Latent Image Stability in High Resolution Plates

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LATENT IMAGE STABILITY IN HIGH RESOLUTION PLATES

A study of the stability of the latent image in high resolution plates is presented. The factors have been investigated relative humidity before and after exposure and the length of time under such conditions. It was found that no conditions of 60% relative humidity or lower falling short of any real threat to the eventual result and that under 100% R.H. conditions today taken place.

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by

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ABSTRACT

A study of the stability of the latent image in High Resolution Plates is presented. Two factors have been investigated—relative humidity before and after exposure and the length of time under such conditions.

It was found that in conditions of 60% relative humidity or less, fading does not pose any real threat to the commercial user and that under 100% R.H. conditions fading takes place quite rapidly.
BACKGROUND INFORMATION

The problem of latent image stability has been plaguing photographers since the invention of photography. Investigation into this area has become of great importance in this age of information technology. A loss or gain of density or contrast may result in a considerable loss of or mistake in pre-recorded information.

There have been numerous investigations, many of which are conflicting, into this area since the early days of photography. "In 1889, an article in the British Journal of Photography stated that storage of exposed plates produced a "continuing action of light.""\(^1\) W. I. Rogers in his 1891 book called *A Casket of Photographic Gems*, wrote that plates known to be underexposed could be intensified by delaying development for several weeks.\(^2\) C. E. K. Mees in 1915 observed a speed increase in aging the latent image.\(^3\) In 1924, Strauss reported a fading of the latent image with age.\(^4\) In 1929, Jausseran discovered a linear relationship between the logarithm of the storage time and the resulting density.\(^5\) This was confirmed by E. R. Bullock in 1930. He found that humidity was a factor in latent image stability and theorized that latent image growth was physical rather than chemical and was caused from within the silver halide grain.\(^6\)\(^7\)
"One of the first investigations of a practical nature was done by Pamulener and Judkins in 1947. Working with cine negative films, they found the latent image increased 1/2 - 2 1/2 stops in speed during a one year storage period under average conditions. The panchromatic films showed the greatest increase in effective speed and unsensitized film the least."

These and many other articles have been published but little confidence can be put in them due to their contradictions.

INTRODUCTION

In a late article by Micanek, four primary factors were tested for their effect on latent image stability.

These are:
1. time of storage
2. temperature of storage
3. relative humidity in storage
4. spectral sensitization of the emulsion

In addition, the literature has reported the following factors thought to influence latent image stability.

1. relative emulsion sensitivity
2. chemical sensitization
3. wavelength of exposing illumination
4. support material
5. emulsion pH and pAg
6. manufacturing techniques
7. atmosphere during storage interval
8. silver halide type
9. developer time
10. developer strength

One explanation given for image fading or regression is oxidation of the latent image centers. This is due to the oxygen in the air in the presence of moisture contained in the gelatin. All other causes studied are secondary and influence only the rate of oxidation. Rate of regression, other things being equal,
depends upon the size of the latent image centers and also upon the sensitivity of the emulsion.\textsuperscript{9}

In nuclear emulsions, investigations by Lauda\textsuperscript{10} and Mather\textsuperscript{11} show a reduction of the rate of regression of about 90\% when oxygen and water vapor were excluded from the surrounding atmosphere. The fading rate was greatest in oxygen and least when in nitrogen; addition of water vapor increased the rate in all cases.\textsuperscript{12}

It was also noted by Eggers, Matejac and Meyer,\textsuperscript{13} that in the interior image of iodobromide emulsions, fading was accelerated by moisture. Markow\textsuperscript{14} found that Kodak Type 649-0 Spectroscopic Film can be kept from fading if kept on dry ice, in a desiccated vacuum of 10^{-14} \text{ mm Hg}, or in a neutral atmosphere of argon after exposure. See figures 1 and 2 below.

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**Figure 1.** Results of dry ice and vacuum storage: (a) vacuum exposure and storage (pumped); (b) dry ice stored, exposed at 22\textdegree C; (c) dry ice stored and exposed; (d) normal latent image fading for 22\textdegree C exposure.

**Figure 2.** Results of sealing in stainless steel package in vacuum and argon: (a) vacuum packaging; (b) argon packaging; (c) normal fading.
EXPERIMENTAL PROCEDURE

The experiment was carried out during the winter months inside a well heated and ventilated laboratory. Thus humidity was very low and constant, approximately 35%. At this low water vapor content, the latent image fading in Kodak High Resolution Plates was very slow. The original objectives of the experiment were to investigate fading in the first few minutes after exposure. At such low humidities there was no change to study. Noting this, the relative humidity of the atmosphere was raised to 100% through using a desiccator jar partly filled with distilled water. To have an intermediate water content of approximately 60%, a saturated solution of calcium nitrate (Ca(NO₃)₂) was used in another desiccator jar. This then gave three levels of the factor relative humidity: 35%, 60% and 100%.

