Majority Science Journal (MSJ) Vol. 1 No. 4, Desember 2023
P-ISSN: 0000-0000; E-ISSN: 3025-1990
Available : https://jurnalhafasy.com/index.php/msj DOI: 10.61942/msj.v1i4.50

LINEARITY TEST ANALYSIS OF AIRCRAFT RADIATION OUTPUT X-RAY FLUOROSCOPY

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Abstract
The number or intensity of X-ray photons produced correlates with the increase in tube current per time (mAs), which affects the image density on the final film. To ensure the consistency of the increase in X-ray radiation output and the Linear Coefficient of X-ray radiation output, is within the tolerance limits specified in PERKA BAPETEN Regulation Number 9 of 2011. The aim of this research is to determine the linearity of the X-ray Fluoroscopy radiation output in one of the houses. Jakarta sick. The method used is an experimental approach with a quantitative model. Measurement of radiation output using a PM1610 Personal Dosimeter on a Fluoroscopy aircraft. The results of measuring the linearity of X-ray radiation output with voltage variations of 40 kV, 50 kV, 60 kV, 70 kV show that the value of the Linearity Coefficient (CL) is (0.08 ; 0.06 ; 0.09 ; 0.07). So it can be said that the X-Ray Fluoroscopy equipment is in good condition because the CL value obtained in this study is below the Tolerance Limit Value according to PERKA BAPETEN Number 9 of 2011, namely CL ≤ 0.1 or ≤10%. This research can be carried out as a reference in further research.

Keywords : *Linearity, Radiation Output, X-Rays, Fluoroscopy*

1. Introduction

Wilhelm Conrad Roentgen discovered X-rays in 1895. Apart from being used in everyday life, X-rays can still be used for radiodiagnosis, radiotherapy and medical research. X-ray fluoroscopy is a type of X-ray used in the medical world (Anggraeni, 2020). The peak tube voltage (kVp) affects the radiation dose released in irradiation, and its magnitude depends on the patient to be examined. However, fluoroscopy operations use a small current of no more than 50 mAs (Indah, et al., 2023).

The number or intensity of X-ray photons produced correlates with the increase in tube current per time (mAs), which affects the image density on the final film. To ensure consistent increase in X-ray radiation output and Linear Coefficient of X-ray radiation output, it is within the tolerance limits specified in PERKA BAPETEN Regulation Number 9 of 2011 (Dewilza, et al., 2023). Output on the Fluoroscopy Plane. The X-ray beam will penetrate parts of the body and be captured by film. Before an X-ray aircraft can be operated, parameters must be set to obtain the desired X-rays. Voltage (kV), tube current (mA), and exposure time (s) are some parameters that can be changed on an X-ray aircraft to reduce scattered radiation and reduce the radiodiagnostic dose used (Akhadi, 2020). In an experimental setup, dosimetric measurements are used directly to determine the contrast in X-ray tube voltage. (Wiharja, et al., 2019).

According to Wiharaja and Bahar (2019), the measured dose is in units of µSv/mAs, if using the mA variation, then use the following equation:

$$\mu Sv / mAs = \frac{\mu Sv}{mA \cdot s} \quad (1)$$

To find out the value of the linearity coefficient, use the following equation:

$$CL = \frac{X1 - X2}{X1 + X2} \quad (2)$$

Substitute equation (1) into equation (2), so it becomes:

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$$CL = \frac{\left(\mu Sv/_{mAs}\right)\max - \left(\mu Sv/_{mAs}\right)\min}{\left(\mu Sv/_{mAs}\right)\max + \left(\mu Sv/_{mAs}\right)\min} \quad (3)$$

To minimize unnecessary patient exposure and maintain the facility's overall quality assurance program, compliance testing is an important part of the diagnostic radiology quality assurance program. This guarantees correct results and correct operation of radiology equipment (Hidayah, 2021). Transportable units The X-ray system and its subsystems form a portable X-ray radiography machine. Due to its simple mobility design, the device is suitable for intensive mobility scenarios such as bedside and emergency room scanning. The equipment consists of an X-ray tube, collimator, control panel, high voltage generator, and tube support pole. To ensure the safety of the tube, the tube support pole supports it and allows position adjustment. For reliable and safe operation, each component must be calibrated and maintained periodically (Hyperastuty, et al., 2021).

It is important to monitor the use of X-ray equipment and assist installation owners in improving radiation safety. Interlock system, tube housing leakage, maximum radiation dose rate, collimation quality, illumination reproducibility, and illumination warning indications are some of the test parameters. New X-ray aircraft, aircraft with modified technical requirements, and aircraft with expired certification are all subject to testing. Quality control, including collimation tube testing, is needed to guarantee the safety and quality of radiodiagnostic services within the validity period of the certificate (Nurchyo and Aryani, 2023).

