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# THE ACETATE NEGATIVE SURVEY: FINAL REPORT

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(The following talk and illustrations were excerpted from a written report of the same title which is available from the University of Louisville Photographic Archives.)

Those of you who were in Louisville in 1984 when our Winter Meeting was held at the Photographic Archives may recall that the title of my talk there was "A Nightmare in My Closet." In it I described the efforts we were making to monitor and determine the extent of the deterioration of our own acetate negative files. The last several years I have learned a lot more about acetate film and I have just completed a National Museum Act funded project to survey collections at other institutions as well. So now I can call this talk "A Nightmare in Their Closets."

In presenting the results of my work, I will talk more today about the methodology of the study, the compilation of results, and my conclusions, rather than the historical research or results of my literature search. These areas are discussed in detail in The Acetate Negative Survey: Final Report.

## METHODOLOGY

The prime focus of this study was a survey of film collections and a determination of the extent of cellulose acetate dgradation. Institutions were selected for the survey based on their holdings of negatives from the period 1925-1955. Collections included had accurate documentation for the dates of

particular negatives available either directly on the negative sleeves or through the use of indexes or other finding aids. A variety of collections were included in the sampling to get the best possible variety of film types, uses, and formats. Institutions were also selected which presented a variety of storage and environmental conditions.

The site surveys themselves consisted of two steps. First, worksheets were completed for each collection. Entries were made on the worksheets for negatives which fit the project's chronology. Samples were included for both degraded and non-degraded examples and for all manufacturers and film types (notches) represented. The total number of samples would vary with each collection depending on the arrangement of the negatives, the size of the collection, and the ease of dating particular samples.

The worksheet contained the following items of data:

**COLLECTION/NEG #** This column was used to record a collection specific number for each individual sample included. A two to four letter prefix designating the institution was included with the institution's own negative number (location).

**MANUFACTURER & NUMBER** The manufacturer of a particular negative sample was recorded here with any number that appeared embossed in the film edge with the manufacturer's name. This number, referred to as the "machine number," is generally considered to be the number of a particular notching machine used in the finishing of the film. Historically, these numbers have been used by various manufacturers to follow the movement of raw film stock, or to indicate the number of an inspector of a particular film batch. More recently Kodak has used the number to identify the film product itself.

**NOTCH** Film notch codes are cuts on the edges of sheet film that can be used to identify the film type, as well as locate the emulsion side of the film when film holders are loaded in the dark. The sample's "NOTCH REFERENCE" (see Appendix B) was recorded or, if not known, the actual notch

was carefully traced in pencil. A notch reference would then later be assigned.

**NOTCH REFERENCE** A unique alphanumeric designation was assigned to each notch. For Kodak negatives this reference refers to Kodak's own notch designation as recorded by their Patent Office. This was useful for their own records and keeping track of notch usage and chronology. Unfortunately, these records are not available from other manufacturers. For these examples a notch reference designation was assigned for this survey. A listing of notch references is included in Appendix B.

**LEVEL OF DETERIORATION** Each negative was assigned a number from 1-6 describing its physical condition at the time of the survey. These six levels can be described as follows:

Level 1-- No deterioration; flat negative.

Level 2--Negative exhibits slight or moderate edge curl with smooth surfaces on both emulsion and base sides. Edge curl is always symmetrical on the two or four sides affected.

Level 3--Smell; the negative smells distinctly of acetic or butyric acid. This determination is difficult to make if there are large numbers of degraded negatives in a confined area such as a box or drawer where the acid odor permeates. Usually in these cases there is level 4-6 degradation evident as well.

Level 4--Warpage; wavy portions in edges and surface of the negative; not symmetrical; no separation of emulsion or base. One of the first signs that a negative may be degrading is that it will show signs of warpage. Slight warpage or deformation can also be caused by the uneven loss of solvents from the negative. The type of warpage which indicates serious degradation is most often verified by the existence of other further degraded samples in the immediate vicinity of the warped negative.

Level 5--Bubbles; occasionally when an acetate negative degrades, bubbles may form between the emulsion and base or between the base and the anti-curl backing of the film. These bubbles vary in size and may appear in a circular pattern from the center of the negative out to the edges. Occasionally these bubbles are filled with a volatile liquid.

