Determination of Half Value Layer (HVL) Value on X-Rays Radiography with using Aluminum, Copper and Lead (Al, Cu, and Sn) Attenuators

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Abstract. Half Value Layer (HVL) has done on X-rays using Aluminum (Al), Copper (Cu) and Tin (Sn) at University Hospital of North Sumatera. The method used is based on BAPETEN Regulation No. 09 of 2011 and Standard Western Australia. From the results of research conducted on X-ray plane obtained the result of measurement of Half Value Layer (HVL) value by using Aluminum (Al) at 50 kVp - 90 kVp, with strong current of 20 mAs, obtained HVL thickness on Aluminum 50 kVp = 3.0 mm Al, 60 kVp = 4.0 mm Al, 70 kVp = 5.0 mm Al, 81 kVp = 5.6 mm Al and 90 kVp = 6.1 mm Al. By using Copper (Cu) at a voltage of 50 kVp = 0.05 mm Cu, 60 kVp = 0.15 mm Cu, 70 kVp = 0.2 mm Cu, 81 kVp = 0.3 mm Cu and 90 kVp = 0.3 mm Cu. By using Tin (Sn) at a voltage of 50 kVp = 0.05 mm Sn, 60 kVp = 0.05 mm Sn, 70 kVp = 0.05 mm Sn, 81 kVp = 0.05 mm Sn and 90 kVp = 0.05 mm Sn. From the results of this study found that of the three types of attenuator, the best as an attenuator for Half Value layer (HVL) for X-ray plane is Aluminum (Al) and Copper (Cu). For Tin type Attenuator (Sn) is not suitable as an attenuator to measure HVL on an X-ray plane at a voltage of 50 kVp - 90 kVp.

1. Introduction

Applications of nuclear technology have been widely used in life, one of them in the field of health or medical in the radiology. The Radiology Service Unit is one of the supporting medical installations, using ionizing radiation sources to diagnose the presence a disease in the form of anatomical features displayed in the radiographic film. Radiology services should pay attention to radiation safety aspects. In a controlling effort, the Government has issued Government Regulation No. 33 of 2007 on the Safety of Ionizing Radiation and Security of radioactive sources, The Decree of the Head of Bapeten No. 01 / Ka-Bapeten / V-99 on Health against ionizing radiation is called radiation safety, which contains dose limits of radiation workers < 50 mSv/year and general public < 5 mSv/year [1]. Installation of Radiology in hospitals require some main room: room inspection, the operator spaces, sanitary spaces, dark room, a reading room and space planning of the dose. A good examination of spaces for the safety of the patient, employees, and the public in General [2].

Radiography X-ray or plane X-ray is a tool used to perform a medical diagnosis by using X-rays. X-rays emitted from the tube is directed at the body parts that will been diagnosed. The X-ray beam
will penetrate the body and will be captured by the film, so will form the image of a body part that is illuminated. Before the plane X-ray parameter settings need to be done to get X-rays that are desired. These parameters are voltage (kV), tube current (mA) and the time of exposure (s) [3].

Tube voltage on the X-ray is one of the factors that can be controlled by the radio diagnostic [4]. The increase in the value of the voltage of the X-ray tube should be offset by a decline in the value of the flow tube X-ray generator and time radiation intensity shines so that produced enough shadow density. Determination of tube voltage plane contrast X-rays done by measurement of dosimetric implemented directly in an experimental setting [5].

Tube current and time is a very mutually bound in determining the intensity of the X-rays emitted into the patient's body so that it will form the image of the organs.

Previous research Wadianto et al. [6] has been doing high-voltage accuracy test tools Mobile Radiography X-rays to find out the value of deviations in voltage tubes (kVp) is still within the tolerances set out in. 9 of the year 2011. The method is undertaken by measuring the voltage of the tube using a Detector Piranha 556 and measuring the distance between the X-ray tube into the detector NiO-32 G-5019 with reference on PERKA BAPETEN NO. 9 of the year 2011. The test results are then analyzed so that at the conclusion of the performance. Trikasjono et al. [7] have been doing analysis of plane beam radiation safety - X in radiology unit RSU Yogyakarta Where the purpose to know the dose of radiation of radiation workers and surrounding communities, by comparison between the thick radiation beam calculation theoretically against the thick radiation beam in the Unit of measurement of radiation dose in radiology and in the area of radiation workers and the surrounding communities.

Suryanto and Sigit [8] have performed an analysis of the image-forming and the limits of tolerance conformance test of plane X-ray diagnostics. In the formation of image on plane X-ray translucent capability is from X-rays to the materials. Now the goal is how to process an image on the film that is formed by the X-rays so that it can be understood the difference in form of pictures on the part of the body that is illuminated. Factors that affect image radiography, among others, the magnitude of the mA, focal distance with film (FFD) and voltage (kV). The increase in the mAs will be followed by a large number of Electrons produced and affect the number of X-ray photons are generated or in other words mAs related to quantity or intensity of the X-rays are produced. The quantity of X-rays will affect density (degree of blackish) picture on the resulting film. The higher the mA is used, it will be increasingly higher density was generated [9].