The purpose of this test is to determine the linearity of the radiation output so that it can be ensured that the equipment used in the hospital can determine the radiation output used so that the radiographer can monitor the radiation output on the X-ray equipment used for patient examinations. If the dose used does not match the size of the voltage and current used in the device then this is considered to be a mismatch between the voltage and current in the dose coming out of the X-ray. One of the control tests recommended in MENKES No. 1250 of 2009 is the X-Ray Radiation Output Linearity Test which aims for radiography aircraft or X-ray machines, radiation output linearity is an important feature that ensures consistent radiation output from the combination of mA and exposure duration. different. A machine must be capable of producing an amount of radiation that is proportional to changes in configuration parameters, including duration of exposure and current (mA). The operator-defined exposure duration and current are included in the exposure factor on the control panel. Equipment performance testing or suitability testing is used to assess the linearity of an X-ray machine. This testing involves operating the unit at different current levels and exposure durations while measuring the radiation output. The machine meets the radiation output linearity performance standard if the findings are consistent with expectations and show strong linearity (Rani, 2020). Researchers have conducted research to determine the linearity of X-ray radiation output in hospitals; This is important to ensure the consistency and accuracy of the radiation dose given to the patient. The term "linearity" refers to the ability of an X-ray system to emit radiation with a desired level of accuracy according to established specifications. The aim of this research is to demonstrate linearity of radiation output by seeing how far the system maintains a tolerance of no more than ten percent for each pair of exposure times with predetermined specifications. This can help ensure that X-rays are used in hospitals

2. Method

The research method used in this research is the Qualitative Method using an Experimental Approach. The linearity test was carried out based on Health Service Regulation No. 1250 of 2009. The X-ray aircraft used in this discussion is the Platinum dRf brand X-ray Fluoroscopy aircraft made by Francis which is located in the Radiology

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Installation of a Hospital in Jakarta. This research was carried out using the X-Ray Radiation Output Linearity test parameters using the PM1610 Personal Dosimeter.

3. Result and Discussion

Measurements were carried out using various variations of mAs for each specified voltage, namely 10 mAs, 12.5 mAs, 20 mAs, 25 mAs, 32 mAs at voltage settings of 40 kV, 50 kV, 60 kV and 70 kV with a focus distance to the detector (Focus Film Distance) Personal Dosimeter is 110 cm, the area of the illumination area is adjusted to the size of the PM1610 Personal Dosimeter.

One of the most important concepts in radiography and exposure settings in X-ray equipment is the milliampere-second, or mAs. It describes the total amount of electric charge flowing through the tube during a certain exposure period by combining current strength and exposure time. Radiation production increases as the mAs value increases, improving image brightness and diagnosis quality. The mAs setting is a common tool used by radiography operators to limit patient radiation exposure. For further control over radiation dose and image features, certain X-ray machines provide the ability to modify mA either alone or in combination with other parameters. Each measurement was carried out once for each condition. The use of large currents and voltages will increase the radiation received by the patient (Aizah, 2023). Vice versa, the use of low current will reduce the radiation dose to the patient (Irsal, et al., 2023). The high use of voltage will have an impact on the examination results, including a lack of contrast in the examination results (Khoirot, et al., 2023); (Yufita and Safitri, 2023).The results of the measurements carried out are as in Table 1.

Table 1. X-ray radiation output measurement results

No	Voltage (kV)	Load (mAs)	Radiation output (µSv/jam)	$\frac{\mu Sv / Jam}{mAs}$	CL	Test Pass Value (CL)
1	40	10	2,565	0,2565	0,08	≤ 0,1
		12,5	3,256	0,2605		
		20	4,831	0,2416		
		25	5,565	0,2226		
		32	7,575	0,2367		
2	50	10	3,562	0,3562	0,06	
		12,5	4,573	0,3658		
		20	7,575	0,3787		
		25	10,100	0,4040		
		32	12,184	0,3808		
3	60	10	4,536	0,4536	0,09	
		12,5	6,008	0,4807		
		20	8,565	0,4282		
		25	10,007	0,4003		
		32	15,237	0,4762		
4	70	10	5,575	0,5575	0,07	
		12,5	7,583	0,6066		
		20	10,464	0,5232		
		25	14,476	0,5790		
		32	18,573	0,5804		

Based on Table 1, measuring the linearity of X-ray radiation output with voltage variations of 40 kV, 50 kV, 60 kV, 70 kV, it is known that the value of the Linearity Coefficient (CL) is (0.08 ; 0.06 ; 0.09 ; 0.07). In the results obtained, it can be seen that the Linearity Coefficient value is below the Tolerance Limit Value according to PERKA BAPETEN Number 9 of 2011, namely CL ≤ 0.1 or ≤10%, meaning that the DR-Fluoroscopy X-ray aircraft tool is in good condition, this occurs due to There is a stabilizer that controls the entry of electric current into the X-ray aircraft so that the Linear Coefficient value is ≤ 0.1.