Level 6--Separation of the emulsion, base, and anti-curl layers. This can be evident in varying degrees, from slight localized separation to massive separation. A white crystalline exudate is often seen under the

separated portions of the base material. This substance is most likely to be the plasticizer used to manufacture the film base such as triphenol phosphate.

**DATE** This column was used to record the date of the negative as closely as it can be determined from the photographer's records. To be included in the final data analysis, the date should be reasonably verifiable within a year.

**FILM THICKNESS** Initially the thickness of each negative sample was recorded using a dial type calipers. Little variation was noted between the sheet film negatives in various conditions, with thicknesses ranging from .008 to .010 inches in all samples in various conditions. After several site surveys this measurement was discontinued.

**FILM SIZE** The nominal size of the sheet film being sampled.

**NOTES** Observations were recorded here for any special conditions of a particular sample, including additional comments about condition, appearance, or environment, as well as qualifications for date or notch information.

The second portion of the site or institutional surveys consisted of an interview with the curator or caretaker of the collection to record the storage and environmental history of the material surveyed. This information would include, if known, how and where the negatives were stored before they arrived at the institution and the same information for the institution's own storage. Of particular interest would be any trauma the collection may have suffered, such as fire, flood, or warehouse storage, that would effect the present condition of the negatives.

## COMPILATION OF RESULTS

Sixteen institutions were surveyed. Twenty-nine individual collections were inspected and a total of 3396 negatives were sampled. Only safety-based sheet film was sampled for this project. Most of the negatives surveyed were considered

"professional" or "portrait" films and few graphics arts type films were encountered. Aerial and other roll film stock were not included.

The earliest dated Kodak safety film was 1926. Agfa safety film samples dated from 1936. Defender safety film dated from 1934-1945 and Dupont Defender from 1945-1955. Only several samples from the Hammer Company were encountered and these dated from 1946-48.

A notch by notch comparison is included in the final report. We don't have the time to analyze it here. Several Kodak film types, specifically the most popular and commonly encountered films appeared degraded in moderate percentages in most collections during the 1930s. These included Super-Sensitive Pan and Portrait Pan films. A very high percentage of Dupont Defender film dated after 1946, particularly Arrow Pan and High Speed Pan films were found degraded in almost every collection surveyed throughout the country. Agfa/Ansco film types appeared degraded in moderate percentages throughout the chronology in percentages similar to Kodak products.

Table 3 totals the number of film types (notches) for each manufacturer and the number of those film types which have degraded samples. All manufacturers' negatives show a high percentage of film types which have degraded, that is, most cellulose acetate-based sheet film can be affected in the same way. Table 2 shows the total number of negatives sampled and listed by manufacturer. This indicates the percentage of samples from each manufacturer that were degraded. Again, with the

exception of Dupont Defender (post 1945) film, percentages for each of the manufacturers were relatively close, varying from 19-38% of the total sampled.

It should be noted that the percentages cited in this compilation are useful only in relation to each other in the specific context of this project. This is due to the sampling method which was heavily weighted toward suspect collections and areas within collections. These figures are not to be extrapolated to collections of materials not sampled. For example, most collections will contain far less than the total 30.9% degraded samples for this survey. A very large collection may contain only a small percentage of degraded negatives. The University of Louisville's Caufield and Shook Collection, for instance, contains roughly 5000 degraded negatives out of a total of approximately 160,000 negatives, or 3.1% Percentages can also be somewhat deceptive in instances where few samples were registered, such as for Hammer film.

A useful summation of the data is seen in a chronological overview for each manufacturer of the total number of negatives surveyed and the number of degraded samples.

Figure 1 shows a comparison between manufacturers and the percentage of degraded samples. It indicates the average for all samples, as well as that for individual manufacturers. Regardless of data skews caused by sampling size, general trends remain consistent. Kodak film accounts for all of the degraded samples dated before 1936. After 1936, the total percentage for all negatives becomes an average of the three major manufacturers

