Study Of Damage To Photographic Films X-rayed by the Rapidscan Security Checkpoint Scanner

Prepared By The I3A Committee for Integrity in Transportation of Imaging Products

Purpose

The purpose of this test was to determine the maximum X-ray exposure high-speed photographic film products can tolerate before functional damage occurs. This information was requested by the Transportation Security Administration (TSA) in an effort to determine the optimum dosage to both minimize damage to film products, yet maintain the ability to recognize the contents and provide an adequate level of security.

Test Summary

Color negative film

The results of this test showed that banding (uneven density areas) was noticed after 25 passes with ISO 400 color negative film, and after 10 passes with ISO 800 color negative film. Prints were made from the ISO 400 film, and it was noticed that there was only a minimal color shift through the scan sequences. Also there was loss of contrast, and an increase in granularity starting at pass 10 and increased as the number of scans increased. This was especially noticeable in the under exposed frames. In each case the base fog (density of the unexposed areas) increased with the number of passes. The density of the exposed areas increased as well, but in smaller amounts.

Black and White film

An uneven fog pattern was noticed, especially with ISO 3200 film between 1 and 5 passes. At 25 passes this effect was extreme.

ISO 500 and ISO 800 motion picture film

Each film showed fogging after a single pass, which increased with the higher number of passes. The higher speed film (ISO 800) exhibited a proportional increase in fog compared to the lower speed film (ISO 500). Even minor fogging of motion picture film will degrade the projected image.

Reversal film

There were density changes to the maximum density areas in proportion to the amount of passes. These changes also took place in the normal exposure areas, but much less. This effect increased as the film was push processed.

Recommendations

Based on the testing completed at the FAA Technical Center in Atlantic City, I3A recommends a limit of five passes through the carry-on baggage security check point systems for all color negative and reversal film, including single-use cameras, up to and including ISO 800 speed film. While in some cases it may take a greater number of passes to cause damage to film, we believe that a five pass limit allows for an appropriate margin for safety. If lower speed film, ISO 100 through 800, is being carried on extended trips, and it is necessary to submit the film through security screeners more than five times, travelers should request hand inspection of their film. I3A further recommends that all film with an ISO rating greater than 800, black and white films, motion picture films, and films used for medical imaging ALWAYS be hand inspected. FAA regulations support the request by passengers for hand inspection of film.

Testing Procedure

<u>Test site:</u> FAA Technical Center, Atlantic City Airport, Atlantic City, NJ

<u>Participants:</u> John Pardo, Eastman Kodak Company
I.J. Maruoka, Fuji Photo Film USA, Inc.
David Carper, Ilford Imaging
Jeff Feldman, Konica Minolta Photo Imaging USA, Inc.
Roy Mason, FAA

<u>Equipment:</u> Rapidscan security check point X-ray scanner

<u>Dosage:</u> Dosage: 0.3mR as measured by dosimeter on sight.
(NOTE: Included X-ray radiation badges which showed the total exposure to be < 10 mR for 100 passes).

<u>Test Materials Submitted:</u>
135 ISO 800 color negative
135 ISO 400 color negative
135 ISO 1600 color negative
120 ISO 800 color negative
APS ISO 400 color negative
ISO 500 and ISO 800 movie film
120 ISO 400 black & white film
135 ISO 400 black & white film

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135 ISO 3200 black & white film
135 ISO 400 color reversal film
120 ISO 400 color reversal film

Testing procedures:

1) All films were placed in trays and transported through the scanner for 1, 5, 10, 25, 50 and 100 passes. Films were placed on trays in a manner indicative of how a typical traveler might pack their carry-on bags.

2) One roll from each category was held out as a reference.

3) After scanning was complete film samples were taken by, or sent to their respective companies for processing and evaluation.

Evaluation procedures.

Each company processed, examined, and in some cases printed the test film. Examination included the following criteria.

1) Dmin (base fog) increase for negative film.
   a) Measured by transmission densitometer as well as visually inspected
2) Dmax decrease for reversal film.
   a) Measured by transmission densitometer as well as visually inspected
3) Midtone gray density change.
4) Banding, and/or other uneven density deviations.

