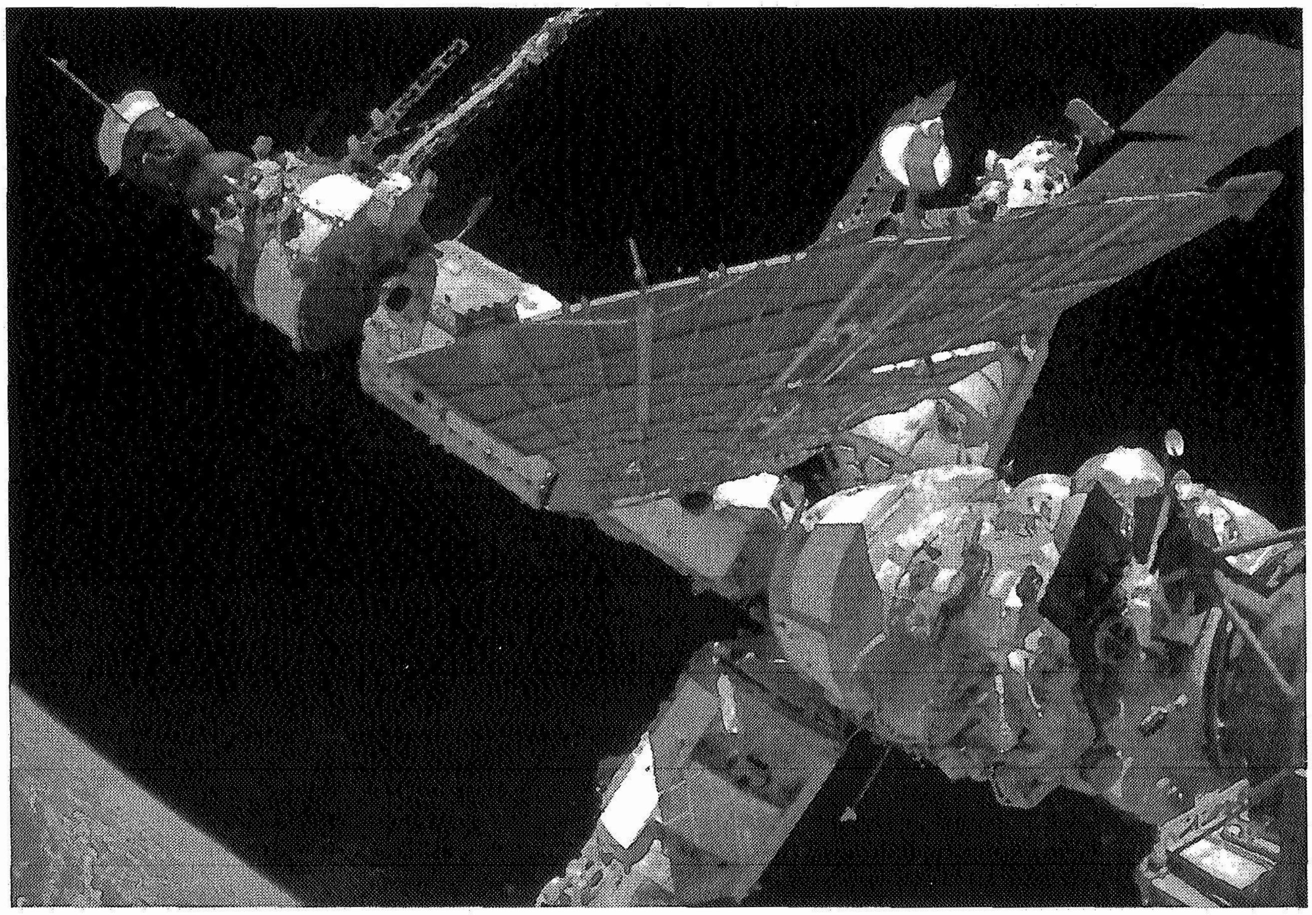
NASA Technical Memorandum 104817

U.S./Russian Joint Film Test

Richard Slater



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U.S./Russian Joint Film Test

1. Overview

The joint Russian/U.S. film test was conducted to show the effects of radiation on photographic film flown aboard the Mir space station for a 130-day period.

