



## The Effect of Radiation on Selected Photographic Film

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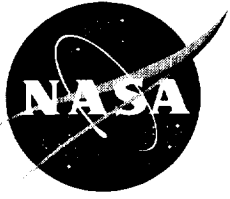
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## **ACRONYMS**

ISO	International Organization of Standardization
ISS	International Space Station
JSC	Johnson Space Center
STS	Space Transportation System (Shuttle mission)

## **ABSTRACT**

We conducted this film test to evaluate several manufacturers' photographic films for their ability to acquire imagery on the International Space Station. We selected 25 motion picture, photographic slide, and negative films from three different film manufacturers. We based this selection on the fact that their films ranked highest in other similar film tests, and on their general acceptance by the international community. This test differed from previous tests because the entire evaluation process leading up to the final selection was based on information derived after the original flight film was scanned to a digital file. Previously conducted tests were evaluated entirely based on 8x10s that were produced from the film either directly or through the internegative process. This new evaluation procedure provided accurate quantitative data on granularity and contrast from the digital data. This test did not try to define which film was best visually. This is too often based on personal preference. However, the test results did group the films by good, marginal, and unacceptable. We developed, and included in this report, a template containing quantitative, graphical, and visual information for each film. These templates should be sufficient for comparing the different films tested and subsequently selecting a film or films to be used for experiments and general documentation on the International Space Station.

## **1.0 INTRODUCTION**

The level of radiation encountered in space is greater than that found at the surface of the Earth. High background levels of radiation damage unprocessed photographic materials, which are typically somewhat sensitive to nonvisible portions of the electromagnetic spectrum.

The absorption of radiation by photographic films causes photographic fog. Fog occurs when photographic materials absorb uniform levels of energy that is part of an intended photographic exposure. Fog affects the coarsest portions of the photographic media that comprise the most light-sensitive portions of films. In negative materials, fog raises the resultant density of the toe of the sensitometric curve. The toe is the portion of the curve that has the first response to light and determines the overall film speed. Fog results in a decrease in the tonal ranges of the photographic response, and of the densities produced for printing results. Most of this lowered contrast is in the less-well-illuminated parts of the photographed scene. As a result, detail there may be absent in the final imagery. In reversal films the fastest grains are also affected, but these are subsequently removed in the processing of the film and any losses in contrast occur in the brightest parts of the scene where contrast is less perceivable.

The purpose of this test is to measure the degree of film degradation caused by radiation and find methods of reversing these effects for both visual and scientific applications. It also augments previous tests conducted on both the Russian space station *Mir* and the Space Shuttle. A test flown in September 1991 on board Shuttle mission (STS)-48 showed that positive film

(preferably low speed) is superior to negative film, a standard lead-lined film bag will not prevent radiation damage, and there is no place in the Shuttle that offers any real protection from radiation. A subsequent film test flown in 1994 on board *Mir* benchmarked how radiation effects routinely flown flight film when left in orbit for a period of 120 days. The 120 days was intended to represent a standard *Mir* or International Space Station (ISS) increment. This test used new technology films available at the time and added a visual image to the test. This resulted in providing visual information on how films would be effected on orbit and established that Kodak Gold 200 did the best job of any negative film. This was significant because previous testing concluded that lower film speeds delivered better results. Kodak Gold 200 fell into the medium-range-speed films.

We intended that this radiation film test would be more comprehensive and would provide some methods for correcting the damage to the film from the effects of radiation. We made several major changes to the scope of this test. We added Agfa and Fuji films to the Kodak films used in the first test, and increased the number of different film speeds tested (ASA 50 to 650, in both positive and negative form). We also tested for a range of time periods that parallel how the film will be used on *Mir* and the ISS, and provided quantitative and qualitative evaluation data on the effects of radiation on each film sample.

Our intention for including Agfa and Fuji film types was to provide a selection of films that scientists from the international scientific community are currently using. A major objective was to determine the threshold at which a film begins to exhibit enough damage from radiation that it compromises its value to the experiment. Another objective was to determine whether each film had a radiation damage limit. Ivan Firsov of the Energia Space Corporation proposed the time period for this experiment. His experience using various types of film on *Mir* led us to vary the time period for the experiment to between 30 and 120 days. He concluded from his own experience that 30 days was the smallest period of time that would cause any significant damage and that, after 90 days, there is a plateau in the damage. For this reason, three sample sets were flown for periods of 39, 63, and 120 days. The 120-day test was included to support the theory that a plateau can be seen at 120 days. Flight constraints did not allow for the 90-day test and modified the 30 and 60 day test periods. This is the first radiation film test to incorporate primarily digital procedures for qualifying and quantifying the image degradation due to radiation. The primary reasons for changing from an analog to digital procedure were the availability of off-the-shelf software using digital files, and the fact that image distribution is primarily digital for human spaceflight using the Intranet and Internet.



## **2.0 TEST PROCEDURE**

This test procedure describes the preparation and testing of the selected films that were flown on a collaborative mission between NASA and the Energia Space Corporation. The three categories of films tested are ECN motion picture films, E-6, and C-41. The films that were tested include:

**ECN:** Fuji 8521 F64D and Kodak 5293

**E-6:** Agfa Agfachrome RSX 50, Agfa Agfachrome RSX 100, Agfa Agfachrome RSX 200, Fuji Provia RDP2, Fuji Provia RHP, Fuji Velvia RVP, Kodak 5017 Ektachrome, Kodak 5069 Elite 100S, and Kodak 5075 Elite 400X

**C-41:** Agfa Agfacolor Optima 100, Agfa Agfacolor Optima 200, Agfa Agfacolor Optima 400, Fuji 8561 F250D, Fuji 8571 F500, Fuji Super Gold 100, Fuji Super Gold 200, Fuji Super Gold 800, Kodak 5245, Kodak 5095 EktaPress Plus 100, Kodak 5204 Kodacolor VR200, Kodak 5097 EktaPress 400, Kodak 5277 Vision 320T, and Kodak 5279 Vision 500T

These films were carried aboard the Space Shuttle to the ISS and returned to Earth after a period of 39, 63, and 120 days. These times were long enough to cause some radiation effects to be sensitometrically and digitally detectable while allowing the effects of the solar radiation to eventually plateau.

Two samples of each film type were given a set of exposures. These included a sensitometric exposure and a visual, bracketed-scene exposure of a controlled test setup. The control strips were stored at -18°C in the film vault at the Johnson Space Center (JSC).

We performed the following five steps to prepare the film for the test.

### **2.1 Sensitometric Film Preparation**

The Precision Sensitometer Type 1-B was calibrated to a color temperature of 2850 K with a luminance of 0.685 lux. Each film type was exposed in the sensitometer using a 5500-K conversion filter. Films with ASAs (film speed rating) less than 200 were exposed at 1/50th of a second, while films with ASAs greater or equal to 200 were exposed at 1/100th of a second. After exposure, these films were rewound into their cassettes.

### **2.2 Standard Scene Imagery Preparation**

A standard indoor scene was photographed and used as a subjective and qualitative reference. The scene consisted of three neutral-colored models of black, white, and gray; a Macbeth color checker card; three photographic mannequin busts with fair, medium, and dark skin tones; a gray scale; a resolution chart; three boxes covered with gold, black, and silver cellophane,

respectively; an American flag; and cue cards describing the exposure conditions. The props were arranged in a Macbeth Spectra Light II Color Matching Booth and illuminated with a daylight light source. The film was exposed with a Nikon F4 through a Nikon F/1.4 50-mm lens. Through-the-lens metering was used to determine the normal exposure. Three exposures were made: one each at the film's normal exposure rating, one underexposed by one stop, and one overexposed by one stop.

### **2.3 Packaging and Storage of Film Samples**

The film was placed in a film can sealed with photographic tape approved for spaceflight. The storage conditions of the samples were maintained as best they could, considering the process required to get the film onboard *Mir* and back to JSC. Under ideal conditions, the film would have only been subjected to 18°C before on the ground and room temperature conditions for the test period in space. These test conditions were impossible to maintain due to manifesting considerations and may have had some impact on the results. Weight and volume were minimized as much as possible. We used four duplicate sets of film for this test:

- a. **Control Set**—This set was put in the JSC film vault after the sensitometry was put on the film and kept at 18°C.
- b. **39-Day Test Set**—This set was sent up on Progress 234 on April 6, 1997, and returned to JSC after 39 days on the ISS on STS-84.
- c. **64-Day Test Set**—This set was sent up on Progress 233 on November 20, 1996, and returned to JSC after 63 days on the ISS on STS-81.
- d. **120-Day Test Set**—This set was sent up on STS-81 on January 12, 1997, and returned to JSC after 132 days on the ISS on STS-84.

