Disaster Preparedness and Recovery: Photographic Materials

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NATURAL DISASTERS MAY STRIKE LIBRARIES AND ARCHIVES in the form of flood, fires, and water damage following attempts to extinguish fires. Much literature has been published on such occurrences and their prevention and is summarized in Technical Leaflet 114, published by the American Association for State and Local History.[1] During the past decade or so, several papers have described the freezing and subsequent drying of water-soaked documents. One of the first reports appears to be by Flink and Hoyer[2] who recommend the freezing and subsequent air-drying of books, but advocate a freeze-drying process for hand-written letters and manuscripts. Vacuum-drying of frozen books was described by Burns[3], Stender and Walker[4], and other authors. Specific disaster cases usually initiated the publication of reports on salvage operations, such as a severe flood in The Corning Museum of Glass,[5] a fire at the National Personnel Records Center in Overland, Missouri, or the fire in the Temple University Law Library. While the application of freeze-drying methods to the salvage of water-soaked records seems to have been successful in most

[1]John E. Hunter, "Emergency Preparedness for Museums, Historic Sites, and Archives: An Annotated Bibliography," *History News* 34 (April 1979).

[2]James Flink and Henrik Hoyer, "Conservation of Water-Damaged Written Documents by Freeze-Drying," *Nature* 234 (December 1971): 420.

[3]Robert Burns, "Space-Age Drying Method Salvages Library Books," *Fire Engineering* 126 (1973): 52.

[4]Walter W. Stender and Evans Walker, "The National Personnel Records Center Fire: A Study in Disaster," *American Archivist* 37 (1974): 521-549.

[5]John H. Martin, *The Corning Flood: Museum Under Water* (Corning, N.Y.: Corning Museum of Glass, 1977).

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cases, critical arguments have also been raised[6]. In a response to such criticism the freeze drying of water-soaked books was defended as being the most effective available salvage technique for the recovery of large quantities of water-soaked books.[7]

Such procedures have been summarized by Waters.[8] More recent reports discuss the salvage operations after a flood in Stanford University's Library[9] and after a fire in a building that housed Provincial Government records in Winnipeg, Manitoba.[10] An article by Buchanan[11] reviews the current knowledge in the field.

While it is apparent from the above that considerable experience has been collected in the freeze-drying of water-soaked books, few observations have been published on the behavior of photographic materials upon soaking and subsequent drying by various techniques.

None of the foregoing reports discussess in any detail the behavior after soaking and drying of still photographic negatives and prints in either black-and-white or color. Flink and Hoyer freeze-dried an album containing photographs and reported that some prints that were frozen emulsion-to-emulsion stuck together after drying. No mention was made, however, of the age or the type of photograph present in the album. Waters[12] recommended in 1972 that photographic prints should be frozen after being held in ice cold water for a maximum period of three or four days, but Waters revised this recommendation in 1975. The possibility of "formation of ice crystals which may rupture the emulsion layer" was mentioned. Black-and-white film negatives and prints could be left in clean cold water for up to 72 hours. If photographic materials must be frozen, the rate of freezing should be high to keep ice crystal size to a minimum. Martin reported the observation that some photographic prints that were frozen, thawed, and vacuum-dried after the Corning flood stuck together tenaciously, both emulsion to emulsion and emulsion to back of the adjacent print.

The objective of this paper is to report the results of some experiments involving the immersion, in tap water, of still photographic negatives and prints in black-and-white and color, and their subsequent drying by various means. We expected that such experiments would allow us to draw conclusions about storage conditions that might prevent water damage to photographic materials and about operations designed to salvage materials after they had become accidentally water-soaked. No attempts were made to restore any of the materials after they were soaked in water and dried.

Our study deliberately did not include motion picture films or microfilms. There is a fundamental physical difference between these materials and historical still photographs. The former are on rolls of various lengths (usually from 100 to 400 feet), which allows them

[6] Erwin C. Surrency, "Freeze-Dried Books," *Library Journal* 99 (1974): 2108-2109.

[7] Peter Waters et al., "Does Freeze-Drying Save Watersoaked Books or Doesn't It?" *American Libraries* 6 (1975): 422-423.

[8] Peter Waters, *Procedures for Salvage of Water-Damaged Library Materials* (Washington, D.C.: Library of Congress, 1975).

[9] James N. Myers and Denise D. Bedford, *Disasters: Prevention and Coping* (Stanford, Calif.: Stanford University Libraries, 1981).

[10] Peter Bower and Charles Brandt, "Operation Paper Lift," *Archivaria* 12 (Summer 1981): 135-144.