The Mir 18 film test grew out of initial discussions between the JSC Earth Science Branch and RKK-Energia personnel while planning the Visual Observations of Earth experiment as part of the NASA-Mir Program. Because the type of film, its length of stay on orbit, and film processing are crucial to data integrity for this experiment, the NASA/JSC Photographic Laboratory was included in the Visual Observations experiment planning at an early stage.

The Russians have considerable experience with the effects of long-term radiation exposure on film. For a variety of reasons, they use color negative films exclusively on orbit. While NASA uses a variety of film types to support Shuttle experiments, color positive film is used for Earth observations. To help determine the best types of film to use for the NASA-Mir program given that (1) the film will be launched and returned to the U.S. on the Shuttle (4 to 6 months on orbit), (2) the JSC Photo Lab processing capabilities place some constraints on film types, and (3) the Earth observations experiments and other U.S. experiments require high quality data returns, the Russian and U.S. parties decided to conduct an on-orbit test on the Mir. The long-range objective was to gather information needed to make photographic film choices for future Mir and International Space Station mission requirements.

Russian personnel agreed to include a small package of film for the test on board a Progress which was launched in mid-February 1994. The film was returned on STS-71 in early July 1994. The total length of stay on orbit, at an altitude of about 200 nautical miles, was roughly 130 days. There was no crew involvement in the experiment, except to transfer the film from the Progress to the Mir for stowage, and again from the Mir to the Shuttle for return to Earth.

Two identical sets of film were flown on Mir to allow the Russians and NASA to process and duplicate the film at their own facilities. The comparative results, to be included in the final report, will identify any inherent differences in processing and duplication between the two photographic laboratories.

This test is a follow-up to a previous radiation study completed in June 1992 (DSO 318). The 1992 study investigated the different types of radiation encountered in a standard Shuttle mission, evauated methods of shielding radiation using various devices, flew photographic films on several Shuttle missions, and performed a comprehensive evaluation using the NASA/JSC Photographic Laboratory to produce the test samples. The results of this study have been documented in NASA Contractor Report (CR) 188427 titled, "The Effects of Space Radiation on Flight Films. This CR should be used as a reference and background for many of the issues that will be referred to in this report. The principle reason for repeating this test on a Mir mission is that the overall level of radiation encountered (approximately 8 rads) is significantly higher than the typical level of exposure on a Shuttle mission (less than 1 rad).

Weight and size restrictions forced a minimum amount of film to be used for the test. Five films were selected which represented the photographic films commonly used for missions. The selection included negative, positive, and infrared films.

This report should be considered preliminary because it does not include the SN-10 film or the Russian test results, both of which were unavailable for evaluation at the time this report was written. And because U.S. and Russian collaboration is required to acquire the Russian test results, they will not be available for several weeks.

2. Test Procedure

The five photographic films used in the test were Russian SN-10 film, Kodak Lumiere 100, Kodak Vericolor III, Kodak VPH, and Kodak Gold 200. Each film had a sensitometric exposure put on it (both at JSC and in Russia) and an exposure of a standard visual test setup at JSC. This standard test includes several objects that make it possible to visually evaluate the images contrast, graininess, and overall image quality. The films were always maintained in their respective film cassettes throughout the test.

Five samples of each film type were prepared at JSC. One sample was frozen at JSC to use as a control and was not thawed until the film returned from the Mir was processed. Four samples were sent to Russia. These had an additional sensitometric exposure put on them in Russia. Two samples of each type of film were placed in a large film can and flown 130 days aboard Mir Mission 18. The third sample was stored in a freezer in Russia and used as a control for the Russian processing of the test film. The fourth sample was returned to JSC and stored in a freezer to be used as the primary control for the JSC processing of the test film. It is not known where the film was stored on board the Mir.

