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Implementation of the Theory of Terri L. Fauber on Various Tube Voltage (KV) and Current (mAs) on Radiographic Density

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ABSTRACT

Research has been conducted to determine the radiographic density value resulting from tube voltage variation (kV) and current time strength (mAs) with 15% rule. The method used in this research is descriptive method with direct experiment. The study used tubular (kV) and strong current time times (mAs) with a 15% rule of 60 kV 10 mAs, 51 kV 20 mAs, 69 kV 5 mAs, 80 kV 6 mAs, 68 kV 12 mAs and 92 kV 3 mAs . Instead of the object is a step wedge. The results of this study can be concluded that the density value with the use of 15% rule on radiography is no difference.

Keywords: Tube Voltage, Strong Flow and Exposure Time, Density, Rule 15%

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1. INTRODUCTION

In line with the development of science and technology in the field of health, technology in the field of radiology also experienced a drastic change. Beginning with the discovery of X-rays by German physicist Wilhelm Conrad Roentgen in 1895 [1]. The first object to be Roentgen's experiment was his wife's hand that was wearing a metal ring. But the first radiographic image produced by Roentgen certainly does not have the same qualities compared to the quality of the radiographs produced in today's sophisticated times. The quality of a radiograph is determined by the exposure factor setting. The exposure factor is a factor that determines the quality and quantity of X-ray radiation radiation required in the manufacture of radiography. The exposure factor is the factor that influences and determines the quality and quantity of X-ray radiation radiation required in the manufacture of radiography [7].

Exposure factors are divided into two parts, namely the main factor and factors that affect the system characteristics of radiography. According to Bushong (245-250) [4], the main factors affecting the quality and quantity of X-rays are kVp (kilovolt peak) or kV, mA (milli Ampere), s (second), and distance (FFD) while influencing factors on radiographic characteristic system ie focal spot size, filter use, high level generator. In addition there are several other factors that also affect the formation of radiography, the collimation, the use of grids, the use of a combination of screen film and film prosessing [6].

Giving exposure factor to get certain density value is used some variation choice such as tube voltage variation (kV), milliampere times second (mAs), FFD (focus film distance), filter usage, radiation field (collimation) and grid usage. Another literature is also found a rule of exposure value variation known as the 15% rule, which states that if kV is increased by 15% to produce the same density on the radiograph then mAs is halved whereas if kV is decreased by 15% to produce the same density on radiography then mAs duplicated [5].

The use of this 15% rule is to maintain the same density value on a radio. Kilovolt (kV) not only affects the density but also other aspects of the radiograph. So kilovolt (kV) is not a major factor in manipulating radiography in density changes. However, it is sometimes necessary to manipulate kilovolt (kV) to maintain or adjust the density [10]. Maintaining or adjusting radiographic density can be achieved using the 15% rule. The 15% rule is a rule that states that if kV is raised by 15% to produce the same density on the radiograph then mAs is halved whereas if kV is decreased by 15% to produce the same density on radiography then mAs is doubled.

The change in tube voltage is the preferred method to change the desired density of the image, as a result by using the 15% rule will always change the contrast of the image. Then formulated as follows by increasing kV by 15% then mAs decreased by half. If the kV decreases by 15% then the mAs is doubled. The effects of changes in kV are not uniform across the kV range. When low or high kV is used, the amount of kV change necessary to maintain the density may be more or less than 15% [5]. To meet the high quality of the radiograph image, a radiograph must meet several aspects to be assessed on a radiograph that is density, contrast, sharpness and detai [8].

A. Density

Density is the degree of blackness in the film. The result of the exposure of the film after being processed produces a blackening effect because it corresponds to the emulsion nature of the film which will darken when exposed. This degree of blackness depends on the level of exposure received in both kV and mAs. This density can be measured so that the density itself will have a value. The highest density that can be generated is 4 and the lowest density value starts from 0.2. While the value of density that can be seen with ordinary eye ranged between 0.25-2 [8]. Density on radiography is defined as follows:

$$D = \log \frac{I_0}{I_1}$$

description:

d = density

Io= rays leading to the film

It = rays passed to the film

B. Contrast

Contrast is the difference in density between two points. a radiograph has a good contrast if it can be distinguished between parts of one another. according to nova rahman [8] film contrast is the contrast produced due to the nature of the film. every movie produced by a company has its own character. There are films that have characters with high film response to exposure by either X-rays or visible light. The film response to this exposure will affect the resulting density value. Films that are highly responsive to exposure will produce higher densities when compared to films that are less responsive to exposure. The radiographic contrast is formulated as follows:

$$C = D_2 - D_1$$

Description:

C = contrast

D2 = Density at Region

D1 = Density at Region 1

C. Sharpness

Sharpness notices how the density changes on the boundary between adjacent areas. The boundary between the two areas that appear can be very sharp, this is because there is a drastic change in the value of density at that limit. The higher the contrast value the sharper the resulting image [9]. The irregularities of the radiograph are influenced by several factors, namely geometric factors, movement factors, and photographic effects consisting of Intensifying screen and parallax.

