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EFFECTS OF WARM TEMPERATURE ON SOME SENSITOMETRIC PROPERTIES OF X-RAY FILMS

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ABSTRACT

The quality of images produced by x-ray films are adversely affected by high temperatures. This usually happens when the climate temperatures values under which films are stored exceeds the storage conditions of the manufacturer specification. The adverse effect of storage conditions resulting from high temperatures on the sensitometric properties of base and fog and speed of Kodak Ekta speed x-ray film have been investigated for 12 months. Characteristics curves were constructed using manual processing. The highest optical density (OD) for base plus fog and the lowest responds of the film (speed) was recorded in the month of March. The responds of the film can be optimize by constantly monitoring storage temperatures to ensure that films are not processed above manufactures specification of storage temperature. The findings from this study could be of clinical relevance to diagnostic centers where storage conditions under which x ray films are stored are not constantly available.

KEYWORDS: storage temperatures, optical densities, speed, base plus fog.

INTRODUCTION

The quality of images produced with an x-ray film depends on the storage conditions of the film. It is important to understand what factors constitutes optimum storage conditions and the possible effects they have on image quality of x-ray films when these conditions are not met. When films are poorly stored, they gradually loose speed and contrast which increases the level of fog in the base. Unexposed unprocessed films should be protected from high relative humidity, high temperatures, harmful gasses and physical damages. The sensitometric features of an x-ray film emulsion can be altered by high relative humidity and high temperatures. Manufactures of films specify conditions under which they should be stored to prevent them from fogging. The film should be packed under controlled conditions of relative humidity (30-65%) and temperatures not exceeding 21^{o}C or 70^{o}F.[1]

Quality control is essential in the monitoring of any film processing system. This includes some sensitometric properties such as film speed, contrast, base and fog, solution temperatures, processing time and film artifact identification.[2-5] Manufacturer of Kodak films in 1981 indicated the advantages of using Ekta speed films. However, some clinicians expressed their disappointment in the initial practical experience with the manufactures description of the Ekta speed films in terms of responds to image quality. The main concern of users of the Ekta speed film was their dissatisfaction particularly in the reduction in contrast produced by the film.[6]

A number of studies have revealed the sensitometric properties of Ekta speed films.[7-11] Some films require approximately 50% of exposure when the contrast is somewhat lower and there is more rapid buildup of fog in the base. Therefore, for accurate diagnosis in carriers detection, it is essential to study the some sensitometric properties of x-ray films such as the effect of storage time and storage conditions on base plus fog.[12]

This research was carried out in an x-ray facility where cooling systems that optimizes storage conditions of x-ray films are not constantly available. Due to this, the quality of images produced is anticipated to be affected and the level of fog in the base will increase. In order to establish the effect of these storage conditions on some sensitometric properties, the procedure for Hurter and Driffield[13] was performed to define the characteristic of a photographic emulsion by plotting logarithms of exposure (E) against the degree of blackening or optical density (D) after the film has been developed. In this study, the effect of high temperatures on the base plus fog and speed of Kodak Ekta speed film has being investigated.

MATERIALS AND METHODS

Daily warm temperatures values in the x-ray storage room were measured and recorded for a period of twelve months from January to December, 2016. The warm temperature was monitored with a digital thermometer placed directly by the x-ray film package in the storage room. The temperature values (Table 1.0) were recorded after every thirty minutes from 9:00 to 12:00 GMT from Mondays to Fridays. Exposures were measured using a PTW Freiburg farmer ionization chamber calibrated to IAEA reference standard.[14] Both the ion camber and the film (placed directly adjacent to the ion chamber) were exposed at the same time. A focus -to-film distance of 100cm was used under Siemens x-ray mobile equipment (XM 100) operating with the routine chest scan protocol at 80kVp and 10mA. The film was then processed in a developer solution (at constant temperatures between 26 to 27^{0}C) for 3 minutes after the exposure was recorded for every temperature measurement. During the processing of the film, the stability of the processor temperature was monitored at regular intervals to ensure that films were not processed outside the range of these temperatures. The film density was measured using an X-Rite densitometer model 301 calibrated to a known standard. The characteristics curve was obtained by plotting the density measured against $\log_{10}$ exposure in compliance with ISO standard 3665.[15] The speed and average gradients were calculated according to the method described in.[16] The speed of the film was calculated from the curve as the reciprocal of the exposure required to produce a radiographic density of 1.0 above the base plus fog density.

RESULTS

The sensitometric data is represented as a function of OD base and fog versus storage temperature in Figure 1 and 2. The base plus fog density levels calculated for all the twelve months were all within the ISSO 3665 recommendations. The base plus fog and speed values are shown in Table 2.0

Table 1: Average monthly warm temperature values measured from 9:00 to 12:00 GMT under which x-ray films are stored at the facility.

	Average Temperature (^{o}C) values recorded						
Month/Time	**9:00**	**9:30**	**10:00**	**10:30**	**11:00**	**11:30**	**12:00**
January	21.8	22.0	22.3	23.4	24.6	24.8	25.1
February	21.7	22.8	23.1	23.4	24.0	24.6	25.0
March	22.8	23.5	24.1	24.3	25.7	26.2	27.8
April	21.6	22.0	22.5	23.8	24.2	25.1	26.5
May	21.4	22.5	23.0	23.8	24.2	25.6	26.0
June	21.5	21.9	22.1	23.0	24.1	24.8	25.2
July	21.4	22.0	23.1	23.6	24.0	24.5	25.8
August	21.0	21.6	21.8	22.2	22.6	22.9	23.0
September	21.1	21.5	21.9	22.5	23.1	23.8	24.1
October	21.7	21.9	22.1	22.8	23.4	24	24.9
November	22.0	22.4	22.8	24.3	24.8	25.1	25.2
December	22.4	23.1	23.7	24.1	24.6	25	25.7

Table 2: Base plus fog and Speed for Ekta film on different months.