Each processing facility developed the film and produced photographic products according to their respective standard processing procedures. The control samples were processed at the same time as the flight film. The photographic products used for the visual evaluation are 8x10 photographic prints and 35mm slides.

3. Results

The overall results are similiar to the results of DSO 318. The positive film had little or no damage to the useful portion of the characteristic curve. There was a reduction in the D-max area (region of maximum density), but this did not adversely affect photographic products made from the film. The negative films, however, had considerable damage. The visual contrast and graininess are very apparent in products made from the negative films.

The films tested included

5046 Lumiere 100	Positive Film
5026 Vericolor III	Negative Film
5028 VPH	Negative Film
5095 Gold 200	Negative Film
Russian SN-10 Film	Negative Film (Infrared Sensitive)

3.1 Comparison Data of All Control and Test Samples

Table 1 Speed

Film Type	Manufacturer Rated Exposure Index	Control Sample ASA (Calculated ASA Before Rounding)	Test Sample ASA (Calculated ASA Before Rounding)
Lumiere 100	100	64* (67)	64* (67)
Vericolor III	160	80 (82)	20 (21)
VPH	400	250 (257)	50 (48)
Gold 200	200	200 (182)	50 (48)
Russian SN-10	25	n/a	n/a

* Note: The ANSI standard for calculating the ASA for positive films does not accurately reflect the useful film speed due to a manufacturing change in the characteristic curve (specifically the D-min. area). A change to the ANSI method of calculating positive film speed is currently under consideration.

Table 2 Average Gradient

Film Type	Control Sample Gamma	Test Sample Gamma
Lumiere 100	1.17	1.13
Vericolor III	.54	.43
VPH	.54	.35
Gold 200	.53	.46
Russian SN-10		

Table 3 Log Exposure Range

Film Type	Control Sample Log Exposure Range	Test Sample Log Exposure Range
Lumiere 100	2.47	2.36
Vericolor III	2.43	1.73
VPH	2.32	1.77
Gold 200	2.55	1.95
Russian SN-10	n/a	n/a

Table 4 Density Range

Film Type	Control Sample Density Range	Test Sample Density Range
Lumiere 100	2.90	2.44
Vericolor III	1.32	.74
VPH	1.26	.62
Gold 200	1.34	.89
Russian SN-10	n/a	n/a

Table 5 D-min.

Film Type	Control Sample D-min.	Test Sample D-min.
Lumiere 100	.20	.20
Vericolor III	.28	.78
VPH	.54	1.16
Gold 200	.31	.80
Russian SN-10	n/a	n/a

Table 6 D-max

Film Type	Control Sample D-max	Test Sample D-max
Lumiere 100	3.20	2.76
Vericolor III	1.64	1.58
VPH	1.84	1.86
Gold 200	1.68	1.76
Russian SN-10	n/a	n/a

Table 7 Summary of Characteristic Changes

Film Type	Increase in Graininess	Reduction in the Average Gradient	Exposure Range Reduction in F/Stops
Lumiere 100	visually not apparent	none	.4
Vericolor III	visually significant	significant 20%	2.4
VPH	visually significant	significant 35%	1.8
Gold 200	visually moderate	moderate 13%	2.0
Russian SN-10	n/a	n/a	

Film Type	Reduction in Speed (ASA)	Increase in D-min.	Reduction in D-max
Lumiere 100	None 67 to 67	None .2 to .2	3.20 to 2.76
Vericolor III	Significant 80 to 20	.28 to .78	None
VPH	Significant 250 to 50	.54 to 1.16	None
Gold 200	Significant 200 to 50	.31 to .80	None
Russian SN-10	n/a	n/a	n/a

3.2 Test Film Comparisons (Visual) and Characteristic Curves

The following page is a visual comparison of the test film. The images were not touched up or enhanced in any way. These plain-paper images are representative of how the photographic prints appeared. The next four pages are the characteristic curves for the four different films evaluated to date. Each graph includes a control sample curve and a curve of the Mir flown sample.