D. Details

Detail is the ability to show the sharpness and the smallest structures on a radiograph. In a radiographic examination, there is a portion of the picture that has a very small but very important structure in diagnosis. Factors that affect the details of the size of focal spot size, FFD (Focus Film Distance) and OFD (Object Film Distance) [3-2]. In hospitals the application of this 15% rule is very rare. Most use of exposure factors is limited only to the provisions contained in the aircraft control panel or solely forecast by Radiogafer. From the research conducted on the implementation of Terri L. Fauber's theory on tube voltage variation (kV) and strong time-current (mAs) to radiographic density, it was found that density value with the use of 15% rule on radiography was no difference.

2. MATERIALS AND METHODS

The research equipment used in this research is x-ray planes, step wedge, Radiographic Cassettes, Automatic Processing, densitometer. In doing this research, the researcher used Fuji film as much as 3 sheets measuring 24x30 cm with step wedge as the object exposed with tube voltage (kV) and different current time time (mAs) that is 60 kV 10 mAs, 51 kV 20 mAs, 69 kV 5 mAs, 80 kV 6 mAs, 68 kV 12 mAs and 92 kV 3 mAs with the same FFD usage at each exposure of 100 cm. After the film is exposed then it is processed through processing automatic. 3 pieces of film consisting of 6 samples that have been processed then measured the value of each density by using a densitometer tool from step 1 to step 11 on the film.

Data processing is done by making table and comparison graph from result of calculation of difference of density value which result from different exposure factor. To support the discussion then used the application of SPSS or Statistical Product and Service Solutions and the method of sensitometry with analysis of the characteristic curve using Microsoft Office Excel program. This research is done in accordance with the scheme of the research flow below.

3. RESULT

From result of measurement done by researcher then obtained result of measurement from population 1 for density value from sample 1 by using kV and mAs base that is 60 kV and 10 mAs as in table 1.

Table 1. Results of measurement of density values from sample 1.

STEP	Density				Fog Level
	1	2	3	Average	
1	0,67	0,65	0,70	0,67	0,41
2	0,87	0,86	0,92	0,88	0,41
3	1,23	1,22	1,26	1,23	0,41
4	1,65	1,65	1,68	1,66	0,41
5	2,05	2,04	2,02	2,03	0,41
6	2,32	2,33	2,29	2,31	0,41
7	2,45	2,46	2,44	2,45	0,41
8	2,51	2,51	2,51	2,51	0,41
9	2,54	2,54	2,54	2,54	0,41
10	2,54	2,55	2,55	2,54	0,41
11	2,54	2,55	2,54	2,54	0,41
Mean $\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$				1,94	
Basic deviation $S_n = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$				0,716	

The contrast value in each sample can be obtained by using the formula :

$$C = Dmax - Dmin$$

Thus, the contrast value for sample 1 with the use of 60 kV and 10 mAs was 1.87 For sample 2 in population 1 with a decrease of kV 15% and mAs doubled ie 51 kV and 20 mAs obtained by measurement results according to table 2.

Table 2. Results of measurement of density values from sample 2.

STEP	Density				Fog Level
	1	2	3	Average	
1	0,47	0,46	0,47	0,47	0,40
2	0,63	0,63	0,64	0,63	0,40
3	0,98	0,98	0,99	0,98	0,40
4	1,52	1,54	1,54	1,53	0,40
5	2,09	2,11	2,09	2,09	0,40
6	2,27	2,26	2,27	2,27	0,40
7	2,36	2,36	2,37	2,36	0,40
8	2,41	2,42	2,41	2,41	0,40
9	2,51	2,52	2,52	2,51	0,40
10	2,54	2,55	2,54	2,54	0,40
11	2,55	2,55	2,55	2,55	0,40
Mean $\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$				1,84	
Basic deviation $S_n = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$				0,803	

From the above measurement results obtained the contrast of the sample 2 of 2.08 For sample 3 with a 15% increase in kV and a reduction in mAs ½ of 69 kV and 5 mAs obtained by measurement results according to Table 3.

Table 3. Results of measurement of density values of sample 3.

