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Assessment and Evaluation of Radiology Darkroom in Benue State University Teaching Hospital and Federal Medical Centre Makurdi, Nigeria

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Abstract:
In every exposure, the primary goal of radiology is to obtain a high quality image with low radiation dose to patient. The research seeks to evaluate all the other factors that constitute high quality image with low radiation level in order that the ALARA (As Low As Reasonably Achievable) principle is maintained. In this work, the effect of safelight, white light, chemicals used for processing of radiology films and the time taken to process X-ray film in radiological units of some Hospitals in Benue State are determined and evaluated. The quality of the image in the darkroom is found to depend on how short the film is exposed to safelight. The processing chemicals and the temperature at which these films are processed and stored are also evaluated. The result obtained, show that the contrast level decreases as the exposure time increases as shown in the blue nature of the films exposed at longer time. Furthermore, the temperature of the processing solutions is seen to be very high when compared with ICRP and NCRP standards which indicates that the processing tanks at the two hospitals are not within the recommended standards and the standard humidity of (40-60%) are also not met.

Keywords: *Dark room, safelight, X-ray film*

1. Introduction

In radiography, the camera is actually a radiation source which is placed on the opposite side of the object being imaged. The radiation is not reflected to the film, but rather passes through the object and then strikes the film. The image on the film is dependent upon how much the radiation makes it through the object and to the film [2]. Some materials like bones and metals stop more of the radiation from passing through than materials like plastics and flesh. The amount of material that the X-ray must travel through, also affects how many X-rays reach the film. Difference in the type of materials and the amount of material that the X-rays must penetrate are responsible for the details in the image [7].

The use of X-rays to detect the presence of ionizing radiation goes back to the Becquerel and the discovery of radiation itself. In its use for X-ray imaging, it is also one of the better known methods. The basic method of operation is quite straight forward in that; the radiation ionizes the silver halide crystals in the film emulsion. This process of ionization causes chemical reduction reaction in the crystal which, when developed, blackens that part of the film emulsion. The greater the amount of exposure to ionizing radiation, the greater the degree of film blackening [8].

The majority of variation in radiography is due to chemical processing of X-ray film. A variation in X-ray film processing can give rise to delay in image availability when making a print in a radiology dark room, a safe light is normally used to illuminate the work area, which is monochromatic in nature (yellow colour) and is not sensitive to black and white prints [3]. Furthermore, a change from the recommended processing conditions always results in higher patient dose [9]. There are five basic steps involved in processing X-ray film; developing, rinsing, fixing, washing and drying.

The radiology darkroom is a light-tight room with safe and white light illumination. The overhead white light is at the ceiling, but the safelight is usually not lower than 1.3m (4ft) from the working bench or processing tanks, thermostatically controlled supply of water, thermometer, timer, film hangers, drying racks and storage space.

It is required that safelight illumination gives enough visibility for the technician in the darkroom to handle and process film resulting in minimum detrimental effect to unprocessed film. Safe light handling times (i.e. maximum time for which a film can be exposed to safelights without any appreciable degree of fogging) should always exceed film handling times. Fogging is the deterioration in the quantity of the image caused either by extraneous light or the effect of processing chemical. Possible sources of darkroom fog include; safelight filters, (old or compromised), auxiliary indicator lights on processor, safelight housing, etc. [13].

J. B. Tuffy and P. C. Brennan (2005) measured and determined the safelight handling time and film handling time in seven Dublin hospitals [10]. Causal agents for unacceptable safelight handling times were sought. They showed that only three (3) hospitals out of the seven tested were operating under appropriate lighting conditions. The maximum mean film handling time noted was 28secs, indicating that the minimum safelight handling time of at least 30secs was needed in the darkroom. Working area light levels were found to have a significant relationship with safelight level of 1.3m (4ft) which is the required distance for safelights [9, 14].