Selected films were printed to determine at what Dmin increase a functional and unacceptable degradation of the image would occur.

Summary of results

135 ISO 400 color negative		
No. of Passes	**Average Dmin increase from reference [a]**	**Observed results**
1	.00 .00 .00	Banding noticed between 25 and 50 passes. No banding at 25 passes. Strong observable banding at 50 passes
5	.01 .02 .00	
10	.02 .03 .01	
25	.04 .05 .02	
50	.08 .10 .06	
100	.09 .11 .07	
a = (R,G, B)		

135 ISO 400 color negative

No. of Passes	Average Dmin increase from reference [a]	Average midtone gray increase from reference [a]	Observed results
1	.01 .01 .01	.01 .01 .01	Banding (uneven density areas) noticed on pass 50 and 100. There areas were noticed on the prints
5	.02 .02 .03	.01 .01 .00	
10	.02 .02 .04	.01 .02 .02	
25	.06 .06 .06	.0 .0 .02	
50	.12 .14 .13	.02 .03 .01	
100	.17 .16 .13	.02.01 .01	

Print evaluation

Images were printed at the same fixed exposure time relative to negative exposure

- Minimal color shift through the scan sequences
- Contrast loss, and granularity increase starting at pass 10 and increasing in effect as passes increased. Especially noticeable in the under exposed frames. **This is a significant finding since it degrades print quality.**

a = (R,G, B)

135 ISO 1600 color negative

No. of Passes	Average Dmin increase from reference [a]	Average midtone gray increase from reference [a]	Observed results
1	.02 .03 .01	.03 .03 .02	No observed results
5	.02 .03 .03	.02 .02 .04	
10	.04 .06 .07	.01 .0 .04	
25	.06 .08 .08	.03 .03 .08	
50	.14 .20 .20	.04 .03 .10	
100	.19 .23 .22	.05.04 .09	

a = (R,G, B)

120 ISO 800 color negative

No. of Passes	Average Dmin increase from reference[a]	Observed results
1	.01 .01 .01	No observed results
5	.02 .02 .03	
10	.02 .02 .04	
25	.06 .06 .06	
50	.12 .14 .13	
100	.17 .16 .13	

a = (R,G, B)

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120 ISO 800 color negative	
Observed results	a) Banding evident between 10 and 25 passes. b) No banding at 10 passes. Banding evident at 25+ passes.

120 ISO 400 black & white film	
Observed results	Slight banding at 5 passes

135 ISO 400 and ISO 3200 black & white film

Film manufacturer's report

"ISO 400 and ISO 3200 films exposed to varying doses of X-ray, i.e. passes through an X-ray hand baggage check, have been processed and evaluated. I have tabulated the results below and given a brief description of the effects seen on them.

The films were processed using a Refrema dip & dunk processor. Developer ILFOTEC DD 1+4 at 24(superscript: o)C . N(subscript: 2) gas burst agitation 2 seconds in every 10. The films were given slightly less than the standard development time because the developer was very fresh.

ISO 400 = 6 minutes
ISO 3200 = 9 minutes

Between 5 and 10 passes through the X-ray hand baggage scanner caused fog on the ISO 400 and ISO3200 35mm film

On the 35mm film the fog detected is not even and has a pattern of a lighter band that repeats at about 7.5 cm at the leader end of the film, gradually reducing to about every 4 cm at the spool end. This pattern is probably due to the mouthpiece of the film cassette with the extra layers of metal in the mouthpiece giving a slight shielding effect.

Oddly the more sensitive ISO 3200 35mm film seemed slightly less affected than the ISO 400

Between 1 and 5 passes through the carry on baggage X-ray scanner caused fog on the ISO 3200 roll film.
The ISO 3200 roll film was clearly the worst affected, once again the fog is not even, with the higher doses, i.e. 25 and above, producing a clear image of the film's spool.

As well as a visual inspection the base fog of the film was measured. The small measured changes in density do not reflect the ease of seeing the fog caused. The ease of visibility is due to its unevenness.

Both of these films are design for push processing by up to 4 stops. Push processing would emphasize the fog formed.

