type and brand name of laminating adhesives
12. Light fading stability
13. Types of dyes, pigments, and mordants, if used
14. Types of fluorescent brighteners, if any
15. Tests conducted to determine physical strength (e.g., the Mullen test to determine bursting strength, the Elmendorf test to determine tearing strength)

Notes and References

1. See, for example: Debbie Hess Norris, "Platinum Photographs: Deterioration and Preservation," **PhotographiConservation,** Vol. 7, No. 2, June 1985, p. 1.
2. George T. Eaton, "Photographic Image Oxidation in Processed Black-and-White Films, Plates, and Papers," **PhotographiConservation,** Vol. 7, No. 1, March 1985, pp. 1, 4.
3. Eastman Kodak Company, **Conservation of Photographs** (George T. Eaton, editor), Kodak Publication No. F-40, Eastman Kodak Company, Rochester, New York, March 1985, p. 106.
4. American National Standards Institute, Inc., **ANSI PH1.53-1984, American National Standard For Photography (Processing) – Processed Films, Plates, and Papers – Filing Enclosures and Containers for Storage**, Sec. 5.1, p. 10, American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-642-4900; Fax: 212-302-1286. This Standard is now obsolete and has been replaced by **ANSI IT9.2-1991** (see Note No. 8 below). The Photographic Activity Test described in **ANSI PH1.53-1984** is different from the primary test specified in **ANSI IT9.2-1991**.
5. James M. Reilly, Evaluation of Storage Enclosure Materials for Photographs Using the ANSI Photographic Activity Test, Final Narrative Report of Accomplishment for National Museum Act Grant #FC-309557 (Administered by the Smithsonian Institution, Washington, D.C.), March 1984. See also: James M. Reilly, Care and Identification of 19th-Century Photographic Prints, Kodak Publication No. G-2S, Eastman Kodak Company, 343 State Street, Rochester, New York 14650, 1986 (pH and other considerations of mount boards and other paper products used with albumen prints, cyanotypes, platinotypes, and other kinds of 19th-century photographs are discussed on pages 93–94).
6. James M. Reilly, Rochester Institute of Technology, telephone discussion with Henry Wilhelm, September 27, 1984.
7. In continuing support of James Reilly's research on improved test

methods for storage materials, Rochester Institute of Technology (RIT) received a grant in 1984 of $15,000 from the National Museum Act (NMA) grant program administered by the Smithsonian Institution. Also in 1984, RIT accepted a grant for $39,750 from the National Historical Publications and Records Commission (NHPRC) for this project. In 1985 RIT received a $72,547 grant from the National Endowment for the Humanities (NEH) for continuation of the research.

In January 1986 Reilly was appointed director of the newly established Image Permanence Institute at the Rochester Institute of Technology, a research laboratory initially funded and presently supervised primarily by Eastman Kodak, Polaroid Corporation, and other photographic manufacturers. The Image Permanence Institute, located at RIT in Rochester, New York, is jointly sponsored by The Society for Imaging Science and Technology (IS&T) and the Rochester Institute of Technology.