Safelight conditions were determined as described in the ISO-8374 (2001) using a modified version of the safelight handling test. This consisted of a pre-exposed film held in a darkroom environment under increasing times of safelight exposure. Image densities were measured and the safelight handling time was established. The film handling time was determined by recording the mean time taken for each technician in each darkroom to handle film over a two-hour period. A safelight handling time to film handling time ratio was calculated. Technical information of safelight and darkroom were recorded for each hospital [5].

Darkroom should be well ventilated, with the minimum dimension of 2.0m × 1.5m, constructed with an air inlet and outlet with an exhaust fan. These openings must be designed such that no light shall enter the darkroom while the processing is done. Preferably a darkroom must have louver blocks, painted black to absorb white light, placed on the lower portion of the door for ventilation. Loading and processing of film with drying all take place in the darkroom of radiography [1, 4].

Many X-ray darkrooms have no scientific method of control of the temperature of the solutions and wash tankers. R. B. Wilsey showed that there is a range for exposure and development time which results to the best radiograph and that outside of this range the quality is distinctly inferior. The degree of development depends not only upon the time that the film is in the developer but also upon the temperature of the latter. Variations in developer temperature can significantly affect image contrast, optical density and the visibility of recorded details. Therefore, developer temperature should not vary by more than ±0.5^{o}F (0.3^{o}C) from the manufacturers recommendations. Thus a density reached by 8.9mins development at 60^{o}F would also be reached by 5mins development at 65^{o}F, 4mins at 70^{o}F, 3mins at 75^{o}F and 2.2mins at 80^{o}F. Therefore, if uniform development is desired, the temperature of the solution must be measured and the development time estimated from this. If the temperature control is not automatic, constant attention must be paid to the details of development. Uniform development results in a better quality of radiograph and also permits and encourages a more uniform exposure technique [11, 14].

Other reasons why development should be carried out at 65^{o}F include; the swelling due to excessive temperature. This may give rise to a gravity appearance of the film and the softening makes the emulsion very susceptible to pressure and scratches.

Variation in developer time can have the same effect on image quality as solution temperature; therefore, developer time should be maintained to within ±2% to 3% of the manufacturer's specifications.

Also, the temperature of all the solutions should approximately be the same or the emulsion may be damaged when the film is transferred from one tank to another. Where temperature control is not employed, the temperature of the wash tank is especially apt to be considerably different from that of the other solution [3].

Water regulating the temperature of the solutions enters the darkroom from a conditioning tank. This is a large tank of about hundred gallons capacity containing two copper coils A and B, an inlet pipe at the top, and an outflow pipe extending down to the bottom. This tank is surrounded by a good heat insulating material such as cork [3].

X-ray cassettes play a central role in the X-ray processing medical imaging. An X-ray cassette is a flat, light-tight container in which X-ray films are placed from exposure to ionizing radiation and usually packed by lead to eliminate the effect of back scattered radiation [15]. Radiology x-ray cassettes are available in a wide variety of sizes to suit all body parts that require X-ray. Included in the medical X-ray cassettes are choices of the X-ray screen. Screen types are determined by the type of film being used and it aids in creating the best possible image. Hence, there is need to have a fully functional X-ray cassette to obtain the best dependable diagnostic images [2, 12].

For the purpose of this research we will determine the effects of safelight, white light, chemicals used for processing radiology films and time taken to process X-ray film in radiology darkroom. Also, the temperature of the processing solutions (Developer, Rinser, Fixer and Washer) will be determined at the same time.

2. Materials and Method

The following materials were used to study the effectiveness of the ruby light (safelight) and temperature of the manual processors on sensitized films in quality assessment of image quality at facility A and B; A filtered safelight (Red spectrum), a meter rule, a stop watch, a sheet of films by size 18 × 24cm with expiry dates of 08:2014 and 10:2014 respectively, a stool on which thee films were placed on at required intervals to avoid a change in distance from the safelight, a pair of scissors, a feed tray, film holders, a manual film processor consisting of; The developer, the rinser, the fixer and the washer. A peg or hanger, a marker or pen, and a nitrogen-filled thermometer

The nature of the method employed was such that the following variables were taken into consideration; Bromide drag and bromide flow (directional flow), location effect, time of day and variability, temperature of the solutions.