[11] Sally Buchanan, "Disaster: Prevention, Preparedness and Action," *Library Trends* 30 (1981): 241-252.

[12] Peter Waters, "Emergency Procedures for Salvaging Flood or Water-Damaged Library Materials," *Information Document.* (Washington, D.C.: Library of Congress, 1972).

to be developed, fixed, washed, and dried in mechanized machines (film processors) constructed for that purpose. Because these machines can be used to reprocess water-damaged photographic films on rolls, the literature generally recommends that water-damaged films be sent to professional processing laboratories for treatment there. A publication by the U.S. Federal Fire Council[13] suggests that water-soaked film should be placed in cool, clear water, bathed in a photographic hardening solution, spray-washed, and dried. Spray-washing is typically done in some film processor models. Reprocessing of microfilm which was affected by hurricane Agnes was described by Montuori[14,15]. An interesting case study of salvaging rolls of processed microfilm that had been soaked and allowed to dry was written by H. Klein.[16] We do not know of a case where still photographic film negatives with a gelatin layer have been re-processed in a film processor after a natural disaster. The numerous types of photographic processes in use throughout the history of photography seem to preclude the application of volume treatments, making recovery operations labor-intensive as historical photographic documents must be treated on an item-by-item basis.

Experimental

In preparing the project that is reported here, it was decided to investigate four types of drying selected from various possibilities.[17] Table 1 presents the freezing and drying variables that were considered.

It was further considered that the response of photographic records to soaking and drying would depend upon a number of factors. Table 2 shows those factors that were thought to be of greatest importance.

The photographs chosen for this project were broadly divided into three groups: contemporary black-and-white silver gelatin materials that were prepared for the experiments, historical materials that originated mostly from the National Photography Collection at the Public Archives of Canada as surplus material, and color photographs. Table 3 presents details about the contemporary materials used.

The type of fixer used in processing contemporary photographic films and papers may have some influence on the stability of the gelatin layers in these materials. The American National Standards Institute (ANSI) specification, entitled "Method for Evaluating the Processing of Black-and-White Photographic Papers with Respect to the Stability of the Resultant Image," (ANSI PH4.32-1980), provides a sequence of processing steps that yields black-and-white prints essentially free of residual processing chemicals. Part of that sequence is a non-hardening fixing bath that leaves the unhardened gelatin somewhat less stable than if it were fixed in a hardening fixer of the F-5 type.[18] Negatives and prints were processed in

[13]Lewis J. Darter, "Salvaging and Restoring Records Damaged by Fire and Water," Recommended Practices No. 2. (Washington, D.C.: Federal Fire Council, 1963).

[14]Theodore R. Montuori, "Lessons Learned from Agnes," *Journal of Micrographics* 6 (1973): 133-136.

[15]Theodore R. Montuori, "Salvaging Damaged Microfilm," *Microfilm Techniques* 3 (1973): 18.

[16]Henry Klein, "Microfilm Resuscitation—A Case Study," *Journal of Micrographics* 9 (1976): 229-303.

[17]David J. Fischer, "Simulation of Flood for Preparing Reproducible Water-Damaged Books and Evaluation of Traditional and New Drying Processes," *Preservation of Paper and Textiles of Historic and Artistic Value,* J. C. Williams, ed., Advances in Chemistry Series 164 (Washington, D.C.: American Chemical Society, 1977), 105-123.

[18]*Processing Chemicals and Formulas for Black-and-White Photography* (Rochester: Eastman Kodak Co., 1977).

No freeze--air drying
Freeze--thaw--air drying
Freeze--thaw--vacuum drying at 4°C
Freeze drying in vacuum chamber
Rate of freezing
Temperature of freezing
Length of freezing

Table 1. Types of drying and freezing

Type of photograph as indicated by: Process Age Black-and-White Color Mounted or unmounted
Stacked photographs or separate items
Enclosed photographs (in plastic or paper sleeves)
Tap water
Immersion time
Temperature of water

Table 2. Experimental variables for soaking and drying photographs

Eastman Kodak Ektapan Film 4162
Eastman Kodak Commercial Film 4127

These were:

Fixed in non-hardening fixer (ANSI type)
Fixed in hardening fixer (F-5 type)*
Soaked inside sleeves and without sleeves**

Bromide enlarging paper (Manufacturer A)
Chloride contact paper (Manufacturer B)

These were:

Fixed in two non-hardening fixers (ANSI type)
Fixed in two hardening fixers (F-5 type)*
Soaked inside sleeves and without sleeves

Bromide enlarging RC (resin-coated)paper

These were:

Fixed in hardening fixer (F-5 type)*
Soaked inside sleeves and without sleeves

*F-5 is a designation of the Eastman Kodak Company.