### **2.4 Film Processing**

When the film samples were returned to Earth, all film processing of the test samples took place at the same time at JSC. The processors were certified "in-control" before processing any of the film samples. The film samples flown aboard *Mir* were processed together with the control samples. The negative films were processed in the Refrema Dip and Dunk type film processor and the positive films were processed in a Hostert Dip and Dunk type film processor.

### **2.5 Digital Processing**

To analyze and correct the images digitally, we needed to scan the film on a Kodak 3570 scanner and archive it on CD-ROM. The scanned images were stored in the Kodak PhotoCD format so

that a variety of resolutions would be available for image correction and analysis. An accurate analysis required the scan of the gray card to have a resolution of 2k×3k. This is necessary for a requisite number of data points to produce a useful and meaningful frequency histogram of the pixel values.

### 3.0 EVALUATION CRITERIA

We used digital Fujix prints for the visual evaluation. These test prints included the control, unmodified, and digitally corrected images. A group of test subjects rated these prints for contrast, color rendition, and highlight and shadow detail. The test subjects determined the level of image degradation that occurred due to radiation. The actual test criteria are described in the Imagery Analysis section. The visual observer rating average determined the usefulness of the photographic image exposed to solar radiation. The visual observation average led to the elimination of ECN films and selection of four C-41 films and four E-6 films for further analysis. Eight films were selected for further study:

#### C-41

Agfa Optima 100

Fuji SG Plus 100

Fuji SG Plus 200

Kodak Kodacolor VR 200

#### E-6

Agfa Agfachrome RSX

Fuji Provia RDP2

Fuji RVP50

Kodak 5069 Elite

We measured the processed sensitometric film samples on a Macbeth densitometer and plotted them as density versus the logarithm of the exposure using MicroDense 4.0 software. We used the resulting characteristic curves to help evaluate the response to radiation of each type of test film flown. We made calculations of the sensitometric qualities of speed, average gradient, log exposure range, and useful density range of the film samples flown aboard *Mir*, and compared them to the control film samples.

We examined all eight of the above film types sensitometrically and digitally to determine the degree of image degradation due to radiation damage.

### 4.0 IMAGERY ANALYSIS

We divided the imagery analysis into three separate parts: visual evaluation, sensitometric evaluation, and digital evaluation. The visual evaluation used individuals with various backgrounds to determine which films could viably be used after exposure to radiation. The ranking that the test subjects gave the prints was averaged for each film type to give the “average

observer rating.” The eight films chosen by the average observer rating were subjected to further study.

We also quantitatively examined the images digitally since the imagery field will be moving toward the digital image, as opposed to the traditional photographic image. Using the digital evaluation, we determined relative grain size increase and that a radiated image can be partially restored (i.e., small color and contrast corrections). We also studied the effects of solar radiation on color.

## **4.1 Visual Evaluation**

The test subjects ranked the 8×10 photographic prints on a scale of 1 to 5 on the three following criteria.

### ***4.1.1 Image Contrast***

Image contrast is a description of the rendition of the overall density range of the objects in the scene. Good contrast should neither expand nor contract the range of reflectance represented by objects in the scene. The brightest areas and darkest areas should display no apparent changes in their resolvable details and no losses due to too much or insufficient densities.

### ***4.1.2 Color Rendition***

Color rendition is the ability of a film to accurately capture and reproduce shades of color. Significant color shifts or changes in hue, or changes in color intensity or chroma, distort the imagery as it is portrayed in the final products. Some color shifts are not as serious as are others. Minor shifts to the red can enhance flesh tones and may not be objectionable. Other shifts, such as the yellowing of certain shades of green or the rendition of violet as purple, can be severe enough even when minor to preclude using a material for particular applications.

### ***4.1.3 Shadow and Highlight Detail***

Shadow and highlight detail are dependent upon the ability of the original film to capture the details present in the original scene under the exposure conditions present and on the manner in which the imagery is processed and reproduced. The dynamic range of the materials used for both duplication and printing must be great enough to overcome any losses of detail inherent in contrast reduction, should it occur.

## 4.2 Sensitometric Evaluation

The film was examined in the traditional, sensitometric method to see the effects of solar radiation on effective film speed, average gradient, log exposure range, and useful density range.

### 4.2.1 Film Speed

Photographic speed describes the inherent minimum sensitivity of a film to light under the normally specified conditions of exposure and development. A number derived from the sensitometric data contained in the characteristic curve represents film speed. The speed calculations for all film types conform to the International Organization of Standardization (ISO) specifications. The speed equations for color negative and color positive films follow:

$$\text{Color negative film: } \text{ISO speed}_{\text{Color neg}} = \frac{1}{H_{\text{CN}}} * 1.5$$

Where  $H_{\text{CN}}$  equals an average red and green exposure in lux-seconds that produces a 0.15 increase in density relative to the base plus fog.

$$\text{Color reversal film: } \text{ISO speed}_{\text{Color reversal}} = \frac{1}{H_{\text{CR}}} * 10.0$$

Where  $H_{\text{CR}}$  is an average of the two neutral exposures in lux-seconds that produce increases in the visual densities of 0.2 and 2.0 relative to the base plus fog.

### 4.2.2 Average Gradient

The average gradient is the slope of the line connecting the two critical points that define the useful limits of the characteristic curve. The critical points are defined as those values of exposure that are the maximum and minimum that still produce visually discernible changes in density. The portion of the sensitometric curve between the critical points encompasses the regions just beyond the ends of the straight-line portion.

### 4.2.3 Log Exposure Range

The log exposure range of a film is that range of exposures that produces densitometrically measurable changes in the film after development. The useful log exposure range is defined as that which is between the two critical points that delineate the boundaries of visually detectable change due to exposure.

#### ***4.2.4 Useful Density Range***

The useful density range of a film is that which falls between the two critical points that also bound the useful exposure range and define the average gradient of the film.

### **4.3 Digital Evaluation**

We evaluated the scanned samples to digitally quantify the damage caused by solar radiation. We chose the 120-day exposure samples of the eight films picked by the average observer rating for grain analysis. The digital evaluation of the film occurred in the following three sections: grain analysis, color shift analysis, and color layer analysis.

#### ***4.3.1 Grain Analysis***

We used CISlab software to determine the grain increase between the control and 120-day samples. Exporting the pixel values from CISlab into Microsoft Excel created frequency histograms of the pixel values. The standard deviation of the pixel values in the gray patch was used as a digital method to determine grain size.

CISlab produced another digitally generated patch from the difference in the pixel values between the control sample and the 120-day sample. This provided a method of viewing just the induced “noise” from the films’ exposure to solar radiation. We generated a frequency histogram for this patch of induced noise to show the “image” formed from the films’ exposure to radiation.

#### ***4.3.2 Color Shift Analysis***

We also examined the effect of radiation on the films’ ability to accurately record color, using the same 18% gray patch from the Macbeth ColorChecker that was used in the grain increase analysis. The values to determine brightness (L), red/green (a), and yellow/blue (b) were measured using Adobe PhotoShop. Three measurements were taken and averaged to find the reported L, a, and b values of each gray patch.

CISlab was used to help further analysis on the effects of solar radiation on color film by seeing the effects of radiation on each of the three color layers in film.

#### ***4.3.3 Color Layer Analysis***

Each 18% gray patch was digitally divided into the three separate color layers that comprise color film. Once the gray patch was divided into the red/cyan, green/magenta, and blue/yellow layers, we found the average pixel value for the control, 39-day, 63-day, and 120-day samples for the separate color layers. We recorded the increase in average pixel values graphically to show any pattern that emerged as a result of the radiation exposure.

The grain increase as a function of exposure to solar radiation for each layer was examined in a similar manner. We graphically demonstrated the standard deviation in each color layer that we found for the control, 39-day, 63-day, and 120-day samples.

## **5.0 RESULTS**

The overall results were similar to the results of DSO 318 and NASA TM-104817. The positive film had little damage to the useful portion of the characteristic curve and a much lower increase in grain size. The color layers of both the reversal and negative films reacted to the radiation in a similar manner, although the negative material was adversely affected to a greater extent.

We determined the grain size digitally, using pixel values of the scanned image. Ideally, since the patch off of the Macbeth ColorChecker is middle gray, the pixel values of the image would be approximately 127. This is due to the fact that the film has received a uniform exposure from the evenly lit surface of standardized color. However, when the image of the gray card is scanned, the fluctuation in the pixel values shows the non-image grain. We used the standard deviation of the pixel values in the gray patch to determine the amount of grain in both the control film and the flown film. Once the amount of grain for the control patch and the flown patch was determined, we ascertained the percent increase of grain due to the films' exposure to solar radiation.

