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Modification of the Morse Aerial Film Processor to Reduce Processing Variability, and a Method of Estimating Mean Gamma of the Processed Film

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MODIFICATION OF THE MORSE AERIAL FILM PROCESSOR
TO REDUCE PROCESSING VARIABILITY,
AND A METHOD OF ESTIMATING MEAN GAMMA
OF THE PROCESSED FILM

Robin M. Lambert
April, 1962
ABSTRACT

The operation of a Morse Aerial Film Processor was investigated with the object of improving processing, so that statistically significant variability of the gamma of the film would be reduced. The possibility of estimating the mean gamma of the whole film with the aid of sensitometric exposures at the end of the film was examined.

By changing the attitude of the Processor and discarding some footage at the ends of the film, variability of gamma across the width and length of the film was reduced to insignificance. The reduction in variability made it possible to estimate the mean gamma of the whole film by placing sensitometric exposures at one end of the film.

INTRODUCTION

The Morse Portable Aerial Film Processor (also known as the B-2 Rewind Processing Unit), is conventionally used in a vertical position as shown in Figure 1. The unit is very compact, is run by a small reciprocating electric motor, and can process lengths of film up to 180 feet. The disadvantages of processing with this unit in the past have been the large degree of variability produced by the processor, and the unpredictability of the mean of an output variable, such as gamma, resulting in a lack of quality control of the process.

After investigating the processor it appeared that if the position of the unit during processing could be changed from vertical
to horizontal, variability across the 9½-inch width of the film might be decreased. This assumption was made because of the knowledge that the oxidation products of most conventional developers tend to fall to the bottom of the developer solution and to impede development. There was strong reason to believe that this was the situation when the unit was operated in a vertical position.

It was, therefore, decided to investigate the operation of the processor in a horizontal position. The horizontal position is shown in Figure 2.

OBJECTIVES

The objectives of the project were to investigate the processing unit and to discover a method of improving processing to the point where there was no statistically significant variability in gamma across the 9½-inch width or the 75-foot length of the film. A further objective was to find a method of predicting the mean gamma of the film.

PROCEDURE

It was necessary to slightly modify the unit for horizontal processing, but this did not affect its operation in the
vertical position. It was found that the motor would not transport the film when the unit was in the horizontal position because the driving gear was too loose and did not remain engaged with the gear on the take-up spool. The gear was tightened by inserting a small spring behind the driving gear as indicated by the arrow in Figure 2. When processing in the horizontal position the film was wound onto the unit emulsion out. It was thought that this would allow the oxidation products to fall away from the emulsion side of the film rather than collect on it.

To answer the objectives, which depend upon statistical evaluation, the investigation was carried out on a statistical basis. Standard 75-foot lengths of aerial film were used and processed to a gamma of about 1.2. Areas across the length and width of the film were randomly sampled using sensitometric exposures, and gamma was used as the response variable. Speed (calculated by the base + fog + 0.6 D criterion) was at first used as a response variable also. However, statistically speed and gamma agreed completely and in the final analyses only gamma was used. Three areas across the width of the film were sampled and designated as "top",

Fig. 2 Modified Horizontal Position. Arrow indicates placement of spring.
"middle" and "bottom" for the vertical process, and "left", "middle" and "right" for the horizontal process. These areas were randomly placed along the length of the film at 3-, 14-, 24-, 33-, 43-, 52-, 60- and 70-feet from one end of the film. Between the sensitometric exposures were six-foot-long areas flashed to a density of 1.0. (Figure 3). The flashed areas were intended to have the same effect on the developer as a normally exposed film.

Data were obtained for vertically and horizontally processed films by plotting H and D curves for each sensitometric strip. The means and standard deviations of the data from the vertical and horizontal positions were calculated, and a statistical analysis of variance was run on each set of data. A sample ANOVA Table is shown below. The two sets of data were compared and judgements made as to the effectiveness of the change in processing.

<table>
<thead>
<tr>
<th>Source</th>
<th>S.S.</th>
<th>d.f.</th>
<th>m.s.</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>2507.6</td>
<td>2</td>
<td>1253.8</td>
<td>11.6****</td>
</tr>
<tr>
<td>Length</td>
<td>7021.0</td>
<td>7</td>
<td>1003.0</td>
<td>9.3****</td>
</tr>
<tr>
<td>Residual</td>
<td>1502.4</td>
<td>14</td>
<td>107.3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11031.0</td>
<td>23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 4 Sample ANOVA Table – **** indicates alpha=.001

Alpha is defined as the probability of rejecting material of an acceptable quality level. (e.g. Alpha = .001 is the probability of rejecting one acceptable item in one thousand)
DISCUSSION

All the data obtained is of course based on the straight line portion of the curve. The points determining the straight line and toe areas in general plotted quite consistently but there was large variation in the shoulder areas in some cases. Due to this variation, only the toe and straight line were drawn in, curves of best fit being fitted to the points by inspection. At the ends of the film it became difficult to draw curves of best fit because of the large inconsistencies in the plotted points and great care was taken to obtain a representative curve. Figure 5 shows examples of some of the curves obtained.