**"Kodak sleeves" made of clear cellulose triacetate were used in all experiments.

Table 3. Contemporary black-and-white materials soaked and dried

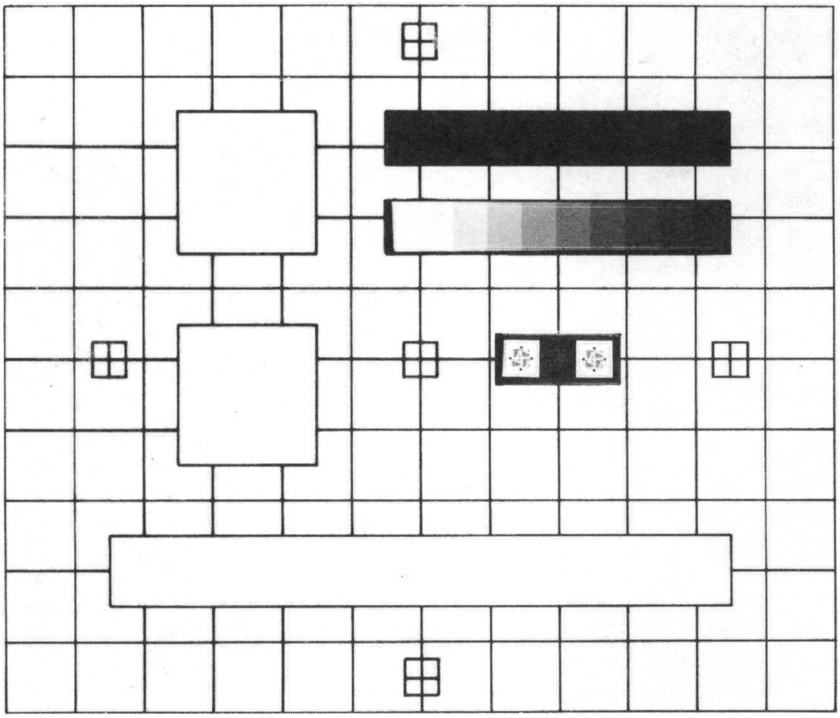

Figure 1. Test sample ("grid print") used in this project, made on contemporary photographic paper

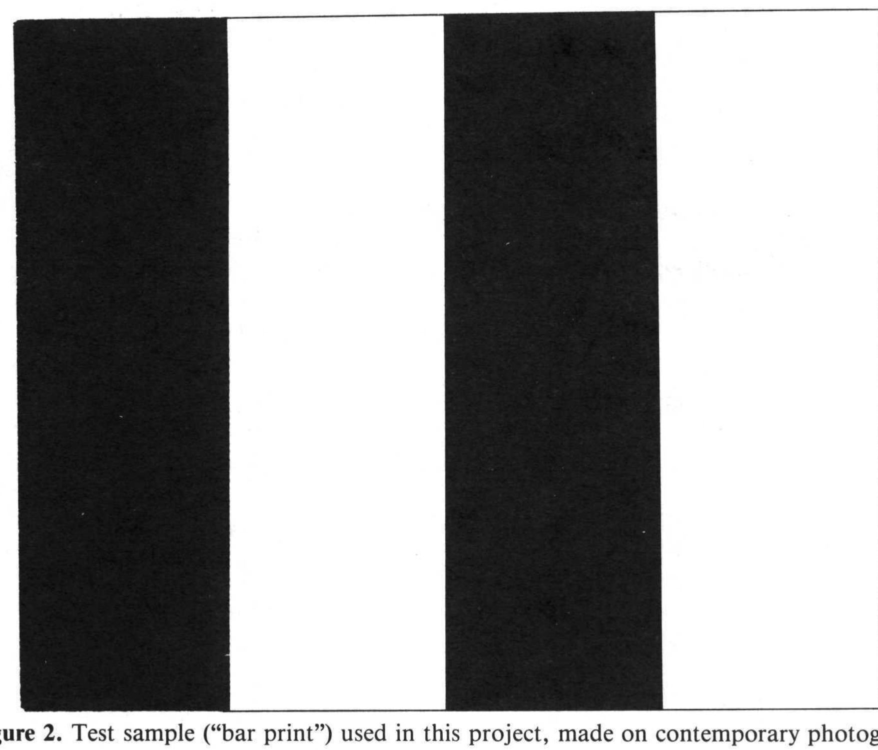

Figure 2. Test sample ("bar print") used in this project, made on contemporary photographic paper