8. American National Standards Institute, Inc., **ANSI IT9.2-1991, American National Standard for Imaging Media – Photographic Processed Films, Plates, and Papers – Filing Enclosures and Storage Containers,** American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-642-4900; Fax: 212-302-1286.
9. T. J. Collings and F. J. Young, "Improvements in Some Tests and Techniques in Photograph Conservation," **Studies in Conservation,** Vol. 21, No. 2, May 1976, pp. 79–84. See also: V. Daniels and S. Ward, "A Rapid Test for the Detection of Substances Which Will Tarnish Silver," **Studies in Conservation,** Vol. 27, 1982, pp. 58–60. Also: S. H. Ehrlich, "Chemiluminescence: A Method for the Determination of Trace Amounts of Hydrogen Peroxide in Photographic Plastics," **Photographic Science and Engineering,** Vol. 28, No. 6, November–December 1984, pp. 226–232.
10. TAPPI Official Test Method T406om-82, **Reducible Sulfur in Paper and Paperboard,** 1982, Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Technology Park/Atlanta, Atlanta, Georgia 30348; telephone: 404-446-1400.
11. Klaus B. Hendriks and Douglas Madeley [National Archives of Canada], "A Comparison of the Collings-Young Test and ANSI PH1.54-1978 Photographic Activity Test," **PMG Newsletter** (newsletter of the Photographic Materials Group of the American Institute for Conservation), No. 3, May 1983, p. 4.
12. James M. Reilly, see Note No. 5, p. 4.
13. R. Scott Williams, "Commercial Storage and Filing Enclosures for Processed Photographic Materials," **Second International Symposium: The Stability and Preservation of Photographic Images,** Ottawa, Ontario, August 25–28, 1985, (Printing of Transcript Summaries), SPSE, The Society for Imaging Science and Technology, 7003 Kilworth Lane, Springfield, Virginia 22151; telephone: 703-642-9090. (Hendriks is quoted on page 29 of the article; his remark took place during a question and answer session following the presentation.)
14. American National Standards Institute, Inc., **ANSI IT9.9-1990, American National Standard for Imaging Media – Stability of Color Photographic Images – Methods for Measuring**, American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-642-4900; Fax: 212-302-1286. See also: Charleton C. Bard, George W. Larson, Howell Hammond, and Clarence Packard, "Predicting Long-Term Dark Storage Dye Stability Characteristics of Color Photographic Products from Short-Term Tests," **Journal of Applied Photographic Engineering,** Vol. 6, No. 2, April 1980, pp. 42–45.
15. Glen G. Gray, "Determination and Significance of Activation Energy in Permanence Tests," in **Preservation of Paper and Textiles of Historic and Artistic Value,** John C. Williams, ed., Advances in Chemistry Series 164, American Chemical Society, Washington, D.C., 1977, pp. 286–313. Includes a discussion of an Arrhenius test method for paper products and its advantages over previous methods. For application of the Arrhenius test method to black-and-white photographic materials see: D. F. Kopperl, G. W. Larson, B. A. Hutchins, and C. C. Bard, "A Method to Predict the Effect of Residual Thiosulfate Content on the Long-Term Image-Stability Characteristics of Radiographic Films," **Journal of Applied Photographic Engineering,** Vol. 8, No. 2, April 1982, pp. 83–89. For application of the Arrhenius test method to plastic film base, see P. Z. Adelstein and J. L. McCrea, "Stability of Processed Polyester Base Photographic Films," **Journal of Applied Photographic Engineering,** Vol. 7, No. 6, December 1981, pp. 160–167.
16. Edith Weyde, "A Simple Test to Identify Gases Which Destroy Silver Images," **Photographic Science and Engineering,** Vol. 16, No. 4, July–August 1972, pp. 283–286.
17. James M. Reilly and Douglas W. Nishimura, "Improvements in Test Methods for Photographic Storage Enclosures," presented at the **SPSE 40th Annual Conference and Symposium on Hybrid Imaging Systems**, sponsored by SPSE, The Society for Imaging Science and Technology, Rochester, New York, May 19, 1987 (see **Advance Printing of Conference Summaries,** pp. 150–154).
18. Peter Z. Adelstein, "Update on National and International Permanence Standards," presentation at the **Third International Symposium on Image Conservation**, Rochester, New York, June 18, 1990. The Symposium, which was held at the International Museum of Photography at George Eastman House, was sponsored by The Society for Imaging Science and Technology in cooperation with Manchester Polytechnic (Manchester, U.K.).