3.2.1 Lumiere 100 (5046)

Lumiere was the only film in the test that was almost entirely unaffected by radiation. The film experienced loss was in the high-density area or the (D-max) portion of the characteristic curve. These areas could appear slightly less than absolute black when printed on reflective photographic paper. This damage will be more apparent if the overall image content is black and less apparent if there is little or no black in the image. A visual comparison of the control and test print showed no damage caused by radiation.

3.2.2 Vericolor III (5026)

Vericolor III was affected significantly by radiation. The overall effect is a large increase in the graininess and a significant decrease in contrast, which made the image look very flat. There was also a significant drop in film speed and reduction in the exposure range.

3.2.3 VPH (5028)

VPH was also affected significantly by radiation. The overall effect is similar, although slightly worse than the Vericolor III. As in Vericolor III, there was also a significant drop in film speed and reduction in the exposure range.

Test Film Comparisons

Control Samples

Test Samples

LUMIERE 100 (5046) CONTROL STOCK

LUMIERE 100 (5046) MIR

GOLD 200 (5096) CONTROL STOCK

GOLD 200 (5096) MIR

VERICOLOR III (5026) CONTROL STOCK

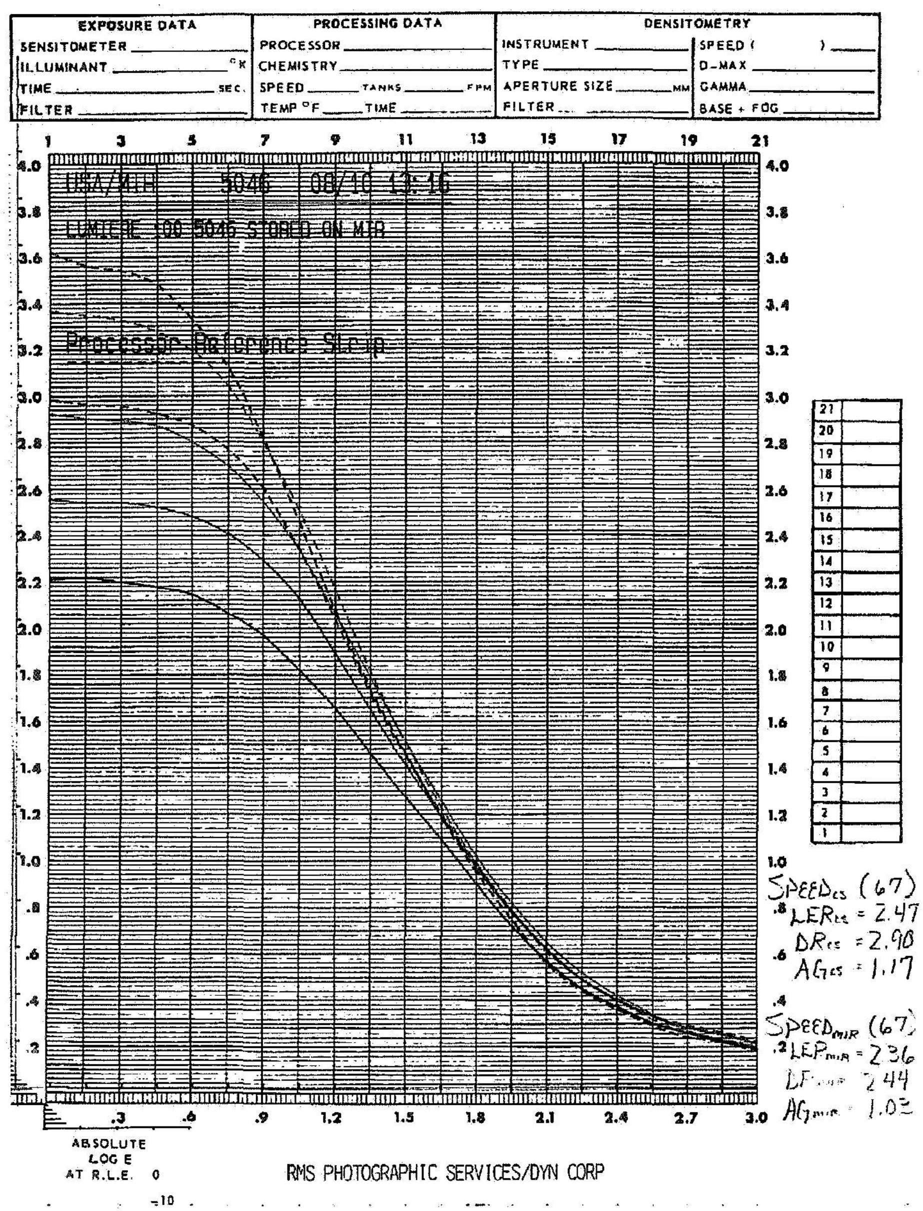
VERICOLOR III (5026) MIR

VERICOLOR 400 (5028) CONTROL STOCK

VERICOLOR 400 (5028) MIR

Lumiere 100 Characteristic Curve

MIR Test film and Control Film

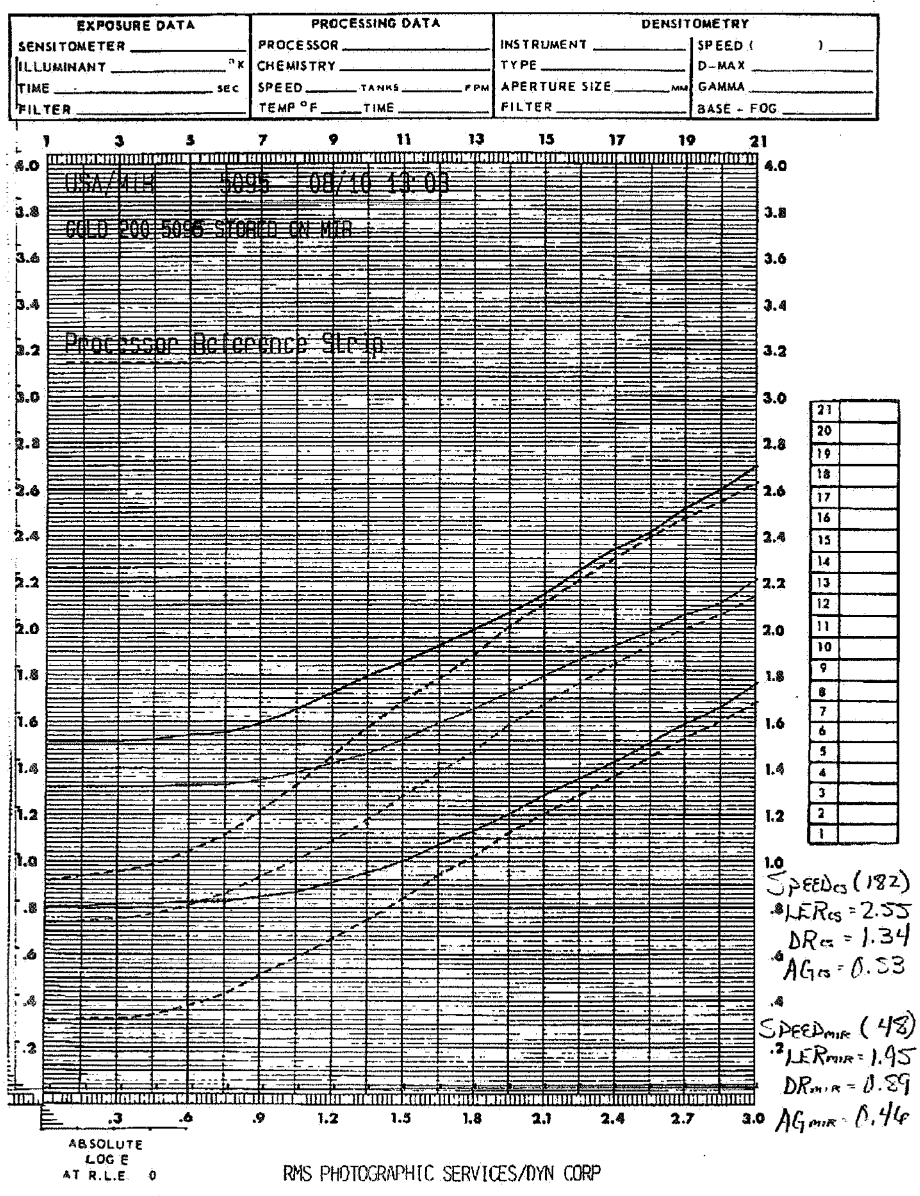


This graph represents the Red, Green, and Blue plots for the MIR test film (solid line) and the Control Stock (dotted line).

The significant change in the MIR film is a drop in the D-max or the upper left-hand part of the characteristic curve. This is apparent, when projected, if there is a significant portion of black in the image, but not readily apparent in photographic prints.

