TECHNICAL NOTE

KODAK FILM TYPE SO-394-4-1 MOTTLING AND HYPERSENSITIZATION TEST

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Prepared By
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Photographic Technology Division
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas
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This report has been reviewed
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INTRODUCTION

Over the past two weeks, a number of tests have been conducted to show the effects of various environmental conditions in terms of mottling and hypersensitization on Kodak Film type SO-394-4-1.

The first two weeks of environmental testing as described in the letter from Mark Weinstein to Noel Lamar dated 15 August 1972, has been completed. The test plan and matrix are included in the Appendix.
TEST PROCEDURES

Sensitometric exposures were made on samples of the SO-394-4-1 film and placed in four different storage locations:

1. A freezer at approximately 32°F.
2. A cold vault at approximately 50°F. and 50 percent humidity.
3. The roof of Building 8 where the temperature varied from 70°F. to 130°F. with humidity changes from 40 to 80 percent.
4. An oven at 140°F.

The film strips were configured in four different manners for each of the four storage conditions. The configuration consisted of:

1. A single film strip in a double envelope
2. Two film strips placed emulsion to emulsion in a double envelope.
3. Two film strips placed base to base in a double envelope.
4. Two film strips placed emulsion to base in a double envelope.

Sufficient samples of these films were made up so that the test could be conducted over a period of 4 weeks.

The results after two weeks show that mottling is not a function of configuration. In other words, the film kept as a single strip in an envelope showed the same degree of mottling as those configured emulsion to emulsion, base to base, or emulsion to base. Very slight mottling was evident on films that were stored in the freezer. Slightly more noticeable mottling occurred on the films that were
stored in the cold vault. An order of magnitude, increase in mottling, was evident for the films stored on the roof over the films that were stored in the cold vault. The films stored in the oven were severely mottled and also had a high fog level. All these effects were seen after 1 week and were even more noticeable after 2 weeks.

Film hypersensitization tests were conducted in the following manner. Film kept at room temperature was exposed at that temperature in the sensitometer. Film that was frozen was exposed in the sensitometer while it was still in a frozen state. Film was heated to 140°F for 5 minutes, and then, while at the temperature of 140°F, was exposed in the sensitometer. These three film strips were then processed together in a Versamat 11C-M with MX-641 chemistry at 85°F, 2 tanks 10 feet per minute. The resultant sensitometric curves are attached. (See Figures 1, 2, and 3). It can be seen from these D-Log E curves that there is no difference in response between the films exposed at room temperature and the film exposed while frozen. There is, however, an increase in speed for the film that was heated for 5 minutes at 140°F as compared to the film that was kept at room temperature. The speed increase is about 0.06 Log E units.

Following this, a more extensive test was conducted. Film samples were placed in an oven at 140°F, unexposed, for 2 hours, and then removed from the oven, immediately exposed in the sensitometer, and processed along with some film that was kept at room temperature. The same test was repeated for film strips that were placed in the oven for a period of 4 hours at 140°F. The resultant D-Log E curves are attached (See Figures 4 and 5). It can be seen from an examination of the curves, after 2 hours at 140°F the film speed is increased by 0.18 Log-E units; after 4 hours at 140°F, the film speed is increased by 0.22 Log-E units. The density data for the film kept in an oven for 2 hours and then exposed was converted to T_a units and plotted with respect to exposure. This was compared to the film strip that
was kept at room temperature for 2 hours and then exposed. The two resultant $T_a$ versus $E$ curves are plotted as Figure 6. The effects shown by hypersensitization is quite different from the $T_a$ versus $V$ curves that were received from Mr. Ron Kelly (Figures 7 and 8).
For temperatures from 35°F. to 135°F., the $T_a$ versus $V$ curves show a decrease in slope for increases in temperature. The $T_a$ versus $E$ curves that were derived as a result of the testing done here show an increase in slope as a function of temperature, and do not show the same drastic effect as the $T_a$ versus $V$ curves. It appears then that the reason for the change in slope of the $T_a$ versus $V$ curves is the result of an increase in recorder exposure, rather than a drastic change in film sensitivity. It should also be noted that there was severe mottling on the film that was maintained at 140°F, then exposed, and processed for both 2 hour and 4 hour conditions.

To form a basis of comparison, for the film mottling tests, four different film types that are used normally in this laboratory were cut into sensitometric strips, placed in the oven for 2 hours, and then exposed and processed. This testing showed severe mottling for the SO-394 film. The films tested were types 3400, 3401, 2485, and 3414. These four films were kept in the oven at 140°F, then exposed in the sensitometer, and subsequently processed. There is no sign of mottling on any of these films.
CONCLUSIONS

These various tests then lead to the conclusions that:

1. Kodak film type SO-394-4-1 is unusually susceptible, in terms of mottling, to environmental conditions.
2. There is an increase in sensitivity with an increase in exposing temperature as a function of time.
3. The inherent mottling of Film type SO-394-4-1 emulsion makes it unsuitable for space flight.
TEST PLAN

1. Prepare 126 Sensitometric strips on Kodak Film Type SO 394-4-1

2. Label the strips for positive identification
   #1 - Freezer
   #2 - Cold Vault
   #3 - Roof
   #4 - Oven (140°F)
   #5 - Emulsion to Base (EB)
   #6 - Base to Base (BB)
   #7 - Emulsion to Emulsion (EE)
   #8 - Single Strip (SS)

   For example, a strip punched 25 means that it was stored in the cold vault and that the strips were placed in the package emulsion of one to base of the other.

3. Store strips in double light tight bags but do not seal. For configurations 5, 6, and 7, two strips will be stored in one bag.

4. After one week in storage remove one test package for each test condition. Process randomly in a Versamat at 85°F 2T 10FPM with MX-641 chemistry. First verify that the processor and chemistry do not produce mottling with fresh strips.

5. Evaluate visually all strips for any signs of mottling.

6. Follow steps 4 and 5 for strips stored for 2, 3 and 4 weeks.

7. Note in the matrix that for some of the strips the clear gel backing will be removed.
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FIGURE 1

Exposure at 72° F.
FIGURE 2
Exposure at 32°F.
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**Figure 3**

Exposure at 140°F.
FIGURE 4

Technicolor

ABSOLUTE LOG E AT R.L.E. = 0

Room temperature, 2 hrs then exposed

14 hrs, -2 hrs then exposed

CHEMICAL ANALYSIS

- SP GR
- pH
- TA
- TRP
- KB

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4.0 3.8 3.6 3.4 3.2 3.0 2.8 2.6 2.4 2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 0.0
VHF \( T_4 \) vs \( V \)

(Temperature Sensitivity Calibration)

Figure 7