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Intensification and Reduction of Kodak No-Screen Medical X-Ray Film

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ABSTRACT

Experiments were conducted on Kodak No-Screen Medical X-ray Film to assess the possible methods for the reduction of overexposed film and the intensification of underexposed film.

The image density on films given 10 times the normal exposure was successfully reduced by decreasing either or both the time and temperature of development and by using Farmer's Reducer (Ansco 310) on the normally developed film. The use of a reducing solution on developed film was judged to be the best approach because the reduction can be controlled accurately and the reduced image suffers no loss of detail.

The methods of intensification assessed included increasing the development time and temperature, intensifying the film after development with Kodak Chromium Intensifier (In-4) or Mercury Intensifier (In-1), and fogging the underexposed film prior to development with mercury vapor or with light. Intensification after development produced the best results; the image density above that of the background was increased 42 percent after one treatment with mercury intensifier and 24 percent after one treatment with chromium intensifier.

PROBLEM STATUS

This is the final report by the X-Ray Optics Branch on one phase of the problem; work continues on other phases.

AUTHORIZATION

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Project RR 002-07-41-4951

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INTENSIFICATION AND REDUCTION OF KODAK NO-SCREEN MEDICAL X-RAY FILM

INTRODUCTION

Experiments were conducted to explore the utility of available techniques for the reduction of overexposed images and the intensification of underexposed images on Kodak No-Screen Medical X-ray Film. This film is normally exposed for 3 minutes in a spectrograph to the x-rays from a copper-target Philips x-ray tube operating at 45 kev, 5 ma. The methods discussed may be applied to other films, and the techniques may be adjusted to suit the particular film.

REDUCTION OF FILMS

The "overexposed" film was exposed for 30 minutes in a spectrograph to the x-rays from a copper-target Philips x-ray tube operated as above. This is designated as 10 times the normal exposure. Kodak No-Screen Medical X-ray Film is normally developed for 5 minutes at 68°F in Kodak Liquid X-ray Developer and Replenisher, rinsed, fixed 10 minutes in Kodak Rapid X-ray Fixer and Replenisher, and finally washed 20-30 minutes in running water.

Normal development of the image overexposed by a factor of 10 produced an almost black film (Fig. 1a). Methods of producing a usable image from overexposed film are (a) reduce the time of development, (b) reduce the temperature of development, (c) combine both (a) and (b), and (d) develop the films normally and reduce the developed film.

Reduced Development Time

A usable image was produced from the 10-times overexposed film by reducing the time of development to 30 seconds at 68°F (Fig. 1b). However, it is extremely difficult to assess the image quality accurately during development and to stop development at the correct time. It should also be noted that considerable detail is lost when the time of development is shortened.

Reduction of the Developed Film

The film was developed normally, then reduced with Farmer's Reducer (Ansco 310) (1a) used full strength. The strength of the reducing solution can be varied depending on the thickness of the emulsion. The reduction was accomplished in a test tube in a lighted room, and the film was removed from the reducing solution when the image was visually assessed to be adequate. Full-strength Farmer's Reducer produced a usable image in 5 minutes (Fig. 1c). There is no apparent loss of detail. Often, however, the reduced negative is yellow. This results from the fact that both silver sulfide and silver are formed during the fixing process and the yellow silver sulfide becomes predominant when the silver is bleached by the reducer. If the yellow color is objectionable, two solutions may be employed.* The first technique is to add potassium iodide (about 1g per

*These solutions were pointed out to us by R.W. Henn, Research Laboratories, Eastman Kodak Co., Rochester, N.Y.

liter) to the fixing bath to prevent the formation of silver sulfide (2). Alternately, Kodak Non-Staining Reducer R14 (3) may be used since it dissolves silver sulfide as well as silver.

Reduced Development Temperature and Time

Development of the overexposed film for 5 minutes at 38°F produced an image that was acceptable (Fig. 1d). Reduction of both the time and temperature of development produced a usable image with little loss of detail as shown by the film developed for 2 minutes at 48°F (Fig. 1e). It appears that the combination of reduced temperature and time could be used to handle an even greater overexposure than 10 times normal. As noted above, however, it is impossible to judge visually when the film should be removed from the developer.

INTENSIFICATION OF FILMS

The "underexposed" image was produced by exposing the film to x-rays in a spectrograph for 18 seconds or 0.1 times the normal exposure. An underexposed film, when developed normally for 5 minutes at 68°F, produced a very faint image except for the characteristic lines (Fig. 2a). Methods available for intensifying underexposed film include (a) increasing the time of development, (b) increasing the temperature of development, (c) developing the film normally and then treating it with an intensifying solution, (d) fogging the film prior to development.

Increased Development Time

The development time of the film exposed at 0.1 times the normal was increased to the maximum recommended time of 8 minutes at 68°F with little apparent effect on the intensity of the image (Fig. 2b).

Increased Temperature of Development

The underexposed film was developed for varying times at 100, 98, 97, 92, and 88°F. The film was not treated with a prehardener. The emulsion of the film developed at 100°F did become soft enough that it could be scraped off the base, and the film was completely black. In general, the films developed at a high temperature were fogged, and image intensification was slight (Fig. 2c).