Gold 200 Characteristic Curve

Mir Test Film and Control Film

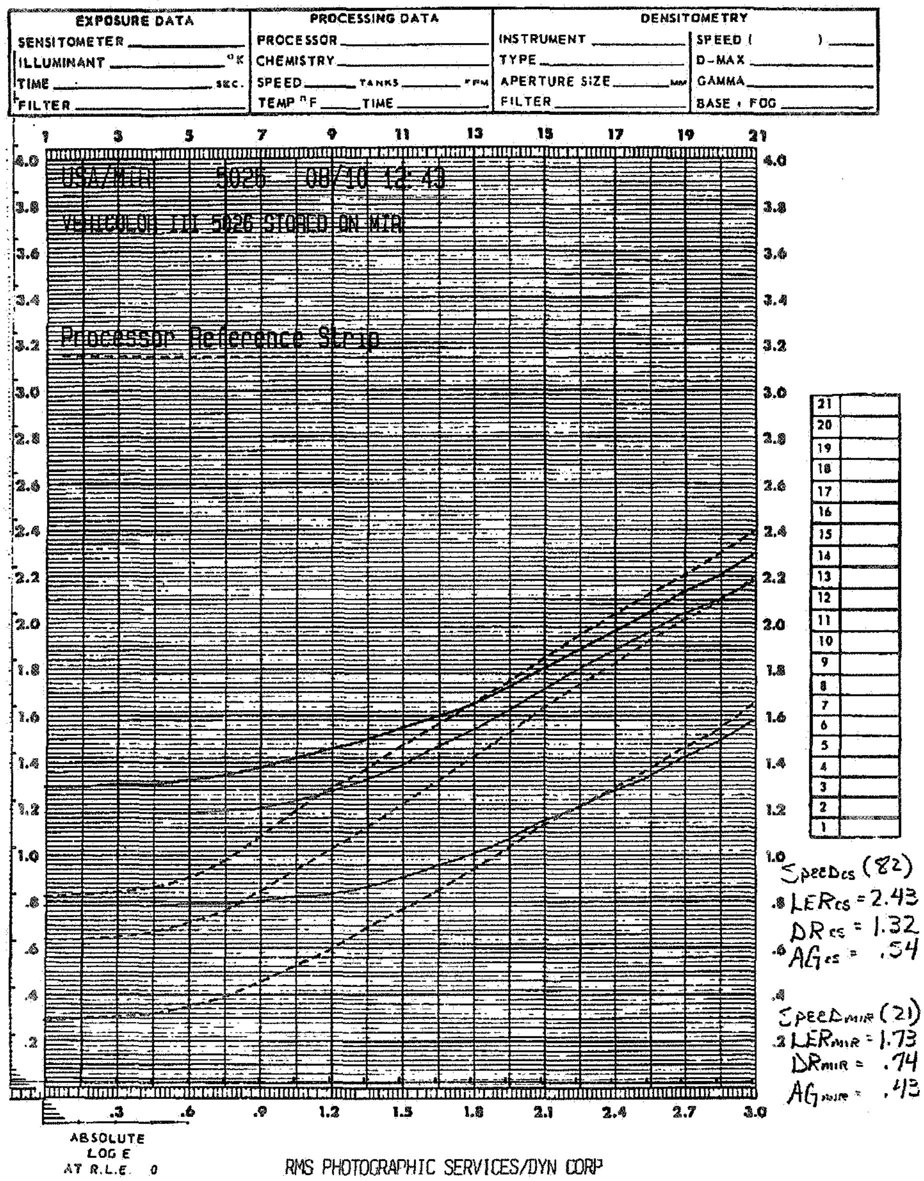


This graph represents the Red, Green, and Blue plots for the MIR test film (solid line) and the Control Stock (dotted line).

The significant change in the MIR film is a reduction in slope of the D-min. and midtone portion of the curve (left 1/2 of the curve.) This loss of information appears as a substantial reduction in overall visual contrast when reproduced photographically. The curve can be changed electronically to match the original contrast, but this will not address the overall graininess issue.