When each of the color layers of the film was examined by means of average pixel values and standard deviation, we noticed an interesting correlation for a majority of the film types. The average pixel value and standard deviation were plotted as a function of the time. This showed that, as the film was exposed to more radiation, the rate of increase in the standard deviation of pixel values was much less than the rate of increase in the average pixel value. This implied that the grain size increase occurs until approximately 60 days of solar radiation exposure. After the 60-day period, a general fogging occurs in the image, exacerbating the grain appearance in the image.

Loss of color and contrast can be corrected in Adobe PhotoShop, but only to a certain extent. The apparent increase in grain size cannot be corrected and becomes readily apparent in the 120-day trial.

### **5.1 Comparison of Sensitometric Data for All Control and 120-Day Test Samples**

The following tables provide data for comparison of test samples of film.

**Table 1: Speed**

<b>Film Type (C-41)</b>	<b>Manufacture Rated ASA</b>	<b>Control Sample ASA</b>	<b>Test Sample ASA (120 day)</b>
Agfa Optima 100	100	139.26	49.98
Fuji SG 100	100	149.22	65.14
Fuji SG 200	200	259.94	76.71
Kodak Kodacolor VR200	200	169.77	95.47

<b>Film Type (E-6)</b>	<b>Manufacture Rated ASA</b>	<b>Control Sample ASA</b>	<b>Test Sample ASA (120 day)</b>
Agfa Agfachrome RSX	50	49.86	59.26
Fuji Provia RDP2	100	79.94	85.54
Fuji RVP50	50	39.15	39.6
Kodak 5069 Elite	100	90.73	112.91

**Table 2: Average Gradient**

<b>Film Type (C-41)</b>	<b>Control Sample Gamma</b>	<b>Test Sample Gamma</b>
Agfa Optima 100	0.53	0.49
Fuji SG 100	0.53	0.41
Fuji SG 200	0.54	0.4
Kodak Kodacolor VR200	0.42	0.35

<b>Film Type (E-6)</b>	<b>Control Sample Gamma</b>	<b>Test Sample Gamma</b>
Agfa Agfachrome RSX	1.46	1.19
Fuji Provia RDP2	1.38	1.22
Fuji RVP50	1.57	1.32
Kodak 5069 Elite	1.36	1.11



**Table 3: Log Exposure Range**

<b>Film Type (C-41)</b>	<b>Control Exposure Range</b>	<b>Test Exposure Range</b>
Agfa Optima 100	2.75	2.03
Fuji SG 100	2.7	2.25
Fuji SG 200	2.65	2.15
Kodak Kodacolor VR200	2.49	2.27

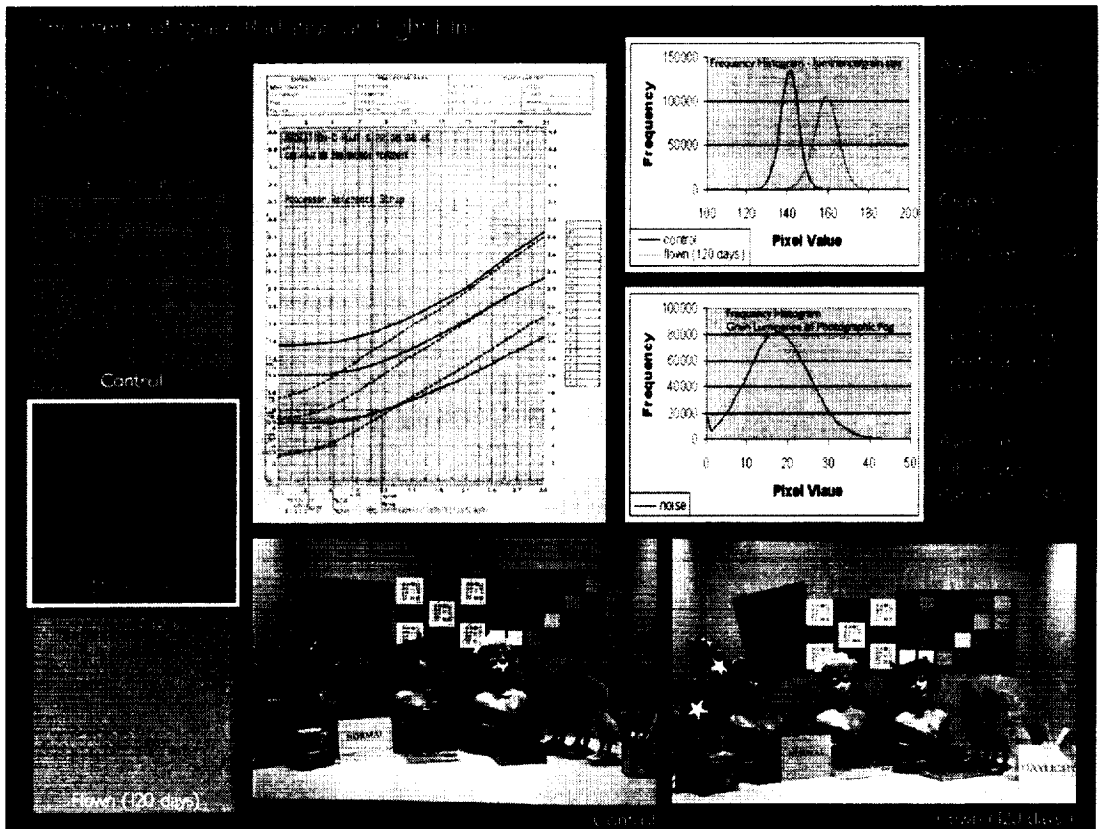
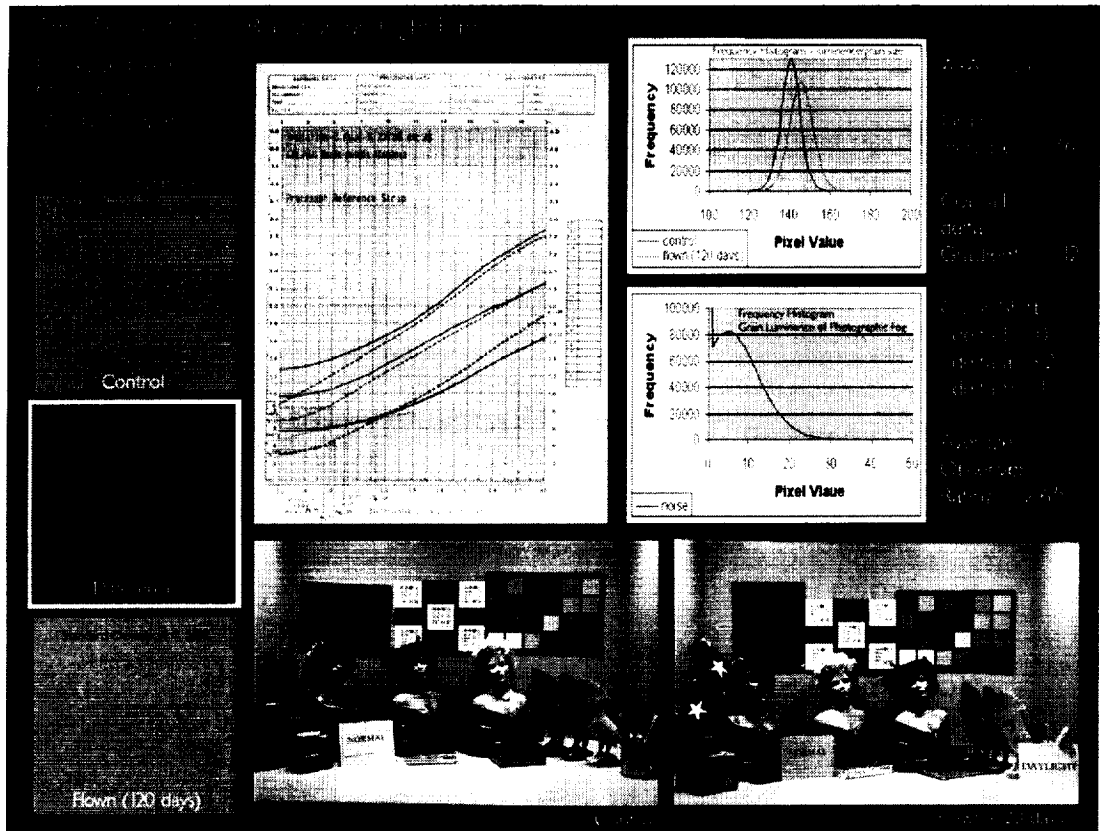
<b>Film Type (E-6)</b>	<b>Control Exposure Range</b>	<b>Test Exposure Range</b>
Agfa Agfachrome RSX	2.78	1.69
Fuji Provia RDP2	2.12	1.89
Fuji RVP50	2.04	2.02
Kodak 5069 Elite	2.17	1.86