19. James M. Reilly and Douglas W. Nishimura, see Note No. 17, p. 150.
20. The enclosure paper and mount board test kit is available from the Image Permanence Institute, Rochester Institute of Technology, Frank E. Gannett Memorial Building, P.O. Box 9887, Rochester, New York 14623-0887; telephone: 716-475-5199; Fax: 716-475-7230.
21. American National Standards Institute, Inc., see Note No. 8.
22. R. Scott Williams, see Note No. 13, p. 21.
23. W. Nishimura, J. Reilly, and P. Adelstein, "Improvements to the Photographic Activity Test in ANSI Standard IT9.2," **Journal of Imaging Technology,** Vol. 17, No. 6, December 1991, pp. 245–252. For the original version of this article, see: James M. Reilly, Douglas W. Nishimura, Luis Pavao, and Peter Z. Adelstein, "Photo Enclosures Research and Specifications," **Topics in Photographic Preservation – Volume Three** (compiled by Robin E. Siegel), Photographic Materials Group of the American Institute for Conservation, 1989, pp. 1–7. Available from the American Institute for Conservation, Suite 340, 1400 16th Street, N.W., Washington, D.C. 20036; telephone: 202-232-6636; Fax: 202-232-6630.
24. American National Standards Institute, Inc., **ANSI IT9.11-1991, American National Standard for Imaging Media – Processed Safety Photographic Film – Storage,** American National Standards Institute, Inc., 11 West 42nd Street, New York, New York 10036; telephone: 212-264-4900; Fax: 212-302-1286.
25. American National Standards Institute, Inc., **ANSI IT9.2-1991,** Sec. 3.2, (see Note No. 8). Referenced ASTM test methods can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103; telephone: 215-299-5400. TAPPI publications can be obtained from the Technical Association of the Pulp and Paper Industry, P.O. Box 105113, Technology Park/Atlanta, Atlanta, Georgia 30348; telephone: 404-446-1400.
26. Klaus B. Hendriks, "Tests of Paper Filing Enclosures According to the New ANSI Standard," presented at **Preservation and Restoration of Photographic Images,** a symposium at the Rochester Institute of Technology, Rochester, New York, March 5, 1979.
27. James M. Reilly, see Note No. 6.
28. Eugene Ostroff, "Preservation of Photographs," **The Photographic Journal,** Vol. 107, No. 10, October 1967, p. 311. See also: Eugene Ostroff, **Conserving and Restoring Photographic Collections,** American Association of Museums, 1976, pp. 14–15.
29. Eastman Kodak Company, see Note No. 3, p. 95.
30. There is a third type of high-quality board, which can be described as a decorative composite board. This board is made of de-acidified wood pulp and is faced with colored papers that have textured or smooth finishes on either side of a bright white core. It is intended for making overmats and, when its finish is highly textured, it is unsuitable for mounting or as a backing. This board is usually 50 to 60 points thick (about the thickness of 4-ply board). Bainbridge Alphamat and Miller Ultimat are examples. The authors advise against the use of these boards in direct contact with valuable photographs.
31. For example, the Fall 1992 Light Impressions Corporation **Archival Supplies** catalog listed the following prices per sheet of 32x40-inch 4-ply mount board when purchased in 10-sheet packages:
    100% Cotton Fiber Boards:
    Westminster 100% Rag Board (White, Natural, Ivory): $7.80
    Non-Buffered 100% Rag Board (White, Cream): $7.80
    Purified Wood Pulp Boards:
    Exeter Conservation Board (White): $6.15
32. Roy P. Whitney, "Chemistry of Paper," **Paper – Art & Technology,** The World Print Council, San Francisco, California, 1979, pp. 36–44.
33. "Cellulose. The chief constituent of the cell walls of all plants and of many fibrous products, including paper and cloth. Cellulose is by far the most abundant organic substance found in nature . . . . The portion of cellulosic material that does not dissolve in a 17.5% solution of sodium hydroxide [at 20°C, under specified conditions] is termed Alpha Cellulose" (p. 49). "Because the permanence of paper depends to some extent on the absence of non-cellulosic materials, the determination of true cellulose (alpha cellulose) gives an indication of the stability of the paper, and therefore its permanence"