Vericolor III Characteristic Curve

MIR Test Film and Control Film

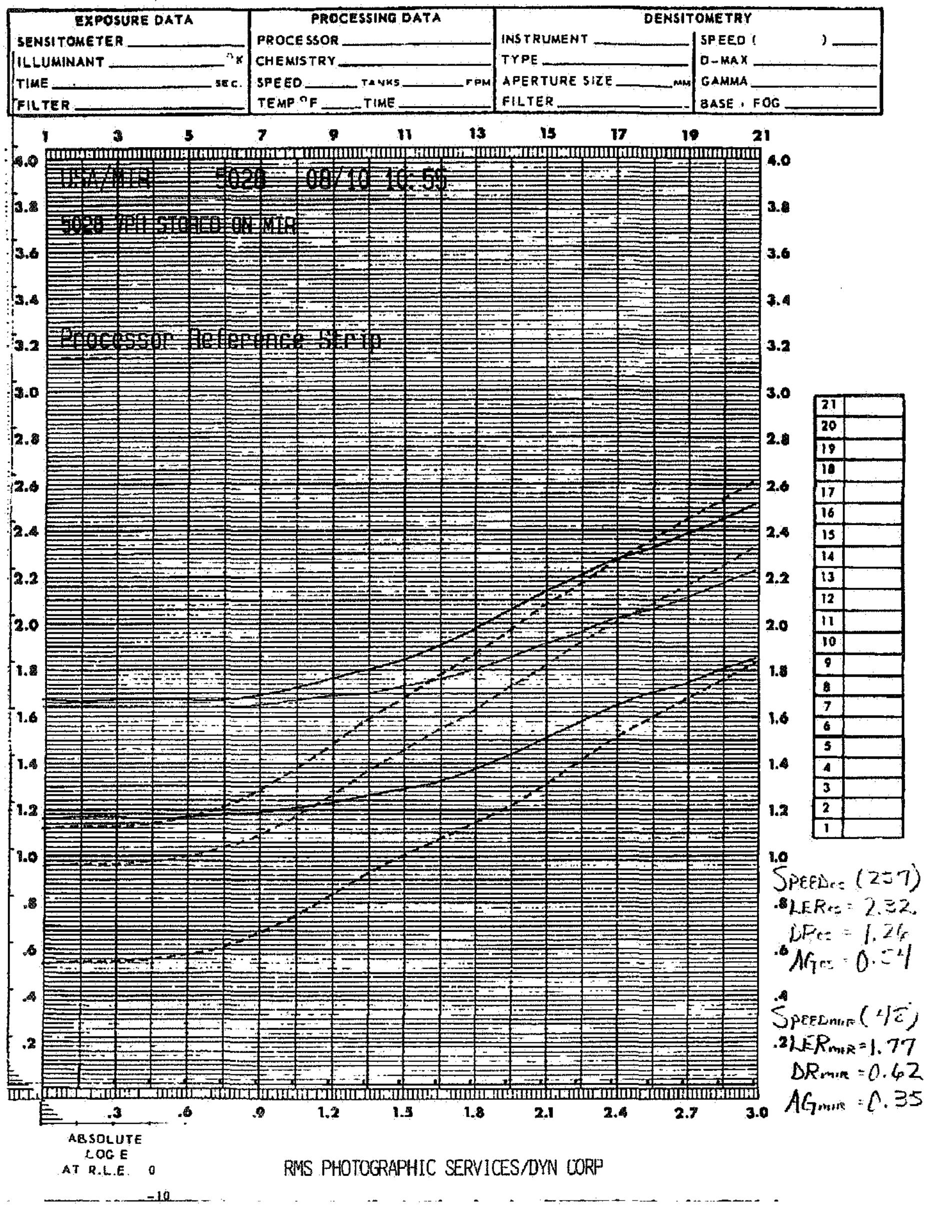


This graph represents the Red, Green, and Blue plots for the MIR test film (solid line) and the Control Stock (dotted line).

The significant change in the MIR film is a reduction in slope of the D-min. and midtone portion of the curve (left 1/2 of the curve.) This loss of information appears as a substantial reduction in overall visual contrast when reproduced photographically. The curve can be changed electronically to match the original contrast, but this will not address the overall graininess issue.

Vericolor 400 Characteristic Curve

Mir Test Film and Control Film



This graph represents the Red, Green, and Blue plots for the Mir test film (solid line) and the Control Stock (dotted line.)

The significant change in the Mir film is a reduction in slope of the D-min. and midtone portion of the curve (left 1/2 of the curve.) This loss of information appears as a substantial reduction in overall visual contrast when reproduced photographically. The curve can be changed electronically to match the original contrast, but this will not address the overall graininess issue.

3.2.4 Gold 200 (5095)

Gold 200 was affected only moderately by radiation, in contrast to the other two negative films. The overall visual effect is slightly grainy with some reduction in contrast. As with the other two negative films, there was a significant drop in film speed and reduction in the exposure range.

3.2.5 Russian SN-10 Film: Negative Film (Infrared Sensitive)

The film was not available for evaluation.

4. Conclusions

The positive films showed no significant damage other than some reduction in D-max. Negative films exposed to radiation on the Mir for durations of 130 days were significantly damaged. The negative film damaged the least (visually) was Gold 200. This film would be the only reasonable choice if a negative film was required.