either way in order to verify whether a difference could be observed in the material's resistance to soaking and drying. To facilitate physical testing, film and print samples, size 4 by 5 inches, were made with either one of two different images on them. The first was a grid pattern 10 by 12 centimeters composed of 1 square-centimeter blocks. Targets were located, within this grid pattern, precisely 9 centimeters apart in both the vertical and horizontal directions. These were to be used with a separate rotating grid in order to determine dimensional changes according to ANSI PH1.32-1979, method C ("Methods for Determining the Dimensional Change Characteristics of Photographic Films and Papers"). Open areas were left in the grid to allow for the performance of abrasion (scratch resistance) tests according to ANSI PH1.37-1977 ("Determining the Scratch Resistance of Processed Photographic Film"). A grey scale was also included to aid in the control of processing as well as in monitoring density changes during the experiments. Finally, three resolution targets were included near the center of the samples of which the finest ruling was 176 lines per millimeter. Figure 1 shows the test sample just described. The second test print had alternating strips of the D_{MAX} and D_{MIN} areas of the materials. The strips were spaced parallel, each being 28 millimeters wide. These samples were designed solely for use in gelatin melting point tests according to ANSI PH4.11-1981 ("Determining the Melting Point of a Nonsupport Layer of Films, Plates and Papers"). This second sample type was included in all test sets with the exclusion of the freezing rate tests. Figure 2 shows the second test print.

The historical black-and-white photographs used in this work are presented in Table 4.

The wet collodion plates were from the Topley Collection of the Public Archives of Canada. The film negatives and silver gelatin prints were from a variety of different manufacturers (including Ansco, Eastman Kodak, Leonar, Ilford) and the photographs in the government album were photofinishing prints.

Table 5 shows the color photographs used in this project.

Emphasis during this investigation was on the properties of black-and-white photographic documents; relatively few color materials were examined. The test group included neither photographs made by the silver dye bleach process (Cibachrome) nor samples of the dye diffusion transfer processes (such as Polacolor 1 and 2, or SX-70 prints by the Polaroid Corporation, or Eastman Kodak's PR-10 and Ektaflex materials).

Evaluation of the samples after soaking and drying was made by close visual examination and by measuring quantitatively changes in physical properties using procedures recommended by ANSI. Table 6 summarizes the testing procedures performed in this project.

Among other physical properties that can be measured quantitatively are the adhesion of the image-bearing layer to the support, the layer thickness, or the curl of the film or paper. Because this laboratory is not equipped with the necessary instruments, such properties could be evaluated only by visual examination.

Of the wealth of experimental data obtained by immersing the various types of photographs in water for different periods of time and by observing and measuring physical changes, two sets of results are presented as being representative of data collected in the course of this project. The present study was carried out in three sections. In a preliminary experiment we attempted to deter-

Wet collodion glass plate negatives
Silver gelatin dry plates
Cellulose nitrate film
Cellulose acetate film
Polyester film
Salted paper prints
Silver albumen prints (mounted and unmounted)
Collodio-chloride prints (mounted and unmounted)
Various silver gelatin prints, D.O.P. and P.O.P. (mounted and unmounted)
Album of government photographs (1935)
Carbon prints
Woodburytypes

Table 4. Historical black-and-white materials soaked and dried

Eastman Kodak Dye Transfer prints
Fuji Dyecolor prints
Agfa reversal paper CU 310
Agfacolor Type 4
Agfacolor Type 5
Ektacolor paper control strips
Ektachrome transparencies (E-4, mounted and unmounted)

Table 5. Color materials soaked and dried

Visual inspection
Changes in dimensional stability
Changes in density
Changes in resolution
Changes in hardness of gelatin through:
(i) melting point
(ii) scratch resistance

Table 6. Physical testing

mine the best freezing rate for a single photographic material. While the second experiment was designed to demonstrate the effects of different drying techniques on a limited number of photographic print materials, the objective of the third, by far the largest run, was to study the effect of a smaller number of drying techniques on a wide variety of contemporary and historical photographs.

In the first experiment five sets, each containing six test prints, were placed in a glass tray filled with Ottawa City tap water (having a temperature and pH of approximately 20°C and 8, respectively) and weighed down by a 20-milliliter glass beaker with enough water in it to keep the materials from floating. The test prints were made on contemporary enlarging speed paper (double weight, glossy surface, of the grid type described earlier, and fixed in a non-hardening fixer, prepared as in ANSI 4.32-1980). After a soaking time of 48 hours the prints were placed into a Beaumark freezer, model No. GH18A, at two different temperatures and with or without a fan (which altered the rate of freezing). The prints were then placed in a Virtis vacuum chamber and freeze-dried. The conditions for this first experimental run are summarized in Table 7. All samples were weighed before soaking and drying and again after freeze drying. Because the sublimation process (transition from solid ice to water vapour without passing through the liquid phase) proceeds inward from the outer edge of the solid mass of ice (removing water vapour from the surface), samples were dried below their original weight. If the samples were removed from the chamber at their original dry weight, they would have remained moist in the center while already being extremely dry at the edges. Density measurements were taken of five steps in the step wedge on a Macbeth RD 519 Reflection Densitometer. The readings of the six prints in each set have been averaged. They are recorded in Table 8.