(p. 8). From: Matt Roberts and Don Etherington, **Bookbinding and the Conservation of Books,** Library of Congress, Washington, D.C., 1982.
34. Eugene Ostroff, see Note No. 28, p. 311.
35. John C. Williams, "A Review of Paper Quality and Paper Chemistry," in **Conservation of Library Materials,** Gerald Lundeen, ed., **Library Trends,** Vol. 30, No. 2, Fall 1981, p. 207.
36. George T. Eaton, "Photographic Paper Base," **PhotographiConservation,** Vol. 4, No. 1, March 1982, p. 1.
37. Eastman Kodak Company, **Preservation of Photographs,** Kodak Publication No. F-30, Eastman Kodak Company, Rochester, New York, August 1979, p. 4. See also: **Conservation of Photographs** [George T. Eaton, editor], Kodak Publication No. F-40, March 1985, pp. 37–39.
38. George T. Eaton, see Note No. 36, pp. 1 and 6.
39. George T. Eaton, see Note No. 36.
40. A. I. Woodward [Wiggins Teape Ltd.], "The Evolution of Photographic Base Papers," **Journal of Applied Photographic Engineering,** Vol. 7, No. 4, August 1981, pp. 117–120. See also: Klaus B. Kasper and Rudolf Wanka [Schoeller Technical Papers, Inc.], "Chemical Formulations and Requirements of Photographic Paper," **Journal of Applied Photographic Engineering,** Vol. 7, No. 3, June 1981, pp. 67–72.
41. Glen G. Gray, see Note No. 15, p. 312.
42. William J. Barrow, **Manuscripts and Documents: Their Deterioration and Restoration,** second ed., University of Virginia Press, Charlottesville, Virginia, 1972.
43. American National Standards Institute, Inc., **ANSI Z39.48-1984, American National Standard for Information Sciences – Permanence of Paper for Printed Library Materials,** American National Standards Institute, Inc., 11 West 42nd St., New York, New York 10036; telephone: 212-642-4900; Fax: 212-302-1286. "To ensure maximum consistency of test results, it is recommended that suppliers subscribe to some form of comparative test program, such as the CIS-TAPPI Collaborative Reference Service, Collaborative Testing Services, Inc., 8343 A Greensboro Drive, McLean, Virginia 22102" (p. 7).
44. Howard Paper Mills, Inc., 354 South Edwin C. Moses Blvd., P.O. Box 982, Dayton, Ohio 45401; telephone: 513-224-1211. The company makes Permalife papers and has also made the Renaissance nonbuffered paper intended for photographic storage applications and sold by Light Impressions Corporation.
45. Walter Clark, "Techniques for Conserving Those Old Photographs," **The New York Times,** June 13, 1976, Sec. D, p. 40.
46. Klaus B. Hendriks, introductory remarks for the session on "Stability and Preservation of Photographic Records" at the 31st Annual Conference of the Society of Photographic Scientists and Engineers (SPSE) in Washington, D.C., May 1, 1978.
47. Henry Wilhelm, "Preservation of Your Black and White Photographs," presented at **Preserving Your Historical Records: A Symposium,** the Olmsted Center of Drake University, Des Moines, Iowa, October 20–21, 1978.
48. Polaroid Corporation, **Storing, Handling and Preserving Polaroid Photographs: A Guide,** Polaroid Corporation, Cambridge, Massachusetts, 1983, p. 28.
49. Eastman Kodak Company, see Note No. 37, p. 35.
50. Eastman Kodak Company, **Storage and Care of Kodak Color Materials,** Pamphlet No. E-30, Eastman Kodak Company, Rochester, New York, May 1982, p. 7.
51. Henry J. Kaska, director of public information, Eastman Kodak Company, letter to Henry Wilhelm, November 17, 1982.
52. Eastman Kodak Company, see Note No. 3.
53. Anonymous, "What Are the Speakers From the RIT Seminars Doing Currently," **PhotographiConservation,** Vol. 4, No. 2, June 1982, p. 7. (Published by the Technical and Education Center of the Graphic Arts, Rochester Institute of Technology, Rochester, New York.)
54. Eastman Kodak Company, see Note No. 3.
55. Sergio Burgi, "Fading of Dyes Used for Tinting Unsensitized Albumen Paper," presented at **The Stability and Preservation of Photographic Images,** SPSE International Symposium, the Public Archives of Canada (renamed the National Archives of Canada in 1987), Ottawa, Ontario, August 30, 1982.
56. Stanton Clay, "Stability of Cibachrome Materials," presented at a conference on **The Permanence of Color – Technology's Challenge, The Photographer's and Collector's Dilemma** at the International Center of Photography, New York, New York, May 6, 1978; Henry Wilhelm, chairman.
57. Peter Z. Adelstein, Eastman Kodak Company, telephone discussion with Henry Wilhelm, September 3, 1983.
58. George T. Eaton, see Note No. 36, p. 6.