The amount of radiation that comes out also has a big impact on the patient. One of them is cancer. After long latency times, stochastic effects occur randomly and are influenced by radiation exposure. These effects can occur at any exposure level and are not considered to have a threshold dose. Radiation exposure can alter biological systems at the molecular and cellular level, regardless of dose. The number of doses taken and the degree of effect are factors that are not related to stochastic effects. If cells change, the resulting qualities will be inherited or have a genetic impact on offspring. As x-ray examinations for medical purposes increase, the dose received by patients also increases (Surachman, 2021).

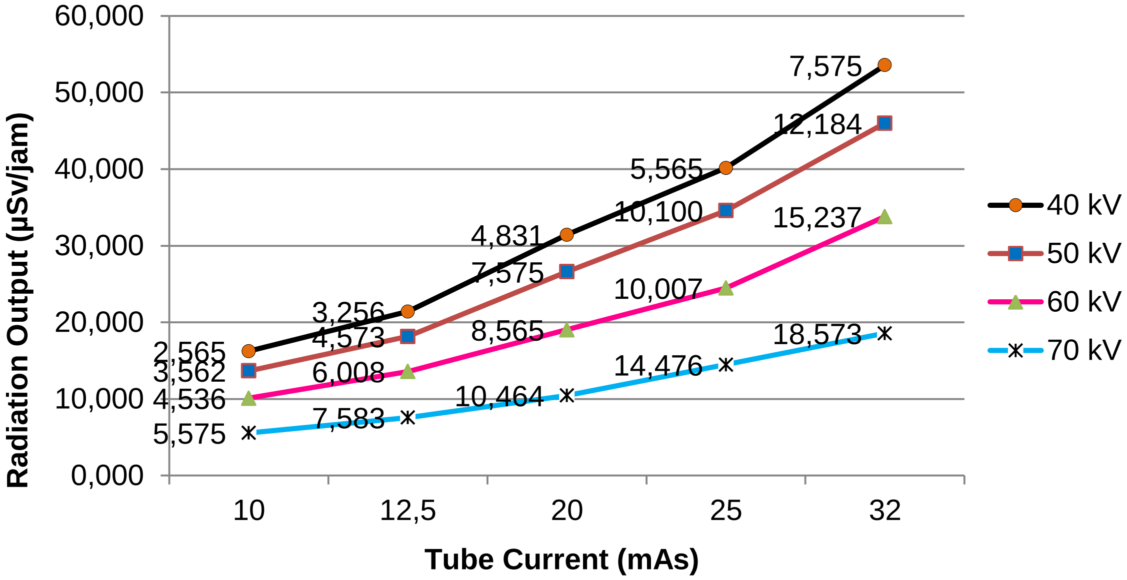

Figure 1. Graph of the Relationship between X-Ray Radiation Output

Figure 1 shows that the X-ray radiation output value experiences linearity according to the use of Voltage and Current on the Control and Monitor panels. Linearity of radiation output is one of the test activities included in Quality Control on x-ray aircraft. To ensure whether the data you have corresponds to a linear line or not. This test uses several variations of mAs for each specified voltage value (Indah, et al., 2023). The influence of the wavelength of electromagnetic photons on their penetrating power through matter is influenced by kVp, which means that the X-ray energy produced is greater when the wavelength is smaller (Akhadi, 2020).

The resulting radiation intensity increases and is proportional to the increase in the value of the current used, the resulting radiation intensity value doubles from the initial state. The mAs value is directly related to the X-ray intensity, when mAs is increased the number of electrons emitted and fired at the target increases so that the X-ray emission also increases. This is in accordance with research conducted by Faesol and Utomo (2017); Nramdiani, et al (2021). The milliampere-second (mA) value is directly proportional to the X-ray intensity. The effect of increasing the milliampere-second (mA) value has an impact on the number of electrons produced by the filament. The higher the milliampere value, the more electrons the X-rays will produce.

4. Conclusions

From the research conducted with voltage variations of 40 kV, 50 kV, 60 kV, 70 kV, the Linearity Coefficient (CL) value was obtained, namely (0.08; 0.06; 0.09; 0.07) ≤ 0.1 or ≤10%. Where these results are below the Tolerance Limit Value according to PERKA BAPETEN Number 9 of 2011. So that the DR-Fluoroscopy X-ray aircraft is in good condition and can be used for examination of patients, so that this research can be used as a reference material for further research.

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