Dimensional changes were determined as described previously and are shown in Table 9. Percentage figures are average values of the six prints in each set. The letters "H" (horizontal) and "V" (ver-

Set	Print No's.	Soaking	Freezing Cond.	Air-Drying	Freeze-Drying
1	1-6	Totally immersed in tap water of pH 8 at 20°C for 48 hours	-17.8°C	-	*
2	7-12		-	at room temperature	*
3	13-18		-17.8°C fan-assisted	-	*
4	19-24		-30°C	-	*
5	25-30		-30°C fan-assisted	-	*
Control Print	31	-	-	-	-

*Freeze-drying occurred under the following conditions: Vacuum 100 micrometers of mercury; chamber wall temperature -30°C; cold trap temperature -58°C.

Table 7. Summary of conditions in first experiment

a) Densities before soaking

Set	Steps on grey scale 0	3	7	11	21
1	.07	.12	1.16	2.00	2.12
2	.07	.11	1.15	2.00	2.12
3	.07	.11	1.11	1.99	2.12
4	.07	.10	1.13	2.00	2.12
5	.07	.11	1.19	1.99	2.12

b) Densities after drying

Set	Steps on grey scale 0	3	7	11	21
1	.06	.10	1.10	1.84	1.95
2	.06	.10	1.11	1.94	2.06
3	.06	.09	1.03	1.77	1.91
4	.06	.10	1.08	1.80	1.88
5	.06	.10	1.08	1.70	1.72

Table 8. Reflection densities of contemporary prints in first experiment

tical) refer to the longer and shorter dimension, respectively, of each sample. A minus sign indicates shrinkage. The melting point of a nonsupport layer of films and papers—which is defined somewhat differently from the melting point of a pure chemical compound—is one of several properties of photographic gelatin that is indicative of its stability. Another such property is the scratch resistance of coated gelatin layers. Gelatin melting points of historical and contemporary silver gelatin materials were measured before and after soaking-drying cycles according to the American National Standards Institute specification ANSI Ph4.11-1981, and the scratch resistance of gelatin layers was determined according to ANSI PH1.37-1977. Melting point data are recorded for the first experiment in Table 10.

In the scratch resistance measurements a sapphire stylus with a radius of .003 inch was used. Two kinds of threshold values were recorded. "B" indicates the load (in grams) on the stylus that produced a broken line,and "C" the load on the stylus (in grams) that produced an uninterrupted scratch. The results produced by the scratch resistance tests are summarized in Table 11.

In the second section an attempt was made to determine the most suitable drying mode for two contemporary print materials soaked in three different ways.

Set	Freezing Temperature or air-dried	H	V
1	-17.8°C	-.91	-.04
2	Not frozen, air-dried	-.66	-.14
3	-17.8°C fan-assisted	-.92	-.09
4	-30°C	-.83	-.13
5	-30°C fan-assisted	-.81	-.07

Table 9. Dimensional changes of contemporary prints in first experiment, measured in percentages

Set	Melting Point
1	0.5 minute at 101°C
2	1.0 minute at 101°C
3	0.5 minute at 101°C
4	0.5 minute at 101°C
5	0.5 minute at 101°C
Control print	1.0 minute at 101°C

Table 10. Melting points of contemporary prints in first experiment

The drying modes are listed in Table 1. The two print materials were processed in a non-hardening fixer (according to ANSI PH4.32-1980) and were of double weight and glossy surface. The prints, in sample sets of six prints per set, were totally immersed in water for five hours, partially immersed in water for 72 hours, and totally immersed in water for 72 hours. The Ottawa City tap water used was 20°C and had a pH of approximately 8. In the freeze-drying of soaked samples the rate of drying was monitored by their weight loss. The freeze-drying was done in a Virtis vacuum chamber in which the wall temperature was set at −10°C and the cold trap was −58°C. The pressure was 65 micrometers of mercury. In the freeze-thaw-vacuum drying cycle the rate of drying was monitored by observing the rise in temperature of the samples. In these experiments a Penwalt Stokes vacuum chamber, whose shelf temperature could be closely controlled, was used. The pressure was 165 millimeters of mercury. The temperatures of shelf and samples were monitored with thermocouples and recorded on a chart. The shelf temperature was kept at 11°C and the samples were held at 4°C until the sample temperature began to rise. At this point the shelf temperature was lowered to 8°C. The samples returned to 4°C, and as drying proceeded their temperature eventually rose to 8°C. The prints were left for an hour at the same temperature as the shelves before being removed dry.