**Table 4: Density Range**

<b>Film Type (C-41)</b>	<b>Control Density Range</b>	<b>Test Density Range</b>
Agfa Optima 100	1.46	1
Fuji SG 100	1.43	0.93
Fuji SG 200	1.42	0.85
Kodak Kodacolor VR200	1.04	0.8

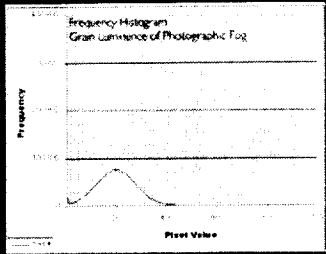
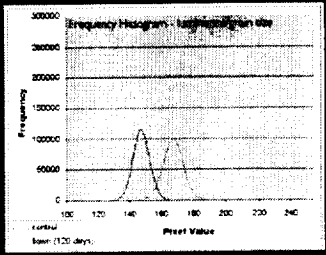
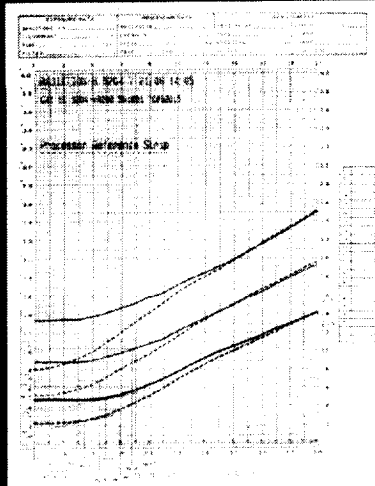
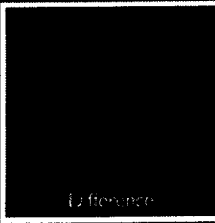
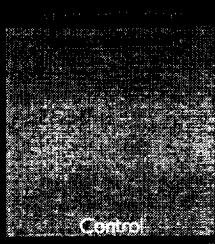
<b>Film Type (E-6)</b>	<b>Control Density Range</b>	<b>Test Density Range</b>
Agfa Agfachrome RSX	2.78	2.01
Fuji Provia RDP2	2.92	2.31
Fuji RVP50	3.2	2.66
Kodak 5069 Elite	2.96	2.06

## 5.2 Test Film Templates



# The Effects of Space Radiation on Flight Film

Kodak 160A  
MIR Film Test  
120 Day Sample

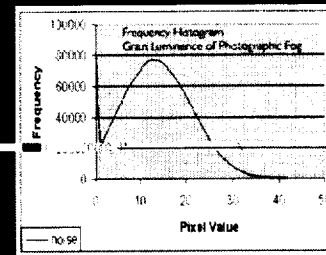
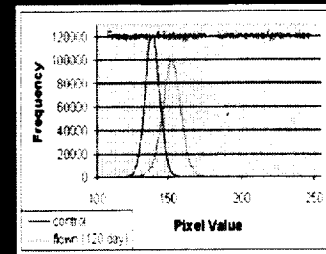
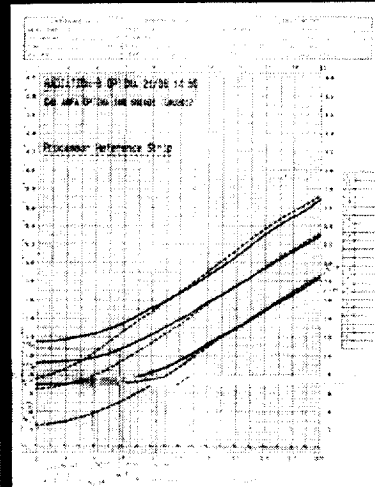
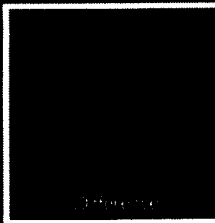
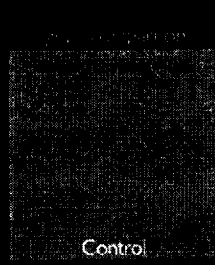


ASA = 160  
Gran  
mean = 150  
Control  
StdDev = 0.47  
Color Syst  
delta a = 7  
delta b = 9  
Aging  
Observed  
Range = 45

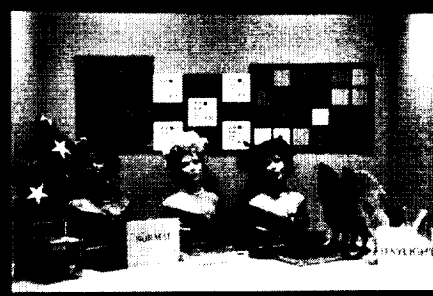
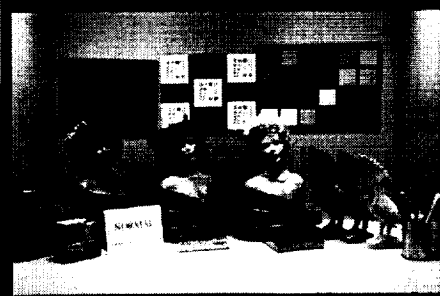


# The Effects of Space Radiation on Flight Film

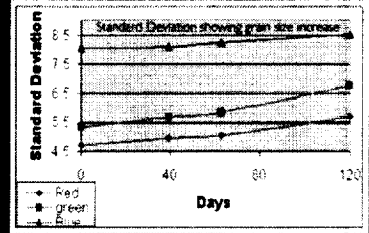
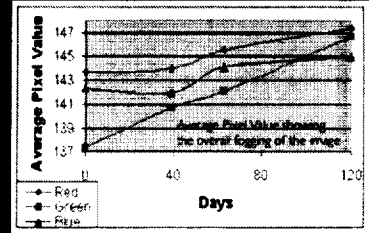
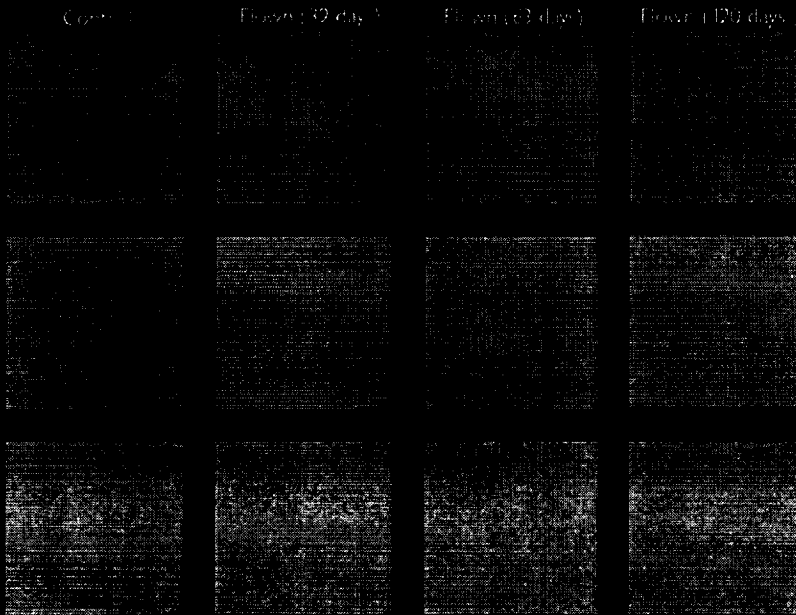
Agfa Optima  
MIR Film Test  
120 Day Sample



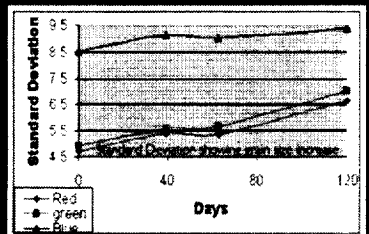
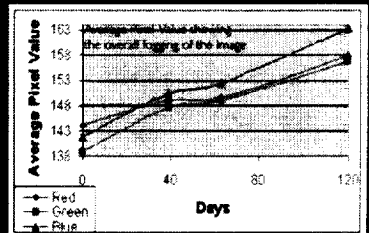
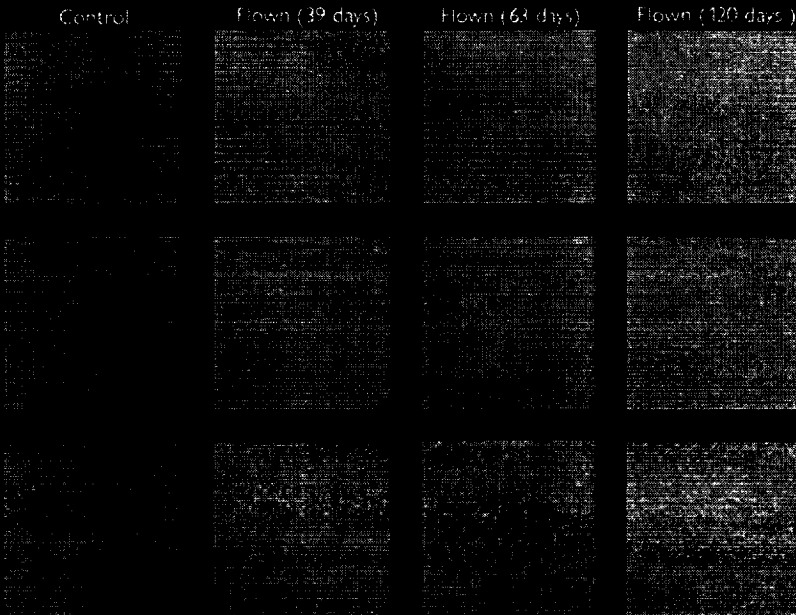
ASA = 100  
Gran  
mean = 150  
Control  
StdDev = 0.47  
Color Syst  
delta a = 7  
delta b = 9  
Aging  
Observed  
Range = 45