Intensifiers Used After Development

The underexposed film was developed normally, fixed, washed, bleached with the intensifying solution, and then redeveloped.

The use of Chromium Intensifier (Kodak In-4) (1b) increased the image density above that of the background by 24 percent (Table 1) after one treatment when the solution was used full strength (Fig. 2d), and the film was darkened with x-ray developer.

The Kodak mercury intensifier (Kodak In-1)(1b) was used at recommended strength. One film was bleached with this solution and then darkened with an ammonia solution. The film turned black, and subsequent reduction did not produce a usable image. Another

Table 1
Intensification of Kodak No-Screen
Medical X-Ray Film*

Treatment	Density above Background
Normal development	0.45
Chromium intensifier	0.56
Mercury intensifier	0.64

*Exposed for 18 seconds.

underexposed film was bleached with the mercury intensifier and darkened with x-ray developer (Fig. 2e). This method increased the image density above that of the background by 42 percent (Table 1), making it the best method assessed.

Intensifiers Used Prior to Development

The film may be treated prior to development in an attempt to put the image density on a portion of the characteristic curve where the gradient is greater. This usually involves fogging the film prior to exposure, but in our experiment we were assessing the usefulness of methods which can be applied after the film is exposed.

The film can be prefogged with mercury vapor by putting the underexposed film in a sealed tube with mercury. One film was exposed to mercury vapor for 64 hours, and another film was fogged for 24 hours (Fig. 2f), but neither film on development showed any increase in image density. Another exposed film was prefogged with light prior to development (Fig. 2g) with no success.

CONCLUSIONS

It is concluded that the density of x-ray film given 10 times the normal exposure can be successfully reduced to the density of a normal exposure by decreasing the time of development and the temperature of development or by using a reducer solution on the normally developed film. The latter method was judged to be the method of choice since reduction is accomplished in a lightened room and there is no loss of image detail.

None of the intensification methods tried caused enough intensification of the film exposed at 0.1 times the normal to produce the density obtained with a normally exposed film. However, one treatment with chromium intensifier increased the image density above background by 24 percent and one treatment with mercury intensifier increased it by 42 percent. It is concluded, therefore, that the greatest amount of image intensification may be obtained by giving the normally processed film several treatments with mercury intensifier.

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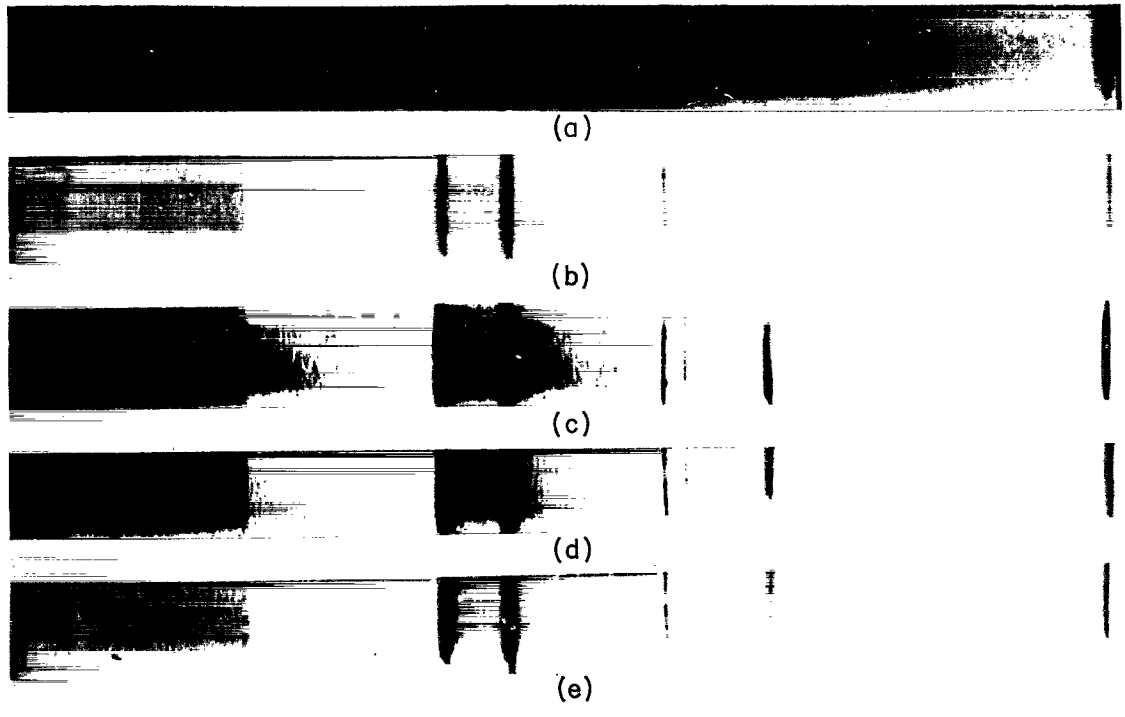

Fig. 1 - The reduction of 10-times overexposed Kodak No-Screen Medical X-Ray Film: (a) Film developed normally for 5 minutes at 68°F; (b) Film of development reduced to 30 seconds at 68°F; (c) Film developed normally, then reduced with Farmer's Reducer; (d) Film developed 5 minutes at a reduced temperature of 38°F and (e) Temperature of development reduced to 48°F and time reduced to 2 minutes.