The sources of the data were gotten from the manual processor as employed predominantly at facility A and B.

The ruby light (safelight in the darkroom) was investigated by using it in the darkroom to expose sections of one and the same film for various periods of time interval.

A sheet of film 18 × 24cm was cut into five different parts say; A, B, C, D, and E using scissors. With the help of the meter rule, a distance of 0.05m (5cm) was measured from the safelight and position. Film A, B, C, D and E were each marked with their exposure time; 5, 10, 15, 20 and 25 seconds and fed into the tray. The films were exposed under the red safelight in the darkroom respectively

beginning with film E, to ensure that the time balance was maintained as it went down to 5 seconds. A sensitometric test was carried on the films exposed under safelight by processing all the sections of the films at the same processing time following the processing order [11].

With all the films hung on a peg, they were inverted at the same time into the developer for 5 minutes and then moved to the rinser 20 to 25 minutes and then to the fixer for 10 minutes and finally to the washer. The fixer process doubled development time at a bath temperature of 18°C to 25°C.

The temperatures of the manual processing solutions were measured at various periods of the day. Four (4) Nitrogen thermometers were partially immersed into four solution tanks (developer, rinser, fixer and washer tanks) at the same time for 3 minutes to allow the thermometric fluid stabilize before taking the reading [7]. Each of the reading were taken three (3) times and the average was obtained. The readings were recorded and compared with the standard specified for each model of the film used.

Temperature in °C was converted to °F by;

$$°F = °C \times 1.8 + 32°$$

The following table shows the different varieties of solution films and their specified temperatures

S/N	Solutions/Films	Made In	Model	Temperature Specified
1	Agfa	Belgium	Septestract 27 62640 mortsel	25°C/77°F
2	Kodak	Produzido U.S.A	Galilee 93192 Noisy Le Grand Cedex France	25°C/77°F
3	Unique	Belgium	1204521911	23^0C/73.4^{0}F
4	Begood	China	101250160	23^0C/73.4^{0}F.

Table 1: Different variety of solution films

3. Results and Discussions

The following tables show the results of the assessment from the two facilities investigated.

3.1. Facility A

Solution	Temperature (^{O}C)		Temperature (^{O}F)	
	Morning	Afternoon	Morning	Afternoon
Developer	26.0	29.0	78.8	84.2
Rinser	27.0	30.0	80.6	86.0
Fixer	26.0	29.0	78.8	84.2
Washers	27.0	30.0	80.6	86.0

Table 2: Temperature measurement of the solutions (Developer, Rinser, Fixer) for the two hospitals

3.2. Facility B

Solution	Temperature (^{O}C)		Temperature (^{O}F)	
	Morning	Afternoon	Morning	Afternoon
Developer	25.0	28.0	77.0	82.4
Rinser	24.5	27.5	76.1	81.5
Fixer	25.0	28.0	77.0	82.4
Washers	24.5	27.5	76.1	81.5

Table 3

From the experiment carried out on the temperature of the radiology solutions in the darkroom, it was found from the different ranges of temperature that; the film artifacts and fog increased with temperature and decreased in time for developing and fixing.

3.3. Safelight Assessment

3.3.1. Facility A

From the experimental proceedings, it was seen from the different sections of the film exposed under the safelight in the darkroom in their different exposure time that their contrast level decreased as the exposure time increase as shown below:

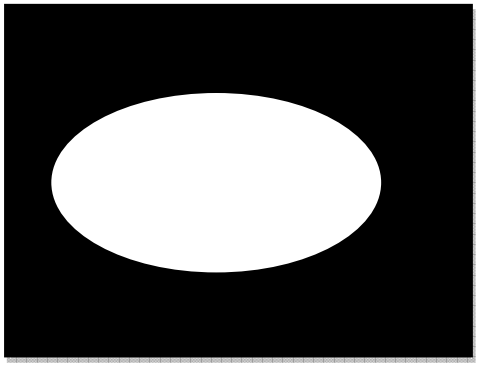

Figure 1: Film A at 5 seconds exposure time

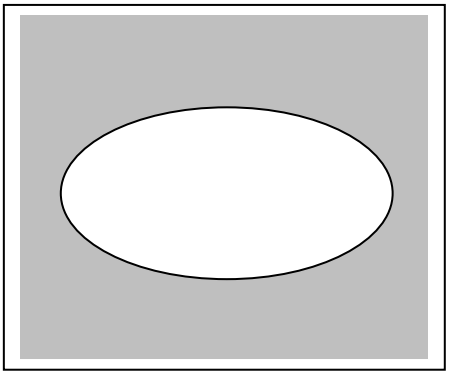

Figure 2: film B at 15 second exposure time

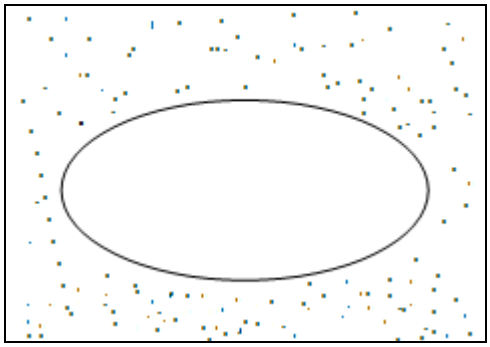

Figure 3: Film C at 20 seconds exposure time

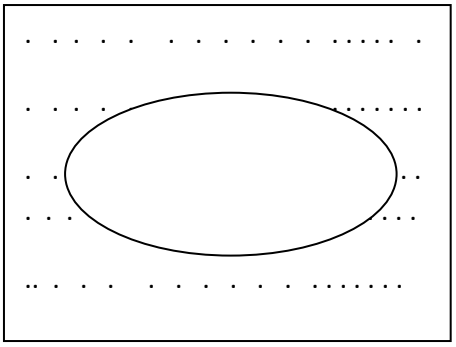

Figure 4: Film D at 25 seconds exposure time

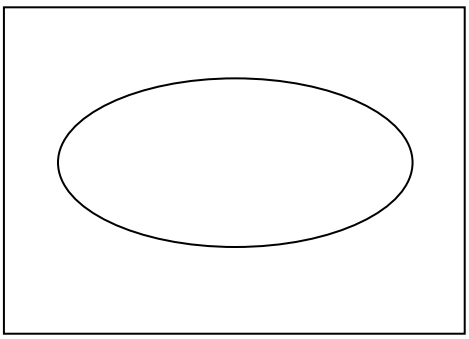

Figure 5: Film E at 30 seconds exposure time

3.3.2. Facility B

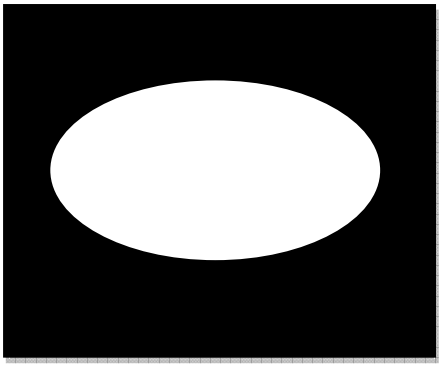

Figure 6: Film A at 5 seconds exposure time

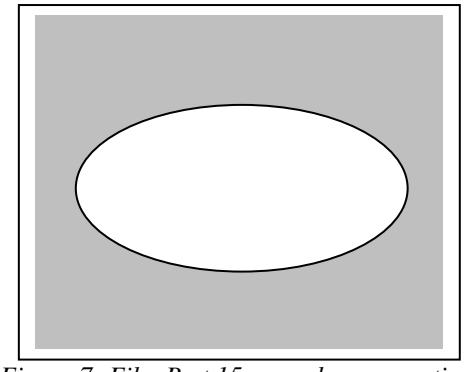

Figure 7: Film B at 15 second exposure time

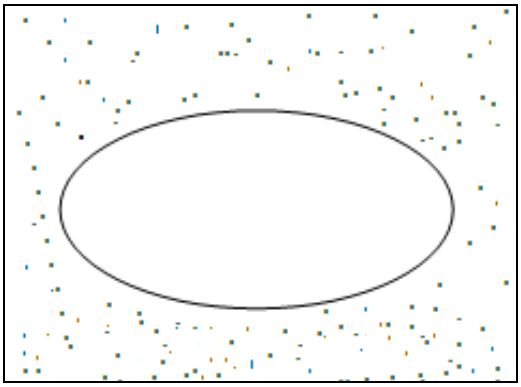

Figure 8: film C at 20 seconds exposure time

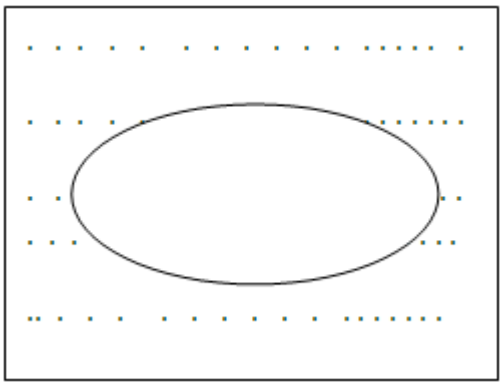

Figure 9: Film D at 25 seconds exposure time

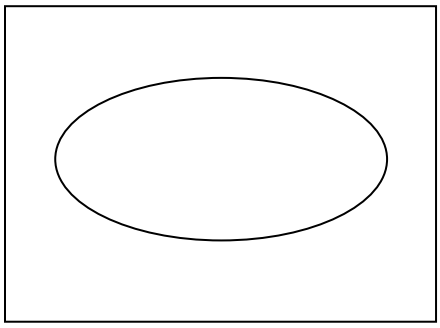

Figure 10: Film E at 30 seconds exposure time

4. Summary

The final investigation of red safelight in radiology darkroom has little but significant effect on unexposed film, the film should not be exposed for more than 15 seconds to safelight, before exposure, at a time above 15 seconds, the contrast of the film will be reduced to a level that the image will no longer be showing clearly, thus proper examination cannot be carried out by a radiographer, which might result in repeated exposure. The examination taken also shows that the safelights were installed at a distance of 1.3m from the working bench which is in line with the standard of international commission of radiation protect (1CRP) and National Council on Radiation Protection and measurements (NCRP) [6].

Again, it can also be seen from the results that the temperatures of the processing solutions were very high compared to the standard temperature specification of the films, and the standard temperature for processing solutions and the standard humidity of (40-60%) for storing films according to international Commission of Radiation Protection (ICRP) and National Council on Radiation Protection Measurements (NCRP) were not met.

This implies that, there is need for thorough quality control measure to be taken in both facility A and B radiology darkroom to stop or reduce unnecessary excess dose to patient. The humidity of film store should be noted as well as safelight filters, auxiliary indicator lights on processor, safelight housing, etc. to avoid fogs and artifacts resulting from the storage room.

5. Conclusion

This study has been conducted to assess and evaluate the effect of safelight of radiology darkroom and temperature of the processing tanks on the image produced, in order to reduce the excess dose to patient. Therefore, from the investigations it shows that unexposed film should not be exposed to safelight for more than 15 seconds.

From table 2 and 3, the data obtained in the investigation of temperature shows that, the processing tanks in Benue State University Teaching Hospital (BSUTH) Makurdi and Federal Medical Centre (FMC) Makurdi, were not within the standard recommendation by (ICRP) and (NCRP). This signifies that most of the exposure may not be in conformity with ICRP and NCRP standards.

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