## Table 2
## Film Types by Manufacturer

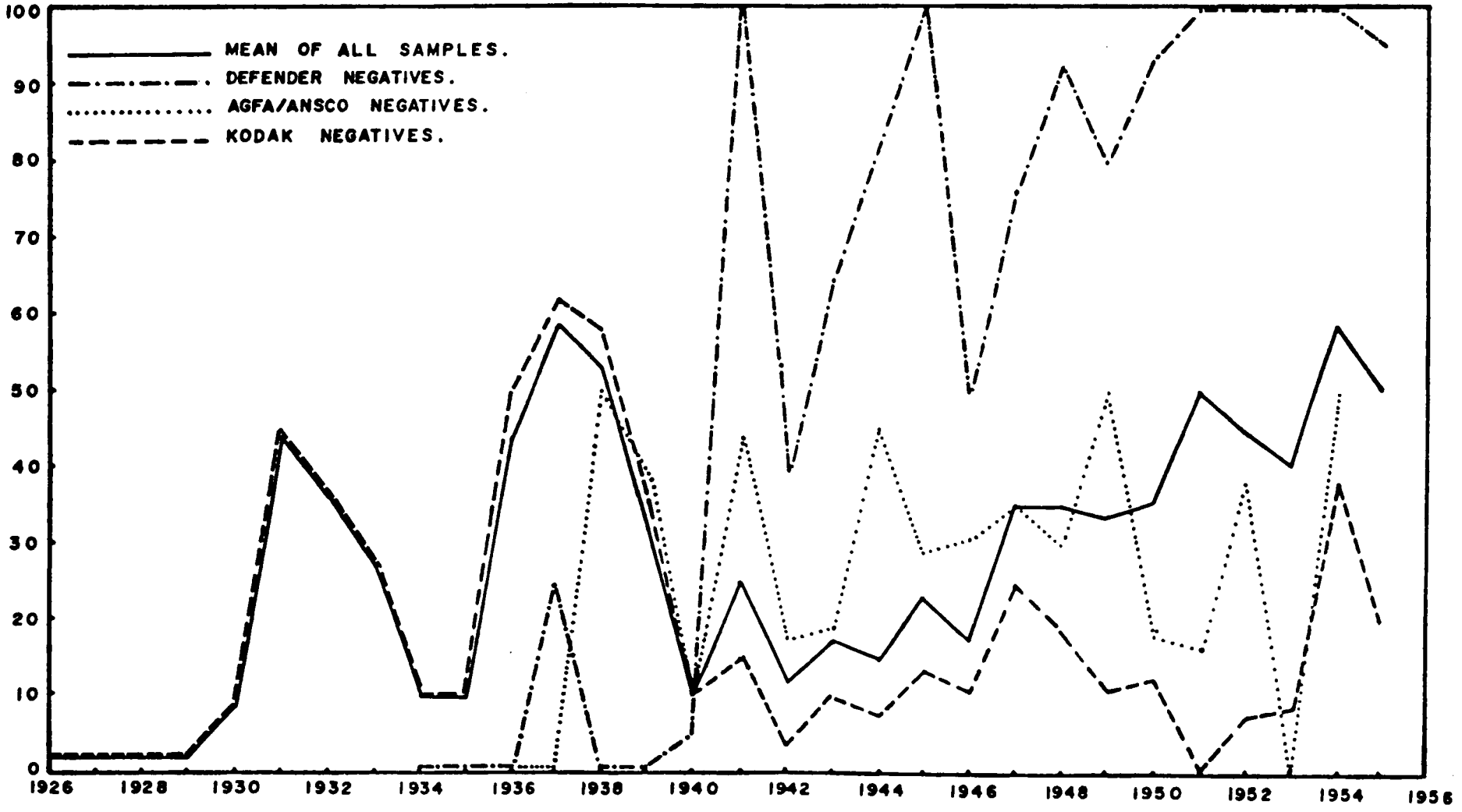
| | |
|---|---|
| Eastman Kodak—total types | 19 |
| Types degraded | 15 |
| Agfa/Ansco | 8 |
| Types degraded | 7 |
| Defender | 10 |
| Types degraded | 9 |
| Hammer | 1 |
| Types degraded | 1 |

## Table 3
## Samples Totaled by Manufacturer

| | | |
|---|---|---|
| Total number of samples | | 3396 |
| Total number degraded* | | 1051 |
| Percentage | 30.9% | |
| Eastman Kodak total samples | | 2607 |
| Total number degraded | | 701 |
| Percentage | 26.8% | |
| Defender (pre-1945) total | | 109 |
| Total number degraded | | 20 |
| Percentage | 19% | |
| Dupont Defender (post-1945) total | | 206 |
| Total number degraded | | 192 |
| Percentage | 93% | |
| Agfa/Ansco total | | 461 |
| Total number degraded | | 133 |
| Percentage | 29% | |
| Hammer total | | 13 |
| Total number degraded | | 5 |
| Percentage | 38.4% | |

*The term degraded here refers to negatives which exhibit definite signs of acetate deterioration, level 4 or greater. Negatives which were only slightly warped and with no other indications of degradation, such as acetic odor, were not included in these totals.