The plates were preconditioned to these three humidities for various times, exposed and then stored at combinations of humidity and elapsed time. The experiment can be followed graphically by the use of the flow diagram and treatment combination as given on pages 5 and 6.

The exposure of the cut in half, two by two inch plates was made by projecting a portion of a Kodak Step Tablet with a magnification of approximately 1:1 with a voltage regulated Kodak Carousel Slide Projector. To obtain the magnification without encountering mis-aligned and easily moved optics, the normal projection lens was removed and a 75mm. Ektar lens was used instead. See page 15.
<table>
<thead>
<tr>
<th>Treatment After Exposure</th>
<th>0 Hours</th>
<th>1 Hour</th>
<th>24 Hours</th>
<th>48 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>35% R.H.</td>
<td>24 HRS</td>
<td>65</td>
<td>71</td>
<td>67</td>
</tr>
<tr>
<td>35% R.H.</td>
<td>48 HRS</td>
<td>69</td>
<td>72</td>
<td>68</td>
</tr>
<tr>
<td>60% R.H.</td>
<td>1 HRS</td>
<td>45</td>
<td>46</td>
<td>53</td>
</tr>
<tr>
<td>60% R.H.</td>
<td>24 HRS</td>
<td>60</td>
<td>43</td>
<td>44</td>
</tr>
<tr>
<td>60% R.H.</td>
<td>48 HRS</td>
<td>51</td>
<td>52</td>
<td>55</td>
</tr>
<tr>
<td>100% R.H.</td>
<td>1 HRS</td>
<td>27</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>100% R.H.</td>
<td>24 HRS</td>
<td>31</td>
<td>37</td>
<td>39</td>
</tr>
<tr>
<td>100% R.H.</td>
<td>48 HRS</td>
<td>59</td>
<td>70</td>
<td>26</td>
</tr>
</tbody>
</table>

Math. Model: \( X_{ijklm} = \alpha + \beta_i + \gamma_j + \delta_k + \epsilon_{ijkl} \)

Factors:
- \( A = \) Humidity Before Exposure (3 Levels)
- \( B = \) Time
- \( C = \) El. After
- \( D = \) Humidity

Numbers in blocks are plate reference numbers.
All plates were processed according to recommended procedures\textsuperscript{15} in D-19 developer for 2-1/4 minutes at 68° F. One gallon size quantities of D-19 were mixed at a time and stored in plastic quart bottles to hold oxidation problems to a minimum.

From the plotted characteristic curves, the parameters of gamma and speed were obtained\textsuperscript{*} and plotted against the logarithm of the time in hours.

RESULTS

Figures 3 and 7, pages 8 and 10, show that when conditions prior to exposure are at 35\% relative humidity, a very substantial decrease in gamma and speed occurs in 2\frac{1}{4} hours at 100\% relative humidity after exposure. The change produced in gamma and speed with plates at 35\% and 60\% 2\frac{1}{4} hours after exposure is just barely significant at the 0.10 level of confidence.\textsuperscript{**} A definite drop in gamma and speed occurs at one week elapsed time at 35\% relative humidity.

Plates in figures 4 and 8 which were preconditioned to 60\% for 1, 2\frac{1}{4}, and 4\frac{1}{8} hours before exposure showed a gamma loss as well as a slight speed loss in 2\frac{1}{4} hours elapsed time at the same humidity.

In figures 5 and 9, there is no loss of gamma or speed in 1 hour in plates which have been preconditioned to 100\% R.H. 1 hour before exposure. There is a very definite decrease in both parameters when stored for 2\frac{1}{4} hours at 100\%.

In the same figures, within one hour, the plates preconditioned for 4\frac{1}{8} hours at 100\% have shown considerable drop of gamma and slight drop in speed. Both parameters tumble to

\textsuperscript{*} See page 16

\textsuperscript{**} A sample calculation of confidence intervals is given on p. 14
VARIABLE = GAMMA

GAMMA LOSS w/ PLATES AT 35% BEFORE EXP.

FIGURE 3

35 AND 60% COMBINED INTO ONE LINE

STORED AT 35% AFTER EXPOSURE

STORED AT 100% AFTER EXPOSURE

GAMMA LOSS w/ PLATES AT 60% R.H. BEF. EXP.

FIGURE 4

24 HRS. 60% BEF. EXP.

1 HOUR 60% BEF. EXP. COMBINED

48 HRS.

LOG ELAPSED TIME

AMMA

0.0  1.0  2.0  3.0  4.0

0  1  2  4  6  8  12  16  20  24  28

0 HOURS 1 HR. 24 HRS. 48 HRS. 1 WEEK

LOG ELAPSED TIME

AMMA

0.0  1.0  2.0  3.0  4.0

0  1  2  4  6  8  12  16  20  24  28

0 HOURS 1 HR. 24 HRS. 48 HRS. 1 WEEK
Gamma loss with plates at 100% R.H. before exposure.

Figure 5

Gamma loss with plates at 100% R.H. before exposure:
- 48 hours, 100% R.H. before exposure
- 1 hour, 100% R.H. before exposure

Log elapsed time:
- 0 hours
- 1 hour
- 24 hours
- 48 hours
- 1 week

Figure 6

Desensitization effect on gamma:
- Effect at elapsed time = 0
- Control
- 48 hours
- 24 hours

20 Squares to the inch
**VARIABLE SPEED (AT A DENSITY OF 2.0)**

**SPEED LOSS w/ PLATES**

AT 35% R.H. BEF. EXP.