Table 12 summarizes the density changes for prints that were fully immersed and dried in four different ways. The density differences recorded in Table 12 are losses except for those marked with a plus sign. The observed dimensional changes in the second experiment are presented in Table 13. The minus sign indicates shrinkage, the plus sign an expansion of the samples.

The third experiment was designed to study the effects of three drying techniques on photographic records made by a variety of different processes and was conducted in two parts. During the first part, samples made from two brands of contemporary sheet films, two black-and-white papers (as above) and one resin-coated paper were soaked for 80

Set	Horizontal Scratch		Vertical Scratch	
1	B: 20g	C: 25g	B: 15g	C: 20g
2	B: 20g	C: 25g	B: 15g	C: 20g
3	B: 20g	C: 25g	B: 15g	C: 20g
4	B: 20g	C: 25g	B: 15g	C: 20g
5	B: 20g	C; 25g	B: 15g	C: 20g
Control print	B: 20g	C: 25g	B: 15g	C: 20g

Table 11. Results of scratch resistance tests on contemporary prints in first experiment

a) Enlarging speed paper (manufacturer A)

Type of drying	5 hr. soaking time Steps on grey scale: 0	3	5	11	21	72 hr. soaking time Steps on grey scale: 0	3	5	11	21
Freeze-dried	.00	.03	.06	.17	.19	.01	.03	.06	.30	.32
Freeze--thaw--vacuum-dried	not obtainable as prints stuck together					.01	+.02	+.03	.25	.32
Freeze--thaw--air-dried	.00	.00	+.01	.08	.06	.01	.01	.03	.12	.08
Air-dried	not available					.01	.01	.00	.07	.08

b) Contact speed paper (manufacturer B)

Type of drying	5 hr. soaking time Steps on grey scale: 0	3	5	11	21	72 hr. soaking time Steps on grey scale: 0	3	5	11	21
Freeze-dried	.00	.01	.02	.10	.20	.01	.01	.03	.14	.25
Freeze--thaw--vacuum-dried	.01	.00	+.02	.08	.15	.01	.01	.02	.12	.27
Freeze--thaw--air-dried	.00	.01	.00	.03	.05	.01	.00	.01	.03	.08
Air-dried	not available					.01	.01	+.01	.05	.07

Table 12. Density changes for two types of prints in second experiment after soaking and drying

a) Enlarging speed paper (manufacturer A)

Type of drying	5 hr. soaking time H	5 hr. soaking time V	72 hr. soaking time H	72 hr. soaking time V
Freeze-dried	-.20	+.15	-.30	-.15
Freeze--thaw--vacuum-dried	not obtainable as prints stuck together		-.35	-.20
Freeze-thaw--air-dried	-.15	0	-.20	-.10
Air-dried	not available		-.20	0

b) Contact speed paper (manufacturer B)

Type of drying	5 hr. soaking time H	5 hr. soaking time V	72 hr. soaking time H	72 hr. soaking time V
Freeze-dried	0	+.45	0	+.67
Freeze--thaw--vacuum-dried	-.10	+.07	not obtainable as prints stuck together	
Freeze--thaw--air-dried	-.05	+.15	-.10	+.05
Air-dried	not available		-.20	+.05

Table 13. Dimensional changes in contemporary prints in second experiment, measured in percentages

hours and dried in three different fashions. Visual observations and physical measurements were taken and recorded. In the second part, various black-and-white photographic records from all periods of photographic history and several types of color materials were immersed for 24 hours under previously described conditions. However, the color prints made by dye imbibition processes (Eastman Kodak Dye Transfer and Fuji Dyecolor) were soaked for only 16 hours. All records were dried in three different ways. The materials examined are listed in Tables 3, 4, and 5. Melting points were taken of silver gelatin materials and of the contemporary color photographic records. Density readings were taken on some papers made by the printing-out process and by the pigment printing processes. Because of excessive damage to some materials, only visual observations could be made.

