The CTX-5OOOSP and Camera Films

Technical Report

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The CTX-5000SP and Camera Films

The International Imaging Industry Association (I3A) has completed a series of tests evaluating the effects of the CTX-5000SP checked baggage inspection system on photographic films. The CTX-5000SP is the first checked baggage inspection system to use computed tomography (CT) to screen airline passengers' checked baggage to detect explosives. The results show that, under certain conditions, the CTX-5000SP has a detrimental effect on camera films.

Background

During March 1997 the I3A established an ad hoc task force to study the effects of the CTX-5000SP on photographic films. Participants included Agfa, Eastman Kodak, Fuji, Ilford, Imation, Konica and Polaroid. Each manufacturer was invited to contribute to the test design and to provide films for testing. Arrangements were made to conduct tests using the CTX-5000SP located at the Transportation Security Administration (TSA) Training Facility (the former Federal Aviation Administration Technical Center) in Atlantic City, New Jersey.

This study's goal was to characterize the effects of the CTX-5000SP upon photographic film. No attempt was made to ascertain the probability of film transported in baggage through the CTX-5000SP being irradiated by the highly energetic X-rays.

Test Design

The CTX-5000SP has two X-ray systems incorporated into its design. The first X-ray system is similar to what is currently in use to examine carry-on baggage. This system irradiates the entire piece of baggage, resulting in an image that is analyzed by the computer system to assess potential dangers. The image is then displayed on a computer screen for operator assessment. The baggage is then positioned under a second, thin X-ray beam that scans portions of the baggage as determined by the computer and/or operator. This second scan has higher energy than the first and is where the X-ray damage, if any, should occur on the film. Given the nature of the CTX-5000SP, the second scan must occur in at least a few locations on each piece of luggage.

To assess the X-ray exposure effects from the CTX-5000SP on typical consumer silver halide films, a series of tests were conducted to characterize the X-ray effects under normal operating conditions. These tests were designed to assess the effects of both the standard and high energy X-ray beams on the film.

One challenge to the experiments was to control where the high energy X-ray beam irradiated the samples. To do this, the tested films were placed into a piece of luggage along with a material used to simulate a threat such that the film was as far from the simulant as possible. This threat material caused the CTX-5000SP to scan its position, and thus we were able to control when and where we irradiated the film samples with the high energy X-rays.

Experiments

Four experiments were conducted. They were:

Experiment #1: Samples, unexposed to light, of each selected film passed through the CTX-5000SP without receiving a direct scan from the highly energetic X-ray beam. This system, as stated earlier, is similar to what is currently in place to examine carry-on baggage at U.S. airports. These films were exposed for 1, 5, 10 and 50 inspections.

Experiment #2: Samples, unexposed to light, of each selected film passed through the CTX-5000SP and received a direct scan from the highly energetic X-ray beam. These films were positioned perpendicular to the X-ray beam.

Experiment #3: Samples, exposed to a subject, of each selected film passed through the CTX-5000SP and received a direct scan from the highly energetic X-ray beam. These films were scanned perpendicular, parallel and at 45 degrees to the scanning plane of the X-ray beam. We selected a low modulation scene (a model with a uniform background) and bracketed the normal exposure by two under and over exposures in one-stop increments. This scene was selected, as it was believed to be a very critical scene for this type of X-ray damage.

Experiment #4: Samples, unexposed to light, of each selected film were located close to a source that is scanned with the high energy X-rays. This acts as a scattering site, and the samples were then examined for the effects of scattered radiation.

Each manufacturer submitted films in the packaging formats they wished to test. Film speeds ranged from ISO 100 to ISO 1000, while formats included a standard 135-size cassette, APS packaging, single use cameras and 120-size films. For Experiment #3, all scenes were exposed by Fuji Film's Sensitized Products Photo Imaging Group in Carlstadt, N. J. For the color negative films, Konica provided a standard C-41 process. Thus, all manufacturers' films received the same exposure and processing.