59. The pH levels of the prints were measured by Henry Wilhelm using an Ingold Electrodes, Inc. Flat Membrane Electrode with Four Liquid Junction Legs for Measurements of Paper, Catalog No. 6147-01, with a Digi-pH-ase pH Meter made by Cole-Parmer Instrument Company.
60. Thomas Woodlief, Jr., ed., **SPSE Handbook of Photographic Science and Engineering,** John Wiley and Sons, New York, New York, 1973, p. 514.
61. Grant Haist, **Modern Photographic Processing,** Vol. 1, John Wiley and Sons, New York, New York, 1979, p. 54.
62. James M. Reilly, Douglas G. Severson, and Constance McCabe, "Image Deterioration in Albumen Photographic Prints," paper presented at a conference of the International Institute for Conservation, Washington, D.C., May 1982; William B. Becker, "New Life for Old Photographs," **Camera Arts,** Vol. 2, No. 2, March–April 1982, pp. 96–98, 102; Debbie Hess Norris, "The Proper Storage and Display of a Photographic Collection," **Picturescope,** Vol. 31, No. 1, Spring 1983, pp. 4–10.
63. James M. Reilly, see Note No. 6.
64. M. Kahn and G. Ayers, "Elimination of Wash Water in Minilab Operations," paper presented at the Society of Photographic Scientists and Engineers (SPSE) **Tutorial Symposium on One Hour Lab Operations and Technologies,** Las Vegas, Nevada, March 26–27, 1985.
65. According to Carol Brower's 1982 survey "The Care and Presentation of Photographic Prints" (see Chapter 12), 35 of 65 queried individuals said that they used nonbuffered, neutral pH boards; however, 19 of the 35 respondents did not answer the question, "If you use nonbuffered, neutral pH boards, who are the manufacturers?" Eight people (out of 65) said they did not use nonbuffered boards. The following numbers of individuals named the corresponding paper companies as suppliers of the "nonbuffered" board they purchase (some people named more than one):
8 – Process Materials Corporation
(now the Archivart Division of Heller & Usdan, Inc.)
7 – Rising Paper Company
2 – C. T. Bainbridge's Sons, Inc.
(now Nielsen & Bainbridge)
2 – Light Impressions Corporation
1 – Andrews/Nelson/Whitehead
1 – Crestwood Paper Company
1 – University Products, Inc.
Given that only 18 respondents gave the names of "manufacturers" and that only Process Materials and Light Impressions were selling nonbuffered boards in August 1982, the above responses suggest that most people were still unaware at that time of the difference between nonbuffered, neutral pH boards and alkaline-buffered, neutral pH boards.
66. Professional Picture Framers Association, **Survey on Mat/Mount Boards,** March 1986. Professional Picture Framers Association, 4305 Sarellen Road, P.O. Box 7655, Richmond, Virginia 23231; telephone: 804-226-0430.
67. American National Standards Institute, Inc., see Note No. 14. The **ANSI IT9.9-1990** Standard includes a 6.0 klux Cool White fluorescent accelerated light fading test suitable for use with mount boards.
68. Process Materials Corporation was the first company to develop and market a line of "New Products for Photographic Conservation," the title of an ad that first appeared in the **American Institute for Conservation Newsletter**, August 1983. It represented a major step forward in the marketing of such products. (In 1990, Process Materials Corporation, which by then had changed its name to Archivart, was acquired from its then owner, Lindenmeyr Paper Company, headquartered in New York City, by Heller & Usdan, Inc., 7 Caesar Place, Moonachie, New Jersey 07074; telephone: 201-933-8100; toll-free: 800-333-4466.)
69. Joseph B. Fiedor, telephone conversation with Carol Brower, May 18, 1983.
70. Robert Stiff, telephone conversation with Carol Brower, November 25, 1985.
71. Atlantis Paper Company Limited, No. 2 St. Andrews Way, London E3 3PA, England; telephone: 071-537-2727 (to direct-dial from the U.S.: 011-44-071-537-2727); Fax: 071-537-4277 (to direct-dial from the U.S.: 011-44-071-537-4277).
72. Stuart M. Welch, Atlantis Paper Company Limited, letter to the authors, March 21, 1985.
73. Archivart Division of Heller & Usdan, Inc., 7 Caesar Place, Moonachie, New Jersey 07074; telephone: 201-933-8100 (toll-free: 800-333-4466). Paper Technologies, Inc., 25801 Obrero, Suite 4, Mission Viejo, California 92691; telephone: 714-768-7497 and 714-768-7498.
74. Stuart M. Welch, letter to the authors, June 20, 1985.
75. Stuart M. Welch, see Note No. 72.
76. Stuart M. Welch, letter to the authors, September 27, 1985.
77. Atlantis Paper Company Limited, **Fine Archival Papers From St.**