Results and Discussion

The S.P.S.E. Handbook of Photographic Science and Engineering[19] flatly

[19]Woodlief W. Thomas, *SPSE Handbook of Photographic Science and Engineering,* Wiley Series on Photographic Science and Technology and the Graphic Arts (New York: Wiley & Sons, 1973).

states as an important storage condition for processed photographic materials: "Protect photographic records from fire, water and physical damage". No other forces are likely to be more destructive than fire and water. Water damage, as was pointed out earlier, may be caused not only by a flood but may occur as a result of efforts to extinguish a fire. The experiments reported here shed light on the reaction of photographic materials toward prolonged immersion in water and subsequent drying. Our observations show that the resistance of photographic materials to wet immersion depends on the type of photograph, whether or not it was hardened during processing, the immersion time, and the water temperature.[20] The contemporary black-and-white enlarging speed paper that had been fixed in a non-hardening fixer was completely destroyed when the gelatin layer slid off the paper support after being immersed in water at room temperature for 72 hours. By comparison, the hardened sample of the same paper essentially kept its gelatin layer intact under the same conditions. The contact speed paper, made by a different manufacturer than the enlarging paper, regardless of whether it had been fixed in a hardening or non-hardening fixer, survived the same treatment virtually without damage. While dimensional changes in black-and-white films could not be observed with our equipment, in paper prints a shrinkage was generally determined to be greater in the length direction than in the width direction. Air-drying caused the least dimensional changes in prints.

After short drainage times no sticking of photographic records to plastic sleeves (made of cellulose triacetate) was observed. A loss of reflection density, which was to a large extent caused by a loss in surface gloss, was regularly observed in black-and-white prints. A similar, but much smaller, loss of transmission density was observed for black-and-white negatives. For both prints and negatives it can be assumed that the filamentary structure of the image silver undergoes changes during soaking, freezing, and drying to form more rounded-out silver particles which show less light absorption and therefore cause a density loss.[21,22] The considerable decrease of reflection density in prints can be explained by the loss of surface gloss[23]. This was also noticed by the mottled appearance of soaked and freeze-dried prints. The effect is small after air-drying or after freezing-thawing and vacuum-drying above freezing point. It was most pronounced after freeze-drying.

Because of the foregoing we feel that air-drying (i.e., without prior freezing) of water-soaked photographic materials appears to be the preferable treatment. Freezing may be necessary, however, in order to slow down deterioration of soaked materials and to gain time for gathering personnel and supplies. In that case, freeze-thaw-vacuum-drying—as done with books—cannot be recommended due to blocking and sticking of gelatin layers in stacked photographic

[20]Soaking experiments, carried out at two different temperatures, showed that samples soaked at higher temperatures disintegrated before others soaked at a lower temperature.

[21]R. K. Blake, and B. Meerkemper, "Developed Image Structure," *Journal of Photographic Science* 9 (1961): 14-25.

[22]H. Zwicky, "Ueber den Unterschied der Schwaerzungswerte photographischer Schichten in trockenem und nassem Zustand," *Zeitschrift fuer wissenschaftliche Photographie, Photophysik, und Photochemie* 50 (1955): 415-424.

[23]Hollis N. Todd and Richard D. Zakia, *Photographic Sensitometry: The Study of Tone Reproduction* (Hastings-on-Hudson, N.Y.: Morgan & Morgan, 1969).

pictures.

When freeze-drying was applied, the results showed that it would be the preferred treatment only for documentary photographs mounted in an album, particularly if they contain historical captions of some value. For all other cases it should be avoided; the loss of surface gloss (as indicated by the loss of density) was strongest after freeze-drying. This can be explained by the observation that water in the freeze-drying process is not allowed to run off as is possible after freezing, *thawing*, and vacuum-drying. As sublimation from solid ice to water vapor occurs, all impurities in the frozen water will be deposited on the surface of the prints or negative, having no place to escape elsewhere. If photographic materials that have been soaked in water cannot be air dried (because of lack of personnel, facilities and time), they should be frozen, thawed, and air-dried. Freeze-drying would be the next preferable alternative, while freezing, thawing and vacuum-drying above freezing point must be avoided.

Although less experimental data on color photographic materials were gathered, our observations indicated that color photographs made by the chromogenic development process showed resistance to immersion in water and subsequent drying which was comparable to that of black-and-white materials. However, chromogenic color print materials made by one manufacturer showed not only loss in surface gloss but also changes in color cast and color saturation after freeze-drying. These changes were not observed when the prints were frozen, thawed, and air-dried. The two samples made by dye imbibition processes were particularly susceptible to soaking. Diffusion of dyes into the water bath was observed within a short time after immersion.