STEP	Density				Fog Level
	1	2	3	Average	
1	1,39	1,39	1,36	1,38	0,35
2	1,73	1,73	1,70	1,72	0,35
3	2,01	2,03	2,02	2,02	0,35
4	2,24	2,25	2,24	2,24	0,35
5	2,38	2,39	2,39	2,38	0,35
6	2,46	2,48	2,48	2,47	0,35
7	2,52	2,53	2,53	2,52	0,35
8	2,55	2,55	2,55	2,55	0,35
9	2,56	2,56	2,56	2,56	0,35
10	2,57	2,57	2,56	2,57	0,35
11	2,57	2,57	2,57	2,57	0,35
Mean $\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$				2,27	
Basic deviation $S_n = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$				0,401	

From table 3 we get contrast value equal to 1,19. Here is a graph of the average density measurement results of samples 1, 2 and 3 ie

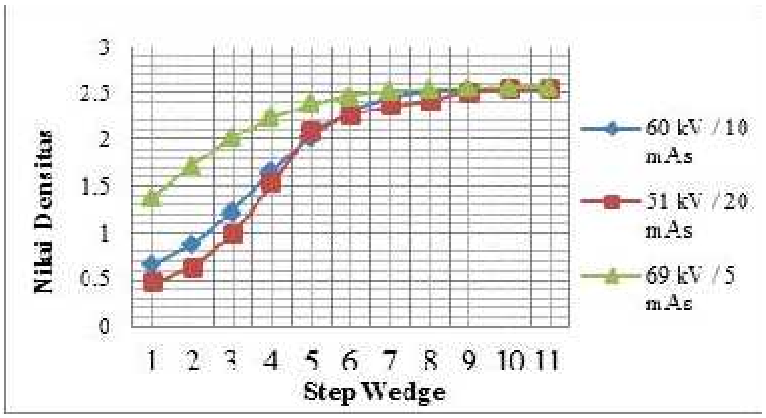

Fig 1. Graph of Radiographic Density of Population 1

For the result of measurement from population 2 obtained table as follows.

Table 4. The result of measurement of density value from sample 4 by using kV and base mAs is 80 kV and 6 mAs.

STEP	Density				Fog Level
	1	2	3	Average	
1	2,49	2,49	2,48	2,48	0,50
2	2,56	2,57	2,56	2,56	0,50
3	2,60	2,60	2,60	2,60	0,50
4	2,63	2,63	2,63	2,63	0,50
5	2,64	2,64	2,64	2,64	0,50
6	2,64	2,64	2,65	2,64	0,50
7	2,65	2,65	2,65	2,65	0,50
8	2,65	2,65	2,65	2,65	0,50
9	2,66	2,66	2,66	2,66	0,50
10	2,66	2,66	2,66	2,66	0,50
11	2,66	2,67	2,67	2,67	0,50
Mean $\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$				2,62	
Basic deviation $S_n = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$				0,056	

From table 4 in population 2 obtained a contrast value of 0.19.

Table 5. Results of measurement of density values from sample 5 with decreased kV 15% and mAs duplicated ie 68 kV and 12 mAs

STEP	Density				Fog Level
	1	2	3	Average	
1	2,30	2,32	2,31	2,31	0,35
2	2,45	2,46	2,45	2,45	0,35
3	2,54	2,55	2,55	2,54	0,35
4	2,60	2,60	2,60	2,60	0,35
5	2,62	2,62	2,62	2,62	0,35
6	2,64	2,63	2,64	2,63	0,35
7	2,65	2,64	2,65	2,64	0,35
8	2,65	2,64	2,65	2,64	0,35
9	2,65	2,65	2,65	2,65	0,35
10	2,66	2,65	2,65	2,65	0,35
11	2,65	2,66	2,66	2,65	0,35
Mean $\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$				2,58	
Basic deviation $S_n = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$				0,108	

Table 6. The result of measuring the density value of sample 6 with a 15% increase in KV and a reduction of ½ mAs of 92 kV and 3 mAs

STEP	Density				Fog Level
	1	2	3	Average	
1	2,58	2,59	2,59	2,58	0,84
2	2,62	2,63	2,62	2,62	0,84
3	2,65	2,64	2,65	2,64	0,84
4	2,65	2,65	2,65	2,65	0,84
5	2,66	2,65	2,65	2,65	0,84
6	2,66	2,66	2,66	2,66	0,84
7	2,66	2,66	2,66	2,66	0,84
8	2,67	2,67	2,66	2,67	0,84
9	2,67	2,67	2,67	2,67	0,84
10	2,67	2,67	2,67	2,67	0,84
11	2,67	2,67	2,67	2,67	0,84
Mean $\bar{X} = \frac{\sum_{i=1}^{n} X}{n}$				2,64	
Basic deviation $S_x = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$				0,027	