Curve (a) represents the end of the film with large variability of plotted points and Curve (b) the middle of the film.

Reduction of Width and Length Variability

An analysis of variance run on the data obtained from vertical processing indicated significant variation (alpha = .001) in gamma both across the width and the length of the film. The ANOVA for horizontal processing, however, indicated no significant
variability for width but significance (alpha = .001) for length. Thus, processing in a horizontal attitude had reduced the width variability of the vertical process to a point of no statistical significance. Figure 6 shows the variability of gamma from end to end on the film at the "top", "middle" and "bottom" positions. It will be observed that the curves for the horizontal process more closely approach an ideal straight line than those for the vertical. It is interesting to note that in the vertical process average gamma for the bottom of the film was somewhat lower than for the top, and that average gamma for the middle was lower than both top and bottom. This partially substantiates the theory that oxidation

![Graph showing variability of gamma across length and width of film for horizontal and vertical processing.](image)

Fig. 6 Variability of Gamma across Length and Width of Film for Horizontal and Vertical Processing
A, B, C, are "right", "middle", "left" respectively
A', B', C', are "bottom", "middle", "top" respectively
products falling to the bottom of the tank retard development at the bottom of the film. That the average gamma at the middle of the film is lower than at the bottom indicates that other factors also contribute to the variability. Perhaps another factor is agitation. It may be that agitation at the edges (top and bottom) of the film is greater than at the middle. Average gammas for the edges (left and right) of the film in the horizontal process were close, but that for the middle was somewhat lower.

It was noticed that on the average for both vertical and horizontal the gamma at the ends of the film was lower than elsewhere. No doubt this contributed to the lengthwise variability. It was, therefore, argued that by discarding the two ends of the film it might be possible to reduce the lengthwise variability. (This is recognized as standard procedure in this field because of known large variability at the film ends.) With this consideration, new analyses of variance were run for vertical and horizontal data omitting the data from the two ends of the film (the three and seventy-foot positions.) With this change, lengthwise variability
was no longer significant either for the vertical or horizontal processes.

Relative Variability of Horizontal and Vertical Processes

The grouped data for each process appear plotted in frequency distribution form in Figure 7. The mean for each curve is shown. It will be noticed that the mean gamma of the vertical process is considerably higher than for the horizontal. (Apparently the change in position necessitates an increase in processing time). This raises some question as to whether variability may have increased with gamma. However, using the Coefficient of Variation, 

\[
\text{100 x standard deviation} \div \text{mean}
\]

it can be shown that standard deviation does not increase with mean. With this calculation the following relative variabilities can be shown, the larger amounts indicating higher variability.

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>REL. VARIABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical</td>
<td>17.8</td>
</tr>
<tr>
<td>Horizontal</td>
<td>11.0</td>
</tr>
<tr>
<td>Vertical (without ends)</td>
<td>7.3</td>
</tr>
<tr>
<td>Horizontal (without ends)</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Predicting Mean Gamma of a Processed Film

The results obtained from horizontal processing indicate the possibility of predicting the mean gamma of the total film (minus some footage at each end) with the aid of sensitometric exposures at one end of the film. It was calculated that the average gamma of representative areas at the sixty-foot position on the film falls within one standard deviation of the mean of the gammas of the whole film. This indicates that a sensitometric exposure at the end of the film can aid in estimating the mean gamma of the film,
since it falls within the same area of the normal probability curve as the mean.

Further work in this area is necessary so that the accuracy of predictions may be increased. It should also be noted that this paper can only be used as a guide since it is valid only for the situation tested. (See "Appendix").

**CONCLUSION**

There is no statistically significant variability in gamma across the width of the film if the Morse Processor is operated in a horizontal position with the film wound on emulsion out.

Significant variability in gamma along the length of the film does not occur if, at most, fourteen feet of film at either end of the film is discarded. Further work may indicate that a smaller amount of film can be discarded without significantly increasing variability.

For the situation tested sensitometric exposures at one end of a film will give reliable information about the mean gamma of the entire film.
APPENDIX

**Exposure:** Kodak 101 Sensitometer with twenty-one step wedge (.15 increments). K2 (minus blue) filter.

**Developer:** Kodak D-76 with 14 grams/liter added borax.

**Processing:** Time: 9½ minutes. Temperature: 68°F. (Film was presoaked before developing.)

BIBLIOGRAPHY


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