Film speed was not a definitive when ranking the negative films for visual quality. The least damaged negative film was Gold 200 which is in the middle for film speeds. Gold 200 fell between VPH at 400 (exposure index) and Vericolor III at 160 (exposure index). The characteristics of the particular emulsion, not the overall film speed, are significant in the amount of overall radiation damage.

5. Recommendations

Positive films should be used exclusively for long-duration missions if minimal damage to image quality is required. Gold 200 should be used if a negative film is required for long-duration missions.

A follow-up film test should be flown on an upcoming Mir mission that defines the film requirements for the various types of image data required and evaluates test films that meet those requirements. These additional films will include more high-speed positive films, motion picture (including IMAX) films, and high-speed negative films.

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13. ABSTRACT *(Maximum 200 words)*
A joint U.S./Russian film test was conducted during MIR Mission 18 to evaluate the effects of radiation on photographic film during long-duration space flights. Two duplicate sets of film were flown on this MIR mission: one set was processed and evaluated by the NASA/JSC Photographic Laboratory, and the other by the RKK Energia's Photographic Laboratory in Moscow. This preliminary report includes only the results of the JSC evaluation (excluding the SN-10 film which was not available for evaluation at the time this report was written). The final report will include an evaluation by JSC of the SN-10 film and an evaluation of the test data by the RKK Energia. JSC's evaluation of the test data showed the positive film flown was damaged very little when exposed to approximately 8 rads of radiation. Two of the three negative films were significantly damaged and the third film was damaged only moderately.

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