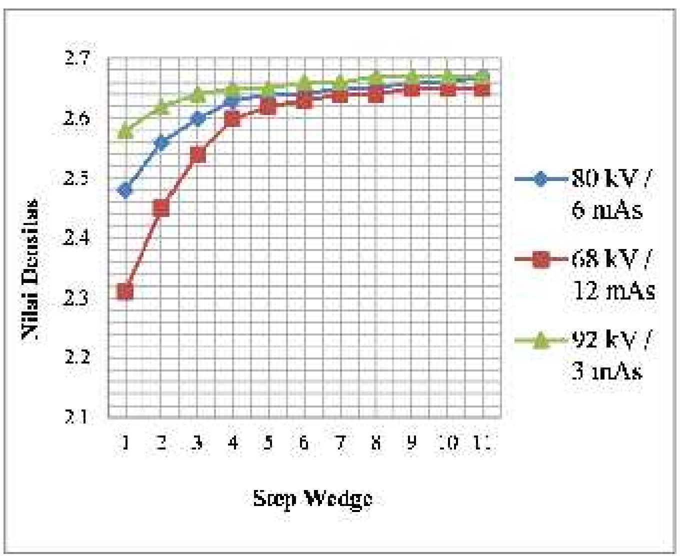

Fig. 2. Graph of Radiographic Density of Population 2

The contrasting value of sample 5 with the use of 68 kV and 12 mAs was 0.34. The contrast value of sample 6 with the use of 92 kV and 3 mAs was 0.09. Here is a graph of the average density measurements of each sample of 4.5, and 6 ie.

An overview of the tables and curves of samples 1,2 and 3 in population 1 shows a slight difference in the resulting density values. So to ensure there is no significant difference then the researchers conducted a statistical test on the density value of 3 samples in the population 1. First of all researchers test the data normality that aims to determine the type of statistical tests to be used next. Normality test using Shapiro-wilk test because sample less than (<) 50. After normality test is done significant value <0,05 so that data is not normally distributed. then the researchers do the next statistical test Kruskall-Wallis H test to see the difference in the density value of the 3 samples. After testing the significant value is 0.240. Because the significance value> 0,05 then it is concluded that the three data there is no difference.

In the table and curve of samples 4, 5 and 6 for population 2, there was no significant difference in density value, no statistical tests were required and it was concluded that there were no differences between the films exposed to both basic kV and mAs using the 15% rule. So the relationship of high use of tube voltage (kV) with contrast value is concluded that the higher the use of kV, the higher the density value produced while the lower the contrast.

4. CONCLUSION

Based on the observations made by the testers it can be concluded that there is no difference in the average density generated, either by the film exposed by using tube voltage (kV) and the strong base time current (mAs) or using the tube voltage (kV) and the current strength time (mAs) 15% rule. This means that the resulting density is the same. High kV usage will result in higher density value while the contrast value is lower.

REFERENCES

[1] Akhadi, Mukhlis. 2001. *Pengantar Dasar-dasar Proteksi Radiasi.* Jakarta:Rineka Cipta.

[2] Sunyoto, Danang., (2012). Statistik Kesehatan, (**1**). Yogjakarta:Nuha Medika.

[3] Bushong, S. Carlyle., (2008). Radiologic Science for Technologist, (**9**). Canada:Mosby Elsevier.

[4] Meredith, W. J. dan Massey, J. B., (1977). Fundamental Physics of Radiology, Bristol:John Wright and So ns Ltd.

[5] Fauber, Terri L., (2000). Radiographic Imaging and Exposure. Toronto:Mosby Elsevier.

[6] Sartinah, dkk. (2008). Jurnal Berkala Fisika Volume 11, No.2, Hal 45-52, tersedia pada http://eprints.undip.ac.id/2293 diakses 21 April 2018 pukul 10.30.

[7] Rahman, Nova, (2009). Radiofotografi. Padang:Universitas Baiturrahmah

[8] Fridawanty, Astuty, (2012). Jurnal Variasi Pemilihan Faktor Expose terhadap Kontras pada Teknik Radiografi

Jaringan Lunak, tersedia pada http://repository.unhas.ac.id/ diakses 25 April 2018 Pukul 14.10

[9] Bushong, S. Carlyle., (2001). Radiologic Science for Technologist, (**7**). Toronto:Mosby Company

[10] Ballinger, P. W dan Frank, E. D., (2003). Merril’s Atlas Of Radiographic Positions and Radiologic Procedures, Volume I : 10. USA:Mosby.