Figure 1 PERCENTAGE OF SAMPLES DEGRADED, (By Year).



individual percentages. After 1940, the Kodak average fell consistently below the mean, while Agfa/Ansco and Defender films suffer from higher than average percentages of degradation.

It is interesting to note that pre-1930 samples of Kodak safety films show no signs of serious degradation. This is despite the fact that these films are most definitely on cellulose diacetate film base. The early samples were part of collections which contained other later degraded samples. Later degraded Kodak films, especially those dated after 1940, were probably made with one of the mixed cellulose esters. Both Agfa/Ansco and Defender/Dupont Defender products were on cellulose diacetate film base throughout the period. This indicates that all cellulose esters are susceptible to degradation and not just diacetate as had been assumed by some curators. Conversely, negatives still in good condition include diacetate, as well as the mixed esters.

Although some degraded Defender films were dated before 1945, there was a clear increase in the percentages of degraded film after 1945, the year that Dupont assumed control of the company.[40] For instance, notch K Defender film (X-F Panchromatic) dated 1934-41 was found degraded in only one of ten collections which contained them. Later Dupont Defender film, from the 1946-1955 period were found degraded in nearly 100% of the samples surveyed.

## CONCLUSION

> "The history of a cellulose derivative can never be completely known, and so the exact behaviour of a given sample cannot be precisely predicted or explained." Vivian Stannett, Cellulose Acetate Plastics, 1951.

This statement best describes the difficulty in discussing the problem of deteriorating safety-based photographic negatives. As described in the full report, the number of technical and storage variables make exact explanations extremely difficult. Each collection is different in terms of storage histories, present storage conditions, enclosure materials, the presence of nitrate film, and other specific factors.

Several generalities are obvious from an analysis of the data and from obvservation, interviews, and literature search. First, some individual collections contain a far greater number of degraded samples than other collections and some institutions contain more of these degraded collections. The following are the major factors which relate directly to the condition of negative collections:

1. temperature and humidity history;
2. storage of nitrate negatives with safety film;
3. storage in acidic sleeving material; and
4. the microenvironment of the negatives.

## Temperature and Humidity History

Given the well-documented susceptibility of cellulose acetates to hydrolytic degradation, it is no surprise that the temperature and, more importantly, the humidity history of a collection plays a major role in the present state of preservation of a negative collection. Many of the collections faced with serious degradation were produced and/or stored in geographic areas with a high average relative humidity or the specific storage history of individual collections has included some degree of temperature and humidity trauma at some point in

their lifetime before arriving at an institution.

Collections stored in geographic areas with low relative humidity and infrequent drastic fluctuations have generally fared much better. These include collections in California and Arizona. Certain film types, mainly Dupont Defender, degraded in these locations as well, but most acetate film is still in relatively good condition in these collections. On the other hand, collections and institutions located in areas of high average relative humidity contain far more degraded negatives of all types and manufactureres. The Florida State Archives, the University of Louisville, the Historic New Orleans Collection, and several collections in Washington, D.C. are good examples.

Collections stored "properly" without extremes in temperature or humidity and without significant "trauma" also seem to contain far fewer degraded examples of all types and manufacturers. Most notably in this category is the collection at the American Museum of Natural History. Although the collection contains a large number and variety of film types of several sizes, taken by many photographers on locations throughout the world, the collection is in very good shape with only one small pocket of degraded negatives. Neither temperature or humidity has beén acurately controlled at the AMNH, but conditions have been kept moderate and consistent.

A major change in the average relative humdity with frequent peaks over 80% also seemed to be a causal factor in the rapid increase in the degradation of negatives at the University of Louisville Photographic Archives.