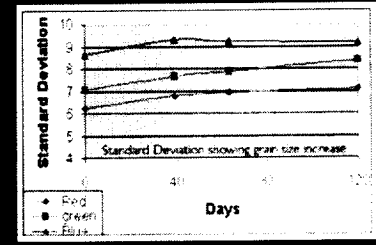
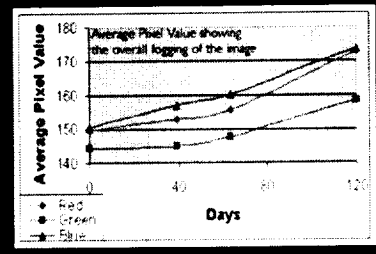
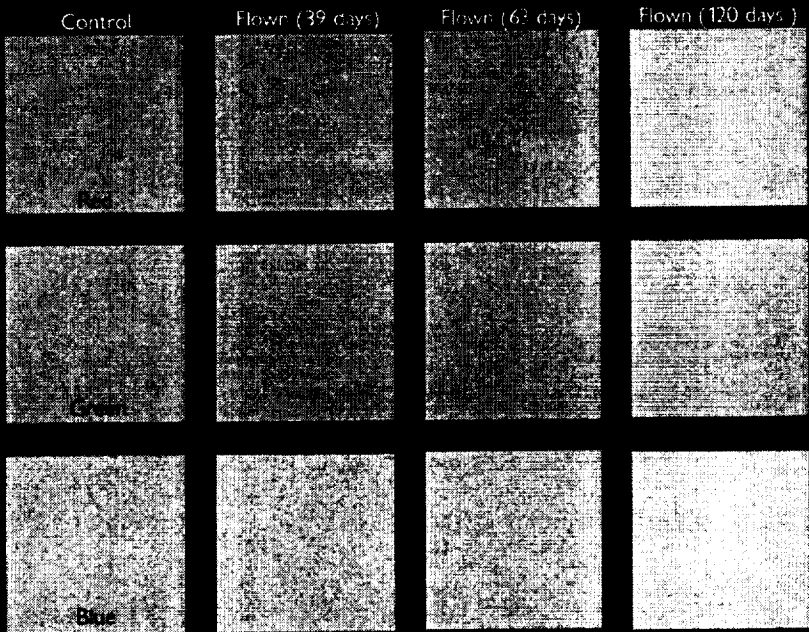
### The Effects of Space Radiation on Flight Film Fujifilm Super Gold 100



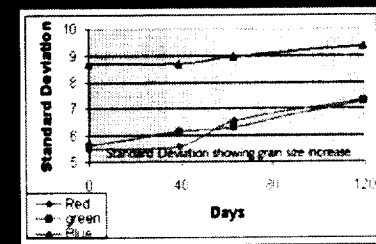
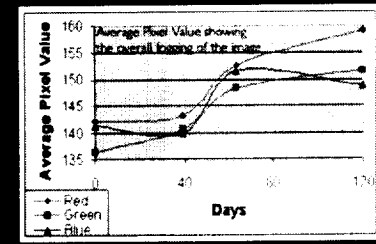
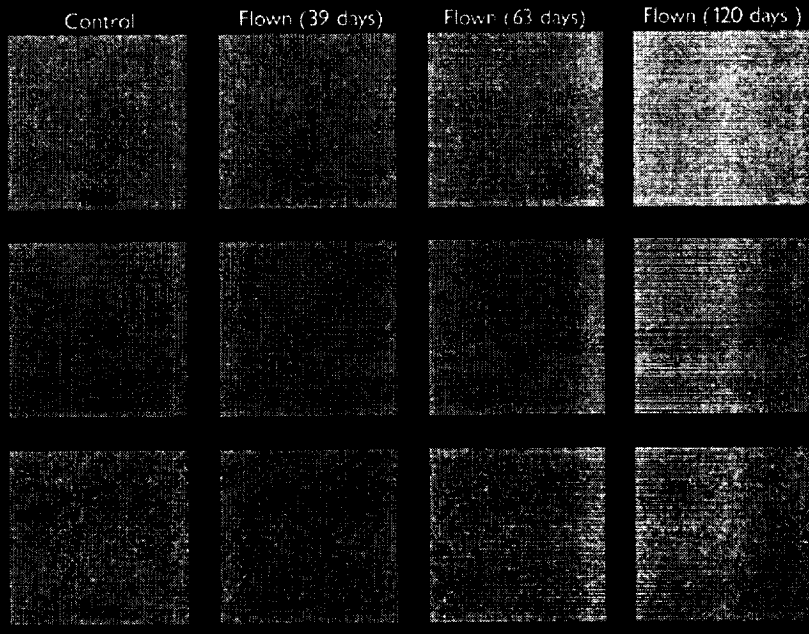
### The Effects of Space Radiation on Flight Film Fujifilm Super Gold 200

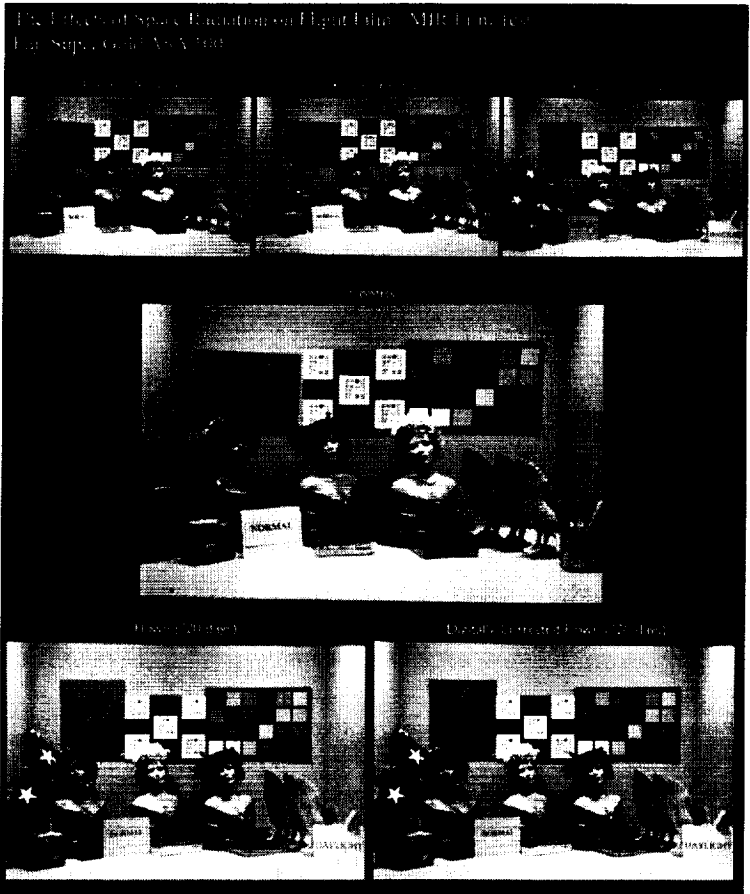


The Effects of Space Radiation on Flight Film  
Kodak 5204 Kodacolor VR200



The Effects of Space Radiation on Flight Film  
Agfa Optima 100





The Effects of Space Radiation on Flight Film - MIP Film Test  
Kodak S204 Kodachrome VR 200



The Effects of Space Radiation on Flight Film - MHR Film Test  
Agfa Agfacolor Optima 100