**PAGE 10**

**FIGURE 7**

- STORED AT 100% AFTER EXPOSURE
- 35 AND 60% COMBINED INTO ONE LINE
- STORED AT 35% AFTER EXPOSURE

**SPEED**

**LOG ELAPSED TIME**

**SPEED LOSS w/ PLATES**

AT 60% R.H. BEF. EXP.

**FIGURE 8**

- 24 HRS. 60% BEF. EXP.
- 1 HOUR 60% BEF. EXP.
- 48 HRS. " " "
- COMBINED
SPEED LOSS w/ PLATES
AT 100 % R.H. BEF. EXP.

FIGURE 9

DE-SENSITIZATION EFFECT ON SPEED
AT ELAPSED TIME = 0

FIGURE 10
an extreme low with 4.8 hours at 100% preconditioning and 24 hours at 100% elapsed time.

Figures 6 and 10 show the desensitizing effects of preconditioning to high humidity. Exposing and processing immediately after preconditioning to 100% R.H. for 4.8 hours shows a very substantial desensitizing effect whereas 60% does little or nothing. It may be interesting to note that if the plates are dried out at 35% R.H. for 24 hours after being in 100% for 4.8 hours, the desensitizing effect disappears and the resulting exposure is normal, i.e. the same as when not subjected to 100% for 4.8 hours.

DISCUSSION

In this experiment, only data from one emulsion batch is presented. By taking only one sample of a whole population of batches the manufacturer has produced, very little meaningful quantitative data can be had. This limits what can be said concerning how other material, produced at a different time, will respond to the conditions in this experiment. Extremely tight controls on exposure and processing are required since the contrast of the material is so high and the development time rather short. The slightest variation in either will show up as what is thought to be latent image fading.

To obtain an idea of the amount of experimental error present, confidence intervals have been placed on points which may be in question as to whether there is a difference. To run an analysis of variance would be of little practical meaning since the treatment combinations have been filled in rather sporadically. See page 6. This incomplete gathering of data may be contributed to a large change of experimental objectives and procedures.
CONCLUSIONS

From this study on one emulsion batch of Eastman Kodak High Resolution Plates, the following conclusions can be made.

1. In the duration of a normal eight hour working day, little if any attention need be given to latent image fading during the "normal" fall, winter and spring seasons indoors. If, however, the plates were to be used in very humid surroundings, processing should follow exposure almost immediately.

2. It would be more than wise to store the plates while not in use under dry refrigeration and be returned shortly after exposure if processing isn't immediately possible.

3. If plates do become subjected to extremely high humidity surroundings shortly before their use, they may be "dried out" for 2½ hours under vacuum or silica gel desiccation and should return to their normal sensitivity.
APPENDIX

Determination of confidence intervals for points which require them.

Using 90% confidence, alpha (\(\alpha\)) = 0.10

\[
\bar{X} = \frac{\sum X}{N} \quad S = \sqrt{\frac{\sum (X-\bar{X})^2}{N-1}} \quad \bar{X} \pm t_{N-1}, \frac{\alpha}{2} \quad \frac{S}{\sqrt{N}}
\]

The Student-t table is used because (\(\sigma\)) is not known.

Sample Determination

\[
\begin{array}{cccc}
3.22 & 17.61/5 & = 3.52 & = \bar{X} \\
3.28 & & & \\
3.76 & & & \\
3.42 & X-\bar{X} & (X-\bar{X})^2 & S = \sqrt{\frac{0.383}{5-1}} \\
3.93 & .30 & .0900 & \\
17.61 & .24 & .0575 & \\
17.61 & .24 & .0575 & \\
N = 5 & .10 & .0100 & \\
.11 & .1680 & .303 & \\
\end{array}
\]

\[
\bar{X} \pm t_{N-1}, \frac{\alpha}{2} \quad \frac{S}{\sqrt{N}} \quad \{ \text{Value comes from a Student-t table.} \}
\]

\[
3.52 \pm 2.132 \quad 0.31/\sqrt{5}
\]

\[
3.23 < \mu < 3.81
\]
KODAK CAROUSEL PROJ. W/ 500 WATT LAMP OPERATING AT 110 VOLTS LEN= 75mm. EKTAR NORMAL PROJ. LENS WAS REMOVED
ACKNOWLEDGMENT

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REFERENCES


* Information from these articles was taken from abstracts which were found in either: Kodak Abridged Scientific Publications, Abstracts of Photographic Science and Engineering Literature, Ansco Abstracts, or Photographic Abstracts.