While albumen prints and collodio-chloride prints survived the soaking and drying cycles remarkably well, the behavior of the binding agent in silver gelatin materials is most interesting. As can be seen from the tables showing experimental data, neither scratch resistance data nor melting points are significantly affected by soaking and drying of materials when compared to control prints. While these treatments caused some observable changes—loss of surface gloss, loss of adhesion, staining, and mottling—such properties as resolution, melting point, mushiness, and scratch resistance did not change appreciably. Gelatin, within a certain range of circumstances, appears to undergo changes reversibly, such as swelling/deswelling or softening/hardening, unless it reaches a breaking point, or point of destruction. There seems to be no gradual deterioration; instead, an abrupt deterioration takes place when conditions are driven past a certain limit.

The most significant result of this study is, in our view, the inability of glass plate negatives made by the wet collodion process to survive immersion in water and subsequent drying. Of several plates tested, one half did not survive a 24-hour soaking period. The image layer of those that barely survived the immersion in water shattered into many pieces during freeze-drying. Recalling the simple fashion in which they were made, it seems reasonable to assume that the lack of a special substratum, which usually serves to improve the adhesion between image layer and support, is one factor contributing to the instability of wet collodion plates. One has to conclude from these observations that negative glass plates made by the wet collodion process—and the collodion positives known as ambrotypes and tintypes, which were made by a

- Keep immersion time to a minimum.
- Keep water temperature low.
- Freezing of photographs retards further deterioration.
- As films appear to be more stable, salvage prints first.
- If personnel and time are available, proceed in this order:
  a. air dry (without freezing)
  b. freeze--thaw--air dry
  c. freeze-dry in vacuum chamber
- Freeze--thaw--vacuum-drying, as done with books, not recommended due to blocking or sticking of gelatin layers.
- Protect wet collodion glass plate negatives completely from being immersed in water.
- Wet collodion glass plate negatives must never be freeze-dried; none will survive.

Table 14. Recommendations for treatment of water-soaked photographs

similar process—should be kept in any collection in a way that will prevent them from ever being flooded or soaked in water. Without having done any experiments in this direction, we have discussed the question informally with curators in the National Photography Collection. The use of water-tight ammunition boxes, or rigid polyethylene boxes with snap-on covers (similar to Tupperware products), or covering cardboard boxes with flexible polyethylene bags, are all under consideration. The problem is urgent and requires a practical solution.

A summary of our conclusions and recommendations is presented in Table 14.

Summary

A fairly large number (more than 630) of still photographic negatives and prints in black-and-white and color were immersed in Ottawa City tap water (approximate pH 8) for varying periods of time and dried in four different ways: air-drying (without freezing); freezing-thawing-air-drying; freezing-thawing-vacuum-drying; and freeze-drying. In addition to evaluating the results by close visual inspection, attempts were made to quantitatively measure changes in test samples after soaking them in water and subsequent drying. These included dimensional changes, density, resolution, and hardness of the gelatin.

Our results show that the materials most susceptible to water damage are glass plate negatives made by the wet collodion process. They should never be freeze dried once they have been immersed in water. While salt prints, albumen prints, and collodio-chloride prints survived surprisingly well, black-and-white silver gelatin materials showed specific deterioration ranging from total destruction—due to solution of the gelatin layer in non-hardened prints—to severe mottling of the gelatin in freeze-dried materials and to a barely perceptible loss in surface gloss in air-dried prints. The formation of ice crystals when freezing water-soaked silver gelatin materials was not observed. Furthermore, there was no evidence of damage due to freezing of water-soaked film. These observations have been confirmed by experiments conducted at the Eastman Kodak Company on a variety of their own photographic materials. While black-and-white materials commonly appeared to be more resistant than color photographs, the former were also more stable when they had been processed using a hardening fixing bath. After photographic materials are soaked in water, air-drying or freezing-thawing and air-drying are to be preferred over freezing-thawing-vacuum-drying and freeze-drying.

No prediction can be made from our observations with respect to the long-term effect of soaking-freezing-drying cycles on the described photographic materials. Photographic records which have undergone such cycles should be labelled accordingly, specifying as many details as possible. Valuable observations may then be made in the future on the possible effects of soaking and drying on the long-term stability of photographic materials.

The Fellows' Posner Prize

For the past several years, the Society has had but one award for writing, the Waldo Gifford Leland Prize, given for the outstanding separate publication of the preceding year. Article-length contributions to archival scholarship, however outstanding, received no special recognition or incentive. Consequently, the Fellows of the Society have offered, and the Council has accepted, the establishment of a new award: The Fellows' Posner Prize. Honoring one of the most outstanding archival scholars and teachers of the 20th century – Ernst Posner – it will reward the best article published in the preceding year's volume of the *American Archivist.* The winning article will be selected by a subcommittee of SAA's Awards Committee. The cash prize will be awarded at the annual meeting. The first award, for an article published in volume 45, will be presented at the annual meeting in Minnesota in October.