Results and Evaluation

The processed films were visually examined under ideal lighting conditions and magnifications. Engineers and technicians from all of the participating manufacturers examined the films. The results were:

Experiment #1 failed to show any X-ray damage to the film by way of visual inspection. Slight fogging did occur, but was determined only by sophisticated scientific instruments. The amount of fog was consistent with inspection systems for checked baggage currently in place and operating under the TSA (former FAA) guidelines of less than 1 milliroentgen (1 mR) per inspection. The amount of fog varied with the speed of the film and the number of passes through the X-ray system. It would not be noticeable by the average consumer.

Experiment #2 resulted in an approximately 1 cm wide line of high density on the photographic negative. The density of this high-density line depends upon the speed of the photographic emulsion. The high-density line becomes more photographically dense as the film speed increases. However, the line is visible for all emulsion speeds tested (ISO 100, 200, 400, 800 and 1000).

Experiment #3 again resulted in an approximately 1 cm-wide high-density line of the photographic emulsions. The orientation and shape of this line depends upon the orientation of the film relative to the incident X-rays. Figure 1[1] shows the scene selected. Figures 2 through 4 show the selected scene after exposure to the highly energetic X-ray beam in the CTX-5000SP for ISO 200, 400, and 800 speed films respectively. In these prints, the film was oriented perpendicular to the direction of the incident X-rays. Figure 5 shows the same scene on 400 speed film oriented parallel to the incident X-rays, while Figure 6 shows the film oriented at 45 degrees relative to the incident X-rays.

Additionally, Figures 7 and 8 show scenes from negatives exposed to the high energy X-rays that, due to scene content, do not show the X-ray damage.

Experiment #4 resulted in some additional fog due to scattering. However, the fog level was not sufficient to cause concern. Again, this fog is consistent with that expected from a typical carry-on or checked baggage system operating under the TSA guidelines of less than 1 mR per inspection. The amount of fog varied with the speed of the film and the number of passes through the X-ray system.

Conclusion

Testing by the I3A Airport X-ray Task Force indicates that the CTX-5000SP will cause significant fogging of all color negative films with an ISO speed of 100 or higher when the film sustains a direct hit by the machine's high intensity X-ray beam. The orientation of this stripe is dependent upon the orientation of the film relative to the X-ray beam. The density of this stripe depends upon the film speed. Additionally, whether this stripe is seen in the photographic print will depend upon the scene content. Busy scenes with flowers, foliage, etc. tend to obscure or lessen the X-ray effects.

Recommendation

In light of the above findings, it appears appropriate to warn air travelers of the potential damage to their unprocessed films that receive a CTX-5000SP inspection. The ways and means of communicating the warning through the manufacturers, retailers and the TSA will have to be developed.

[1] Figures appear at end

Figure 1 Model scene for CTX-5000SP test
ISO 400 Speed film

Figure 2 – Effect of CTX-500SP on ISO 200 speed film.
Film oriented perpendicular to the direction of the incident X-rays

Figure 3 – Effect of CTX-500SP on ISO 400 speed film.
Film oriented perpendicular to the direction of the incident X-rays

Figure 4 – Effect of CTX-500SP on ISO 800 speed film.
Film oriented perpendicular to the direction of the incident X-rays

Figure 5 – Effect of CTX-500SP on ISO 400 speed film.
Film oriented parallel to the direction of the incident X-rays

Figure 6 – Effect of CTX-500SP on ISO 400 speed film.
Film oriented 45º to the direction of the incident X-rays

**Figure 7 – Effect of CTX-500SP on ISO 400 speed film.
Film oriented perpendicular to the direction of the incident X-rays.
Scene content masks X-ray damage**

**Figure 8 – Effect of CTX-500SP on ISO 400 speed film.
Film oriented perpendicular to the direction of the incident X-rays.
Scene content masks X-ray damage**