Cuthbert's England (1985 product sample book and catalog), and 1991 catalog.

78. Process Materials Corporation, "Paper & Preservation No. 4," Process Materials Corporation, Rutherford, New Jersey, February 1983.
79. Process Materials Corporation, "Technical Bulletin No. CP-186-MB," November 1981 (revised February 1983).
80. Introduced in 1974 by Process Materials Corporation, Archivart Photomount Board, a solid, dark ash-gray board, was described as "an acid-free board, of exceptionally rigid construction, made from selected chemical pulp, buffered against acid deterioration. Developed for the mounting and storage of photographs, this board is also used in picture framing and as a binder's board" (Process Materials Corporation, "Conservation Products," second edition, 1982, p. 5). Because of the presence of the alkaline buffering agents and because of possible confusion with the company's nonbuffered Archivart Photographic Board, Arno Roessler, then president of the company, said in August 1983 that this product was renamed Conservation Board, and is now available in other tones.
81. This statement appears on mount board sample cards distributed by Rising Paper Company.
82. The product description for Renaissance Paper in the Light Impressions 1991 Archival Supplies catalog (p. 60) stated that the paper had passed the **ANSI IT9.2** Sec. 5.1 Photographic Activity Test.
83. Conservation Resources International, Inc., 8000-H Forbes Place, Springfield, Virginia 22151; telephone: 703-321-7730; toll-free: 800-634-6932. Summer–Fall 1991 General Catalog, p. 30.
84. Distributed by the Professional Picture Framers Association in Richmond, Virginia, Tri-Test – A Spot Testing Kit for Unstable Papers contains three solutions for detecting the presence of groundwood and alum, and for distinguishing between acid, neutral, or alkaline paper or board products. These are qualitative tests which are easy to perform and will readily identify poor-quality paper products. The user should be cautioned, however, that a paper product which appears to be satisfactory on the basis of these tests may in fact be quite harmful to photographs because of the presence of sulfur compounds which upon aging produce active oxidants, and of other substances to which the tests do not respond. Originally called the Barrow Spot Test Kit, the tests were devised by William J. Barrow (1904–1967) of the now defunct W. J. Barrow Research Laboratory in Richmond, Virginia (see: W. J. Barrow Research Laboratory, **Permanence/Durability of the Book: VI. Spot Testing for Unstable Modern Book and Record Papers,** Richmond, Virginia, 1969).
    The Tri-Test spot testing kit is available from the Professional Picture Framers Association, 4305 Sarellen Road, Richmond, Virginia 23231; telephone: 804-226-0430; toll-free: 800-832-7732. The kit can also be purchased from Light Impressions Corporation, 439 Monroe Avenue, Rochester, New York 14607-3717; telephone: 716-271-8960; (toll-free outside New York: 800-828-6216; toll-free inside New York: 800-828-9629); and Westfall Framing, Inc., P.O. Box 13534, Tallahassee, Florida 32317; telephone: 904-878-3546 (toll-free outside Florida: 800-874-3164).