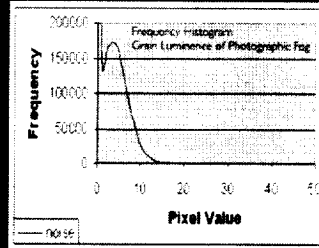
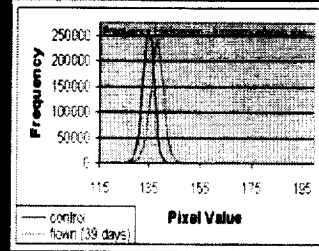
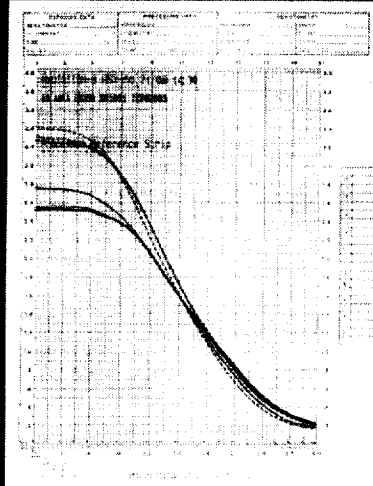
The Effects of Space Radiation on Flight Film

Dr. Philip R. 2/2  
 MR. E. J. 1/2  
 Dr. J. S. 1/2

Control

Difference

Flow (120 days)

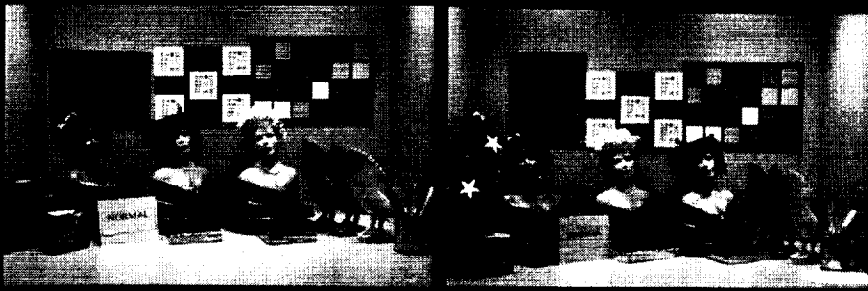


AsA 200  
 Grain  
 Image 200

Control  
 flown  
 Control

Control  
 flown  
 Control

AsA 200  
 Control  
 flown



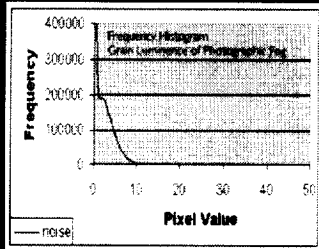
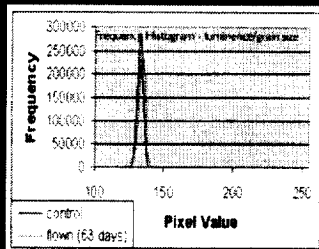
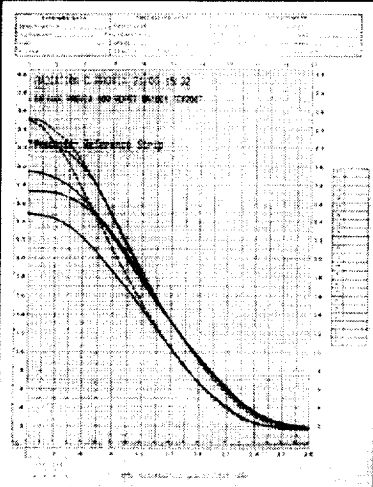
The Effects of Space Radiation on Flight Film

Dr. Philip R. 2/2  
 MR. E. J. 1/2  
 Dr. J. S. 1/2

Control

Difference

Flow (120 days)



AsA 200  
 Grain  
 Image 200

Control  
 flown  
 Control

Control  
 flown  
 Control

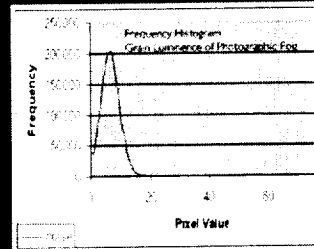
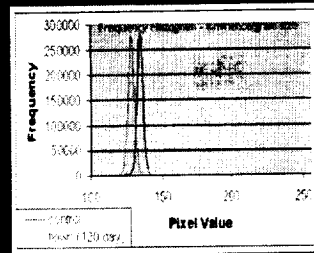
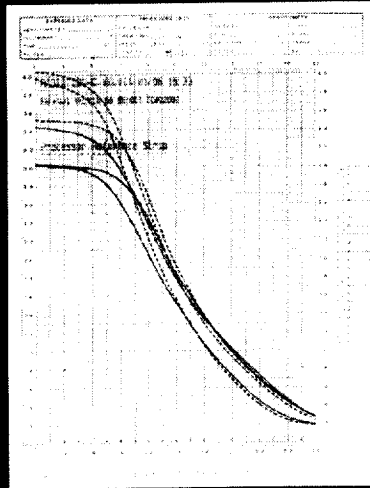
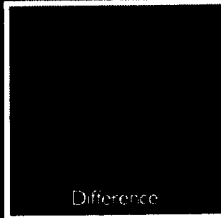
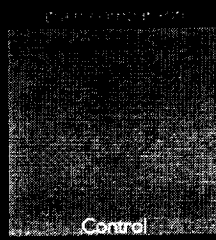
AsA 200  
 Control  
 flown



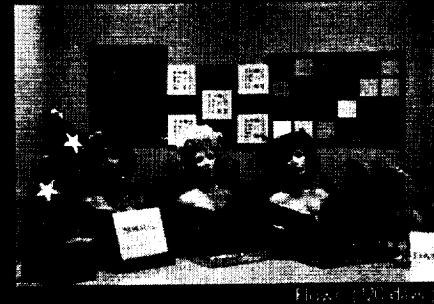


### The Effects of Space Radiation on Flight Film

Fuji RVP50  
MIR Film Test  
120 Day Sample

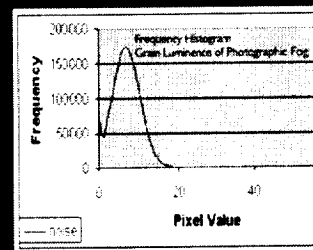
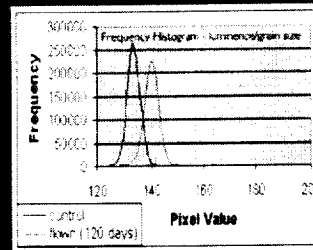
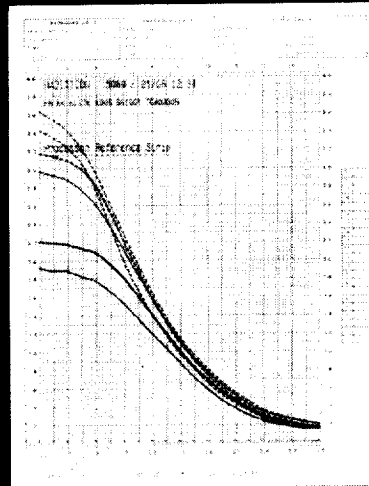
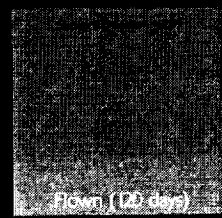
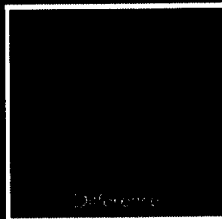


ASA = 50  
Grain Increase = 20.9%  
Overall delta Gradient = 0.25  
Color Shift: delta L = -1, delta a = 0, delta b = 1  
Average Observer Rating = 2.1/5



### The Effects of Space Radiation on Flight Film

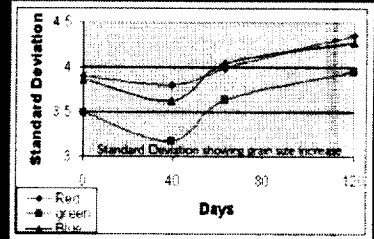
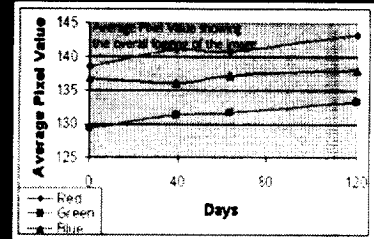
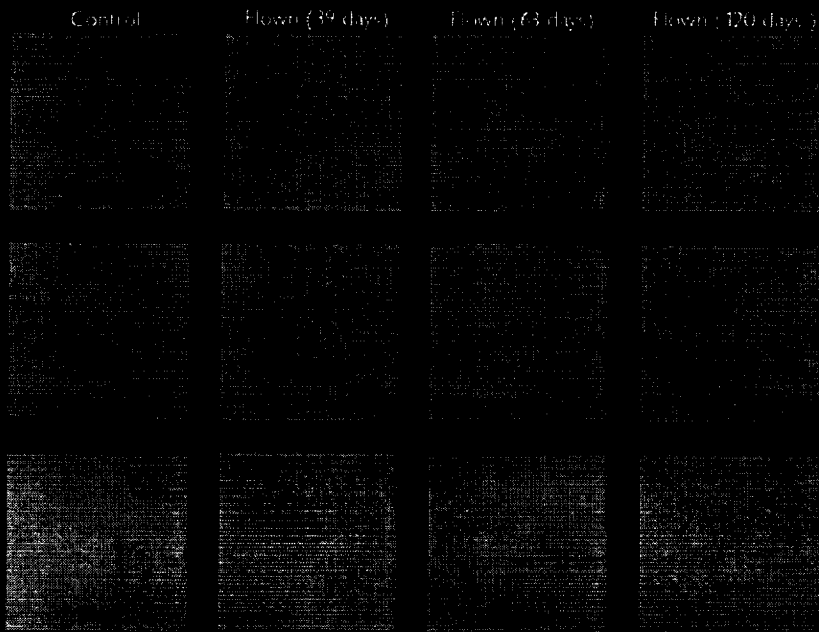
Kodak 5019 Lite  
MIR Film Test  
120 Day Sample