Month	**Jan**	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Base Plus fog	0.20	0.21	0.32	0.22	0.32	0.22	0.19	0.17	0.19	0.19	0.21	0.20
Speed	47.3	46.5	44.4	45.9	46.8	47.9	51.0	55.6	48.0	47.8	47.2	46.1

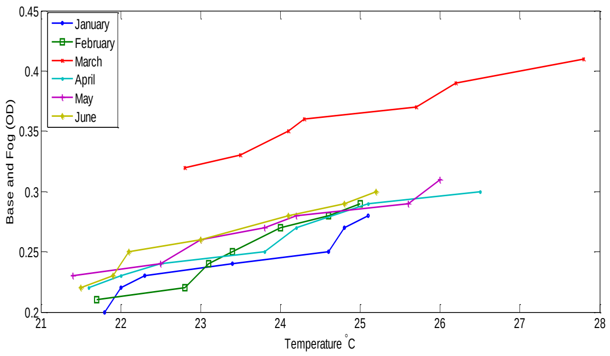

Fig 1: The effect of storage temperature on the base and fog level from January to June 2016.

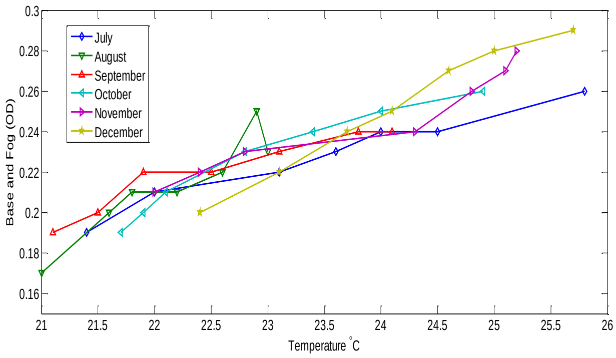

Fig 2: The effect of storage temperature on the base and fog level from July to December 2016.

DISCUSSION

The purpose of the study was to investigate the effects of storage conditions resulting from high temperatures on base plus fog and speed of Ekta speed film. The fogging of x-ray films above certain level that may contribute to the reduction of radiographic contrast has been a major concern in diagnostic radiology.[17] An OD value up to 0.25 for base plus fog is considered acceptable[18] whiles in excess of 0.20 was considered objectionable.[19] The responds of the Kodak Ekta speed film in this study has shown uniform temperature dependence, as optical density increases with increasing storage temperature at specific time intervals. This trend is clearly exhibited in almost all the months except in July, August and September (Fig. 2). The mean range of storage temperatures and OD values of base plus fog from January to December was found to be 21 - 27.8 ^{o}C (Table 1) and 0.17 – 0.32 (Table 2.0) respectively. The highest storage temperature was recorded in the month of March as expected.

As suggested by Kaffe *et al*,[18] if an OD of 0.25 is considered acceptable for base plus fog in diagnostic radiology, then it is critical to regularly monitor and consider storage temperatures at specific times before x-ray films are used and processed. It would not be advisable to use and process Ekta speed films within certain daily periods where storage temperatures are found to above 24^{o}C. This would help regulate and maintain OD's within acceptable limits. However, as reported by Svenson et al.[20] diagnosis of approximal carriers using Ekta speed films would not adversely be affected with OD of 0.6 for base plus fog provided no attempt has been made to offset the increase in OD due to fog. Therefore, we can conclude that, the highest OD recorded is considered acceptable since no attempt was made to balance the increase in density.

Speeds calculated were found to be reducing with increasing OD. The speed of the film for the various months was all found to be within clinically relevant range. The speed of Ekta film increased consistently from 45.9 in April to 55.6 in August and decrease in September from 48.0 to 46.1 in December. The decrease in speed was also observed from January to March. This behavior occurred as a result of high temperatures usually observed between the months of October to May and low temperautes between the months of June to September. The highest storage temperature recorded in the month of March suggests the low responds of the film. This could have an effect on the amount of diagnostic information that would be collected within this period of the month. For a film to be able to collect sufficient diagnostic information, the fog level should not be up to 0.30 since an increase in fog is associated with an increase in film speed.[21]

CONCLUSION

The main aim of radiology is to optimize diagnostic information whiles keeping radiation dose as low as reasonably achievable. The use of high speed films is one surest way to dose reduction. However, the quality of diagnostic information can be affected when storage conditions of x-ray films such as high temperatures are inappropriate. The effect of storage temperature on some sensitometry properties of x-ray films was studied for 12 months. The Ekta film had the highest base plus fog and lowest speed in the month of March. This is due to high temperatures usually recorded within this period of the year. From the study, it is recommended that, routine monitoring of storage temperatures of x ray films should be carried out before films are used and processed. This would help optimize diagnostic information and ensure that x ray films are not used and processed outside their clinical diagnostic range. The findings from this study could be of clinical importance to diagnostic radiology centers where storage conditions of x-ray films are not suitable.

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