Additional References

Helen D. Burgess and Carolyn G. Leckie, "Evaluation of Paper Products: With Special Reference to Use with Photographic Materials," **Topics in Photographic Preservation – Volume Four** (compiled by Robin E. Siegel), Photographic Materials Group of the American Institute for Conservation, 1991, pp. 96–105. Available from the American Institute for Conservation, Suite 340, 1400 16th Street, N.W., Washington, D.C. 20036; telephone: 202-232-6636; Fax: 202-232-6630.

Klaus B. Hendriks, together with Brian Thurgood, Joe Iraci, Brian Lesser, and Greg Hill of the National Archives of Canada staff, **Fundamentals of Photographic Conservation: A Study Guide**, published by Lugus Publications in cooperation with the National Archives of Canada and the Canada Communication Group, 1991. Available from Lugus Productions Ltd., 48 Falcon Street, Toronto, Ontario, Canada M4S 2P5; telephone: 416-322-5113; Fax: 416-484-9512.

Nancy Reinhold, "An Investigation of Commercially Available Dry Mount Tissues," **Topics in Photographic Preservation – Volume Four** (compiled by Robin E. Siegel), Photographic Materials Group of the American Institute for Conservation, 1991, pp. 14–30.

Kimberly Scheneck and Constance McCabe, "Preliminary Testing of Adhesives Used in Photographic Conservation," **Topics in Photographic Preservation – Volume Three** (compiled by Robin E. Siegel), Photographic Materials Group of the American Institute for Conservation, 1989, pp. 52–61.

Appendix 13.1 – Letter to Paper Companies

In June 1982, Carol Brower sent letters to 23 paper companies and distributors asking the following questions:

1. Which paper mills make your mount boards?
2. What is the pH of your museum mount boards?
3. Are your museum mount boards buffered? If so, with what?
4. Do they have an alkaline reserve? If so, how much?
5. What is the raw material content of your mount boards (cotton fiber, wood cellulose, etc.)?
6. Do your sources of cotton fiber vary?
7. Can you supply information about your laminating adhesives and sizings?
8. Have accelerated aging tests been conducted with your mount boards? If so, could you describe the tests and your findings?
9. Do you manufacture or distribute other high-quality boards and papers that are suitable for use in museums, archives, institutions, and galleries?
10. Do you know how or to what extent your materials are used in the photographic fields?
11. Have tests been conducted with your mount boards in contact with common photographic materials including albumen, silver-gelatin, Ektacolor, Cibachrome [currently called Ilfochrome], Dye Transfer, Polacolor, etc. that would indicate what effects the boards might have in long-term storage?
12. Do you have any test data on the dye stability of your colored or tinted boards when they are subjected to prolonged light exposure?
13. Do you have papers which you recommend for interleaving purposes?

The following 12 companies responded in writing, although not all of the requested information was provided:
Andrews/Nelson/Whitehead; Conservation Resources International, Inc.; Crescent Cardboard Company; Crestwood Paper Company; Howard Paper Mills, Inc.; James River Corporation; Light Impressions Corporation; Process Materials Corporation (now the Archivart Division of Heller & Usdan, Inc.); Rising Paper Company; Talas, Inc.; Strathmore Paper Company; and University Products, Inc. In 1985 Atlantis Paper Company Limited of London, England responded in detail to questions from the authors (Atlantis was not sent a copy of the original 1982 letter).

Letters of apology or referral to other companies were sent by the following 5 companies:
Buntin Gillies and Company, Ltd.; Conservation Materials, Ltd.; Domtar Fine Papers; Hollinger Corporation; and Rupaco Paper Corporation. (For example, the Hollinger Corporation no longer distributes mount boards, and Eric Schiffman of Rupaco Paper Corporation referred the author to Rising Paper Company for information regarding the Rising Museum and Conservamat boards that Rupaco distributes; Buntin Gillies and Company, Ltd. no longer manufactures mount board.)

Charles T. Bainbridge's Sons, Inc. (currently Nielsen & Bainbridge) and Miller Cardboard Corporation sent promotional literature containing some information about pH and fiber content. Parsons Paper – Division of NVF Company sent a sample package of their Photomounting Board. None of the companies responded with letters.

The following 3 companies did not respond:
Beckett Paper Company; Hurlock Bros. Company, Inc.; and Monadnock Paper Mills, Inc. Follow-up telephone calls were made and copies of the letters were sent to the companies, to no avail.