Its is clear that on this occasion the dose given by this particular X-ray machine was not very safe for film with relatively few passes causing significant fogging."

135 ISO 400 color reversal film

No. of Passes	Average Dmax change[a]	Observed results
1	.02 .02 .07	No observed results
5	.03 .02 08	
10	0 .01 .03	
25	.01 -.02 .07	
50	-.02 -.01 -.08	
100	-.05 -.03 -.14	
a = (R,G, B)		

120 ISO 400 color reversal film

No. of Passes	Average Dmax change[a]	Observed results
1	-.01 .01 -.03	No observed results
5	.01 .02 .02	
10	-.03 -.02 -.04	
25	-.04 -.02 -.04	
50	-.07 -.05 -.15	
100	-.12 -.05 -.15	
a = (R,G, B)		

135 ISO 400 color reversal film, pushed 1 stop

No. of Passes	Average Dmax change [a]	Average midtone gray change [a]	Observed results
1	.0 .01 -.04	-.02 -.02 -.02	No observed results
5	-.02 -.01 -.07	-.04 -.04 -.03	
10	-.04 -.01 -.08	-.03 -.02 0	
25	-.05 -.02 -.10	-.04 -.04 -.03	
50	-.08 -.08 -.16	-.02 -.02 -.02	
100	-.07 -.07 -.14	-.01 -.01 -.01	
a = (R,G, B)			

135 ISO 400 color reversal film, pushed 2 stops		
No. of Passes	**Average Dmax change [a]**	**Observed results**
1	-.03 -.03 -.04	No observed results
5	-.04 -.04 -.07	
10	-.06 -.06 -.09	
25	-.07 -.05 -.10	
50	-.11 -.13 -.18	
100	-.22 -.23 -.26	
a = (R,G, B)		

135 ISO 400 color reversal film, pushed 3 stops		
No. of Passes	**Average Dmax change [a]**	**Observed results**
1	0 .02 -.01	No observed results
5	0 0 0	
10	-.01 .01 -.01	
25	-.03 -.01 -.01	
50	-.07 -.06 -.08	
100	-.18 -.17 -.24	
a = (R,G, B)		

120 ISO 400 color reversal film, pushed 3 stops			
No. of Passes	**Average Dmax change [a]**	**Average midtone gray change [a]**	**Observed results**
1	.0 -.03 -.01	-.01 -.02 0	No observed results
5	-.02 -.04 -.03	-.03 -.05 -.02	
10	-.03 -.02 -.01	-.02 -.02 -.01	
25	-.05 -.07 -.04	-.03 -.03 -.01	
50	-.12 -.17 -.16	No results	
100	-.24 -.28 -.33	-.08 -.09 -.09	
a = (R,G, B)			

135 ISO 500 and ISO 800 motion picture film

Film manufacturer's report

Each film type was subjected to multiple exposures in an X-ray baggage scanner. A test sample for each film type was exposed 1, 5, 10, 25, 50 and 100-times. Sensitometric exposures of the test films exposed to X-rays were then compared to a control film. A control film traveled with the test exposures. The control film was not subjected to X-ray exposure. The test and control films were exposed with a sensitometric test target and then processed (ECN-2 process) and measured (Status M densitometry) together to minimize test variability.

- Each film showed a density change (fog) during a single X-ray scan. The blue sensitive layer was most affected by X-ray exposure, followed by the green sensitive layer. Multiple X-ray exposures showed a proportional increase in fog.
- The higher speed film (ISO 800) exhibited a proportional increase in fog compared to the lower speed film (ISO 500).
- The increased fog from X-ray exposure flattened the entire toe region of the sensitometric curve (1.20 Log H or four stops. The flattened toe would reduce shadow detail in a telecine or projected image.

The test was designed to provide a uniform X-ray exposure but the presence of fog from X-ray exposure presents the potential for non-uniformity in the image area. The orientation and stacking of multiple film cans in a traveling bag or the presence of other dense objects such as spot meters or cameras may attenuate X-ray exposure and create areas of non-uniformity in the image. Even small amounts of non-uniformity in the image area will be readily apparent in moving images and will become objectionable to most observers."