Other collections which contain degraded negatives have

histories which often include other forms of moisture trauma, such as fire or flood. Observation of the various portions of the Samuel Gottscho Collection (currently housed in three separate locations, fully described in the Report) indicate that early storage conditions, by the photographer or originating agency, are more responsible for present degradation than more recent institutional storage conditions. Degradation which may have started years ago can dramatically increase in rate with continued humidity trauma. It is believed that degradation can be appreciably slowed by colder and dryer storage, but it is not believed that the degradation can be arrested once it has started.

Improper storage is not the only cause of serious degradation, but proper temperature and humidity are extremely critical for the long-term storage of all cellulose acetate photographic negatives, past, present, and future. The recommended levels for both medium term and archival storage can be found in American National Standards Institute specification PH1.43-1985. Archival storage requirements recommend 30% relative humdity with little short-term recycling and a maximum temperature of 21 degrees C (70F).

## Storage of Nitrate Film

Another factor which plays a major role in the process of degradation is the storage of cellulose nitrate negatives in the same or adjacent storage areas. These effects are well-described by Carroll and Calhoun in their study "The Effect of Nitrogen

Oxide Gases on Processed Acetate Film". They concluded that the combination of nitrogen oxides and high humidity are particularly damaging, a fact that has particular relevance for the collections surveyed.

## Storage Enclosures

A third storage-related condition frequently encountered with these collections was the presence of improper filing enclosure materials. Kraft paper, glassine, and highly acidic negative envelopes generally seem to accelerate the process of deterioration. Many degraded negatives begin to show separation of the base and emulsions along the seam of these envelopes. Negatives stored in glassines often show signs of degradation before similar unsleeved negatives or those in paper sleeves.

## The Microenvironment

The physical microenvironment of each negative may also be important to the rate of degradation. More evidence needs to be collected concerning the effects of sleeving a collection of previously unsleeved negatives. Normally the storage of degrading negatives unsleeved in bundles or packs will increase the autocatalytic reactions in the container, and effect more of the surrounding negatives. However, sleeving may appear to increase the rate of the degradation of particular negatives. This seems to be evident in a number of cases as related by collection curators, where previously unsleeved negatives, boxed or bundled in stacks, were sleeved, and the degradation seemed to speed up. This may be due, in part, to the fact that "looser" sleeving provides more surface exposure for interaction between

the negative and moisture, oxidizing pollutants, and, perhaps most importantly, with gaseous acetic acid produced by cellulose acetate degradation.

Currently there is not enough data to predict whether sleeving will accelerate or decelerate the rate of deterioration of negatives that have already begun the degradation process. Further observation and investigations are required to help make the decision as to the appropriate action.

These storage and environmental factors are important in that they offer immediate and observable connections which help to explain the degradation of cellulose acetate negatives. No factor can be identified as a single cause of the problem in all cases. More likely it is a combination of these factors which contribute to the autocatalytic process described in Section 3.

But questions must still be asked, such as why do some negatives within a collection which have always been stored together degrade first? Will collections and institutions which now contain a few of these degraded products begin to see similar "pockets" of deterioration in coming years?

The first question can be answered simply by admitting that certain negatives seem to be "predisposed" to more accelerated degradation and susceptibility to environmental factors. This conclusion is supported by the observation that negatives from some manufacturers made during specific time periods have a very high incidence of degradation. This is most evident in the Defender film manufactured between 1947-1955, and, to a lesser

degree, some Kodak film in the 1930s.

It is believed that "pockets" of degradation spread because of the catalcytic effect of the degradation by-products which infest more stable materials. It would not be inaccurate to relate this to the "bad apple" phenomenon.

A more exact answer to this question would be speculative without considerable analytical testing of historical negatives. This speculation is made more difficult because of the large number of variables involved.

The second question can be answered with a little more certainty. Given the evidence from this project, examples of degraded safety film are widespread, with most institutions surveyed containing a variety of degraded examples from all manufacturers. It is concluded that every institution which contains a substantial quantity of safety film dating from 1925-1955 will find problems with degraded film base somewhere in their collection sooner or later. The extent and breadth of the problem will vary, just as it has with this survey, from institution to institution depending on storage history and the other factors as described in this report.

(A complete copy of the Report can be obtained for $10 by writing to the University of Louisville Photographic Archives, Ekstrom Library, Louisville, KY 40292 )