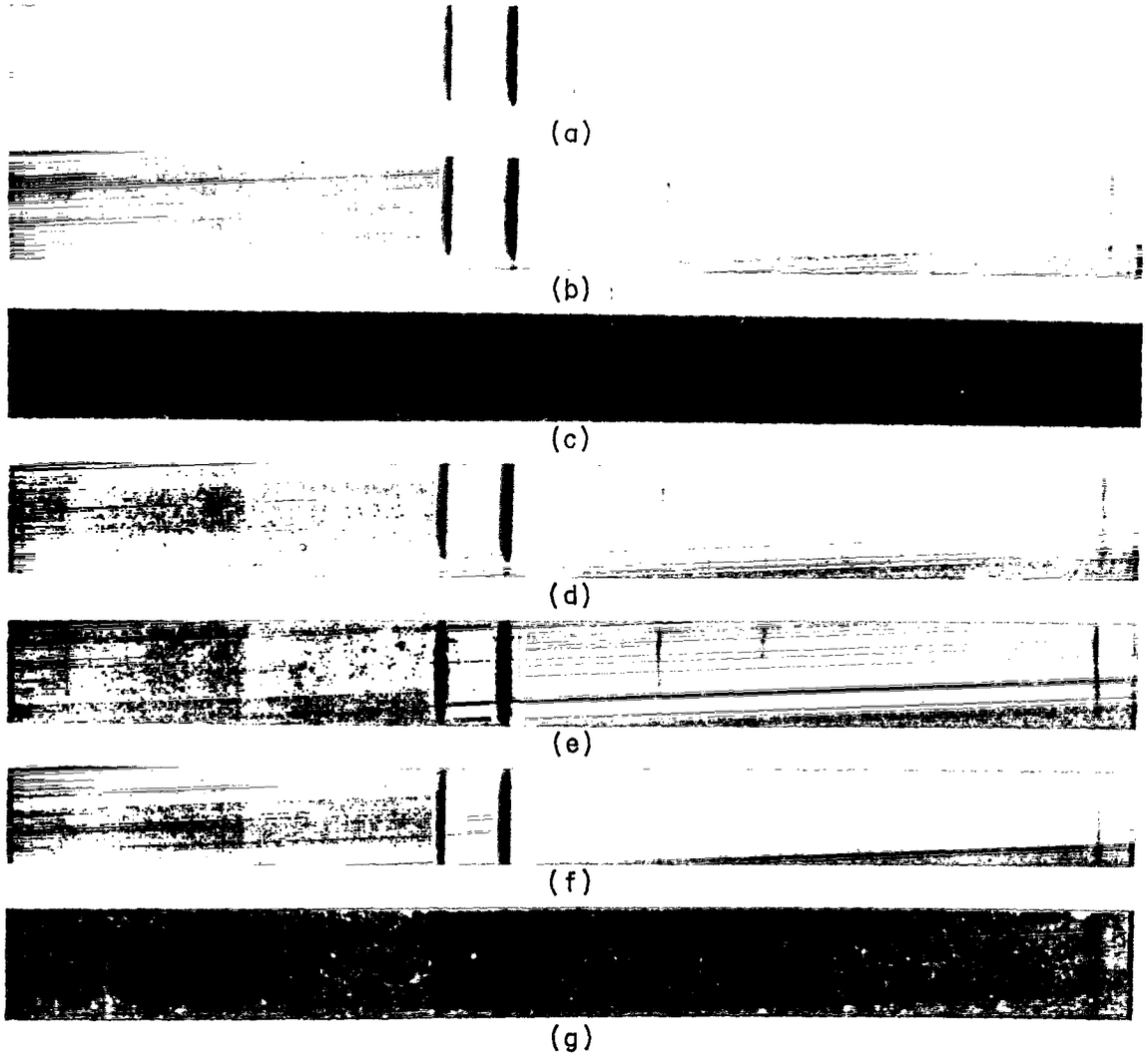

Fig. 2 - Attempts to intensify underexposed films: (a) Film developed as normal for 5 minutes at 68°F; (b) The development time was lengthened to the maximum recommended time of 8 minutes at 68°F; (c) The temperature of development was increased to 88°F and the time of development was 4 minutes; (d) The film was developed normally as in (a), then intensified with chromium intensifier used full strength; (e) The film was developed normally then intensified with mercury intensifier; (f) The film was exposed to x rays, put into a tube containing mercury for 24 hours, then developed normally and (g) The film was exposed to x rays, fogged with light, and then developed normally.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Image density						
Image intensification						
Image reduction						
X-ray film (medical)						
Underexposed film, treatment of						
Overexposed film, treatment of						
Farmer's reducer						
Chromium intensifier						
Mercury intensifier						