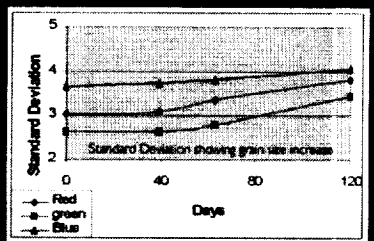
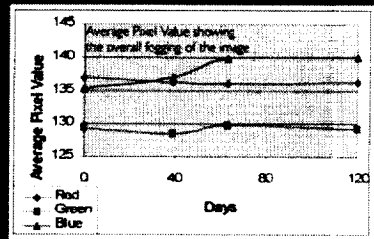
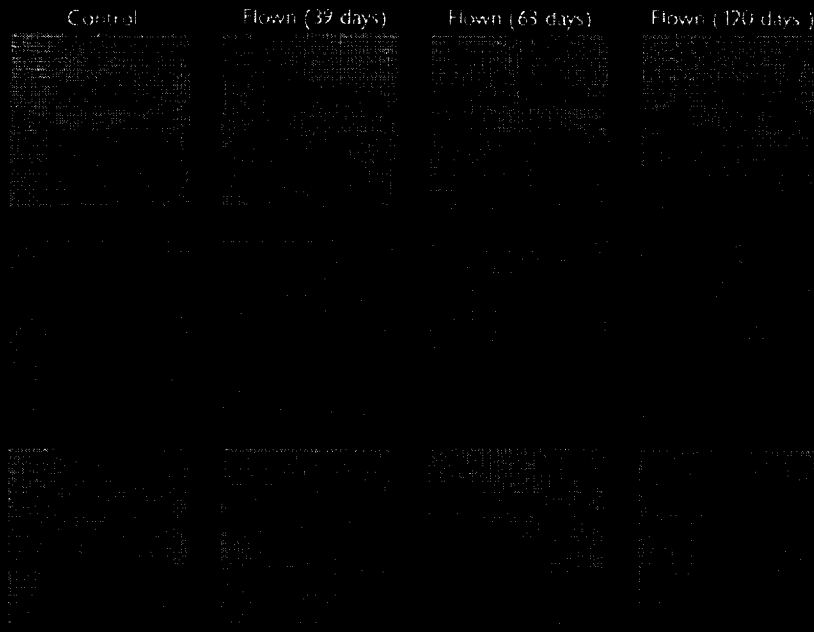
ASA = 100  
Grain Increase = 77%  
Overall delta Gradient = 0.25  
Color Shift: delta L = -1, delta a = +6, delta b = -9  
Average Observer Rating = 2.7/5



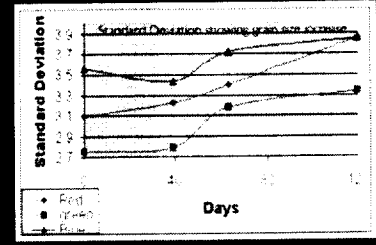
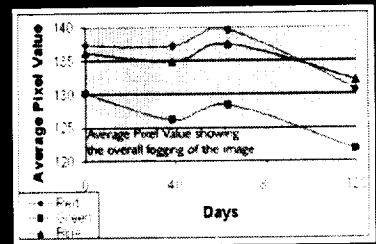
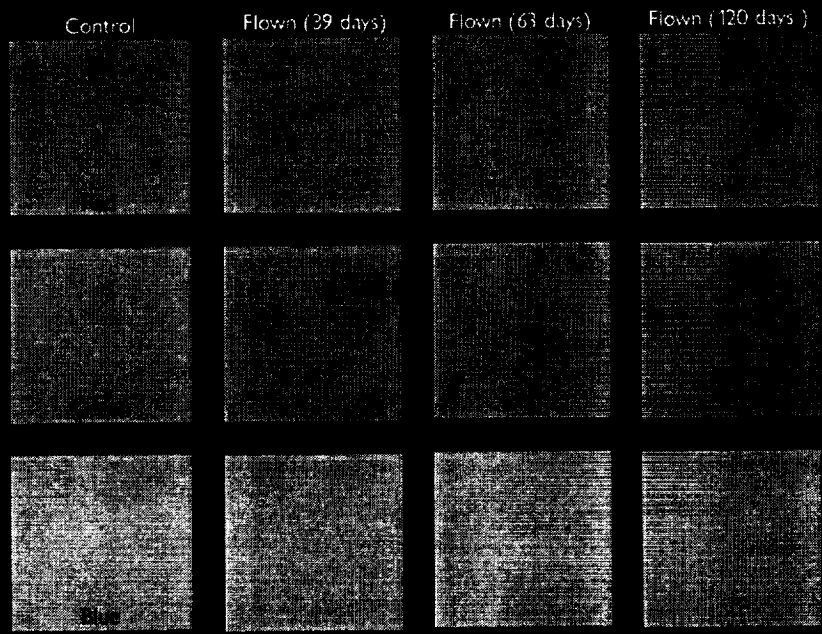
## The Effects of Space Radiation on Flight Film Agfa RSX 50



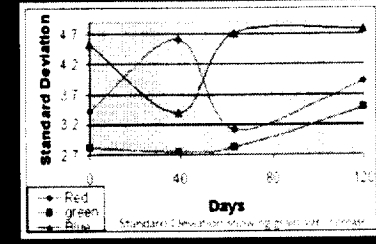
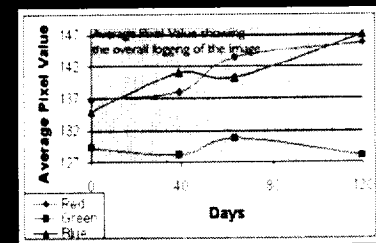
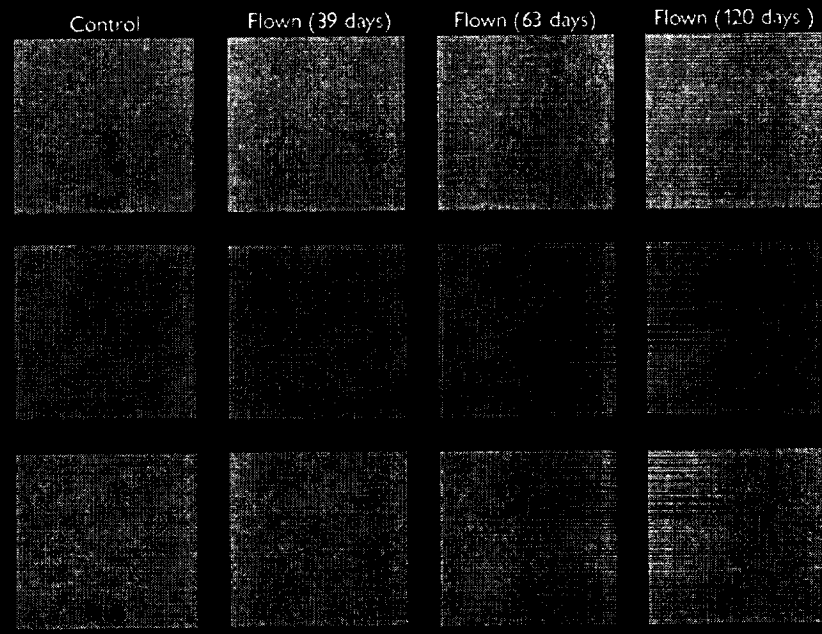
## The Effects of Space Radiation on Flight Film - MIR Film Test Fuji RDP2 E-6



The Effects of Space Radiation on Flight Film  
Fuji RVP 50



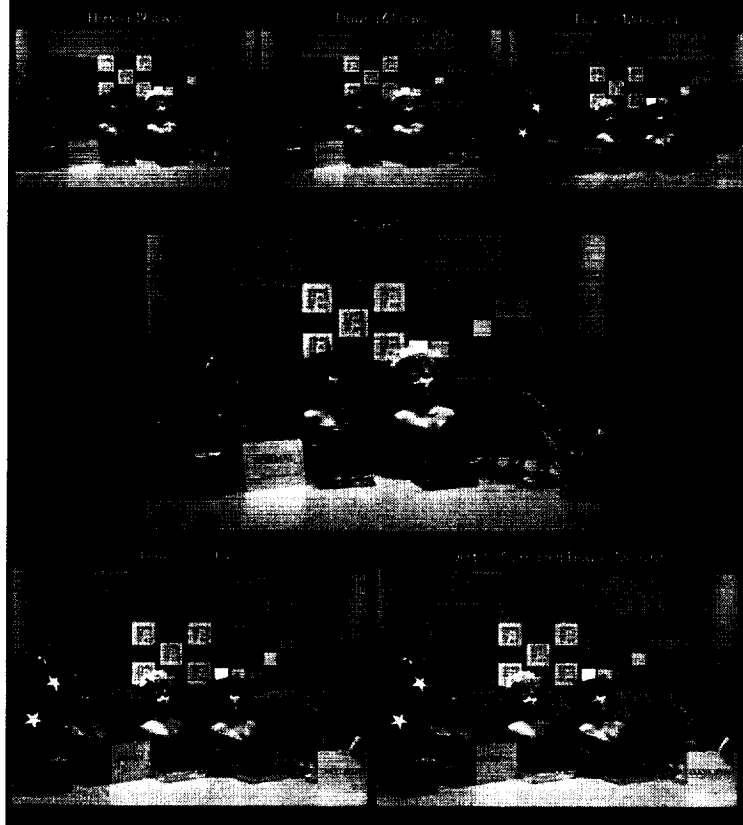
The Effects of Space Radiation on Flight Film  
Kodak 5069



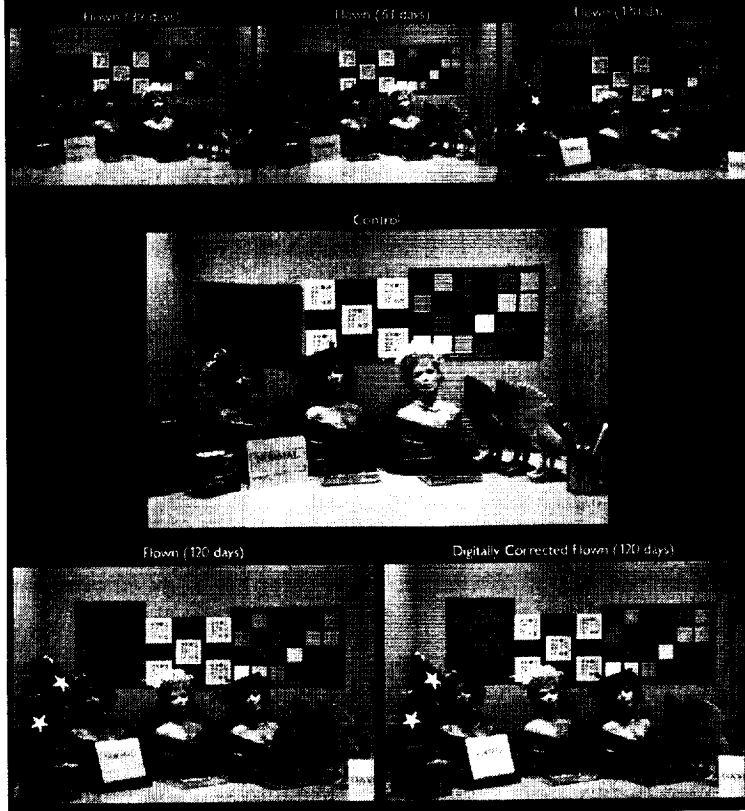
The Effects of Space Radiation on Flight Film - MIR Film Test  
Agfa Agfa-Image RSX 50



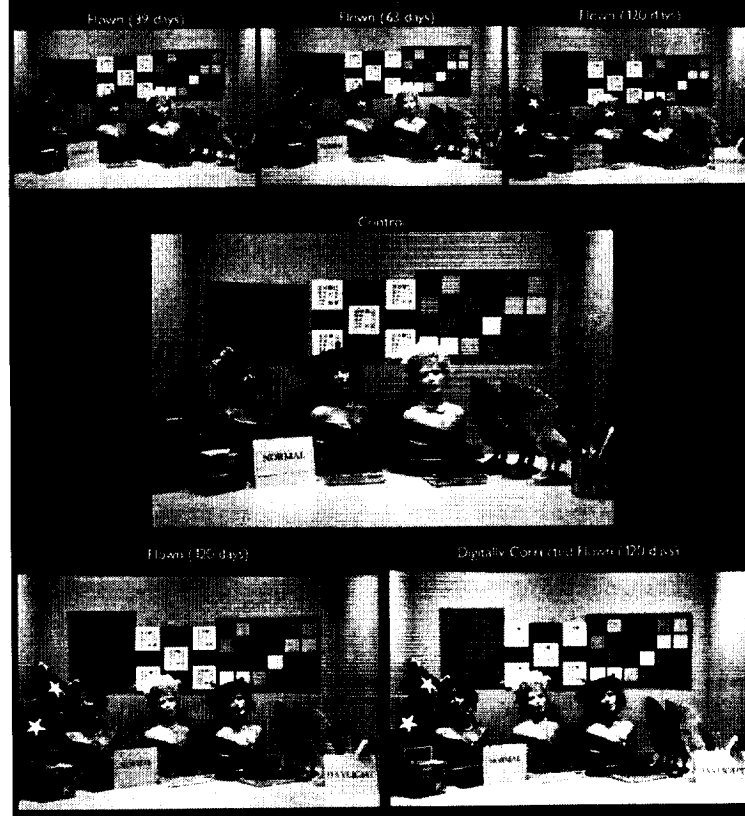
The Effects of Space Radiation on Flight Film - MIR Film Test  
Fuji Provia RDP ASA 100



The Effects of Space Radiation on Flight Film - MIR Film Test  
Fuji Velvia RVP 50



The Effects of Space Radiation on Flight Film - MIR Film Test  
Kodak 5069 Elite 100S



## **6.0 CONCLUSIONS**

Typical ISS increments will be 90-120 days. This makes the 120-day results most realistic in determining which films will provide the best photographic results aboard the ISS. The 120-day samples were used to determine which films fell into the good, marginal, and unsatisfactory categories. Of the three different types of photographic films tested, only the motion picture films had results that were entirely unsatisfactory. IMAX motion picture films have been used in the past with excellent results. However, the films were only manifested on Space Shuttle missions that never exceeded 20 days or 200 nautical miles in altitude. The IMAX Corporation reviewed the test results and concluded that, for the best results, motion picture films used for IMAX productions on the ISS should only be used for short-duration missions (less than 20 days) as they have been in the past. The still photographic films (both negative and positive) used in the test mirrored the overall results from previous film tests. Positive films are visually less damaged from radiation than negative films and, in general, the lower-speed films for both types provide less graininess and better resolution than their high-speed counterparts. Of the still photographic films tested, eight films from all three manufacturing companies provided good results when scanned and digitally printed. No film was clearly better than the others in either the positive or negative category. The data tend to point toward one film in each category. However, when the test results were ranked from a purely visual standpoint, the films were too close to judge from anything but by personal choice. Resolution, saturation, varying lighting conditions, and numerous other variables makes it realistically impossible to state that one film type or manufacturer is the best and should be used for all still photographic imagery aboard the ISS. The test did conclude that, for the eight best films, it was possible to digitally correct the images close to their original image quality. The other films were not correctable due to the increase in film grain. In all cases, a photographic film should be chosen based on these test results, shooting conditions, and the final product to be produced.



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13. ABSTRACT (Maximum 200 words) We conducted this film test to evaluate several manufacturers' photographic films for their ability to acquire imagery on the International Space Station. We selected 25 motion picture, photographic slide, and negative films from three different film manufacturers. We based this selection on the fact that their films ranked highest in other similar film tests, and on their general acceptance by the international community. This test differed from previous tests because the entire evaluation process leading up to the final selection was based on information derived after the original flight film was scanned to a digital file. Previously conducted tests were evaluated entirely based on 8x10s that were produced from the film either directly or through the internegative process. This new evaluation procedure provided accurate quantitative data on granularity and contrast from the digital data. This test did not try to define which film was best visually. This is too often based on personal preference. However, the test results did group the films by good, marginal, and unacceptable. We developed, and included in this report, a template containing quantitative, graphical, and visual information for each film. These templates should be sufficient for comparing the different films tested and subsequently selecting a film or films to be used for experiments and general documentation on the International Space Station.				
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