This research was conducted HVL value is usually determined its minimum value by a regulator body and must be checked periodically. In Indonesia the Decree of the Minister of Health of the Republic of Indonesia number 1250, 2009 on the Guidance of Quality Control of Radiodiagnostic Equipment has been issued. One of the parameters specified in the Minister of Health Decree is the HVL value. In the Minister Decree of Health explained that at a voltage of 80 kVp, HVL value ≥ 2.3 mmAl [10]. The same value is also stated in Regulation of Head of BAPETEN. 9 Year 2011 [11]. HVL values usually increase with an increase in X-ray tube voltage. The HVL value should not be lower than that stated by the regulator. HVL values are too low, causing X-rays not to penetrate the body so be useful in imaging, but provide a large dose on the body. The HVL value should be measured as soon as possible. There are many methods for determine HVL value. The general method is to use several Al plates produce a varied thickness then fired X-rays. From Al thickness variation, it can be known that the thickness yields half dose when compared using the filter at all.

2. Experimental Method
This research was conducted at Hospital of University of North Sumatera (RS.USU), in Radiology section by using 1 (one) unit of X-ray plane that is Philips Public Radiography. Specifications of X-ray plane: Frequency 50/60 Hz, 200 mA current, operational voltage 50kVp-90 kV, and 0.1 second operational time. The X-ray meter used the Piranha brand, calibrated on April 2016. In this study the focus distance to the detector is 100 cm, the field area is 10 x 10 cm² and the current time is 20 mAs. Using voltage variation and filter thickness variation by using Al (Aluminum), Cu (Copper) and Sn
Method of measuring HVL value using attenuator, used voltage that is 50 kVp, 60 kVp, 70 kVp, 81 kVp, 90 kVp. The attenuator variation for each stress is performed 4 times for Al (aluminum) from 1.0 mm to 6.0 mm Al, 4 times for Cu (Copper) 0.05 mmCu to 0.2 mmCu, 1 time for Sn (Tin) is 0.05 mm Sn. Each variation of the attenuator is exposed to determine the dose detected by the detector. After obtaining dose data for variation of attenuator thickness, then calculated HVL value by using interpolation formula and graph. The interpolation method is calculated based at the graphical method used with the Origin 8.5 software. Furthermore, the HVL value of the result and using the variation of the attenuator, is compared. When an X-ray is directed to the object, some photons interact with the material particles and the energy can be absorbed or dispersed. The number of photons passed through the material depends on the thickness, density and atomic number of matter, and energy.

3. Results and Discussion

The result of HVL value on the measurement of 50 kVp - 90 kVp voltage using aluminum and copper attenuators are shown in Table 1 and Figure 1.

Table 1. Results of Attenuators Measurement using Aluminum (Al), Copper (Cu) and Tin (Sn)

| Voltages (kVp) | Thickness of Al (mm) | Voltages (kVp) | Thickness of Cu (mm) | Voltages (kVp) | Thickness of Sn (mm) |
|---------------|-----------------------|---------------|----------------------|---------------|---------------------|
| 50            | 3                     | 50            | 0.05                 | 50            | 0.05                |
| 60            | 4                     | 60            | 0.15                 | 60            | 0.05                |
| 70            | 5                     | 70            | 0.2                  | 70            | 0.05                |
| 80            | 5.6                   | 80            | 0.3                  | 80            | 0.05                |
| 90            | 6.1                   | 90            | 0.3                  | 90            | 0.05                |

Figure 1. Graph of Al HVL Value at 50 - 90 kVp

From Table 1 and Figure 1 it was concluded that by using attenuator with Aluminum type (Al) at 50 kVp voltage obtained thickness of attenuator is 3 mm, 60 kVp obtained thickness attenuator is 4
mm, for 70 kVp obtained 5 mm, For 81 kVp obtained thickness attenuator is 5.6 mm, and for 90 kVp obtained the thickness of the attenuator is 6.1 mm. In the BAPETEN No. 09 Year 2011 and Western Australia Standard, that the HVL for each voltage on the X-ray plane The general radiography tested in this study is still within the permitted minimum range.

Figure 2. Graph of HVL Cu Value at 50 - 90 kVp

From Table 1 and Figure 2 it was concluded that by using attenuator with Aluminum type (Al) at 50 kVp voltage obtained the attenuator thickness is 3 mm equivalent to 0.05 mm Copper (Cu), 60 kVp obtained thickness attenuator is 4 mm equivalent to 0.16 mm Copper (Cu), for 70 kVp obtained 5 mm equivalent to 0.2 mm Copper (Cu), For 81 kVp obtained thick Aluminum attenuator (Al) is 5.6 mm equivalent to 0.3 mm Cu (Copper) and for 90 kVp obtained thick Aluminum attenuator (Al) is 6.1 mm equivalent to 0.3 mm CU (Copper). Sianturi et al [12] reported that the value of tube voltage deviation (kVp) and tube time (mAs) to meet the tolerance limit specified by PERKA BAPETEN No 9, 2011 to four X-ray devices in hospitals at Medan give only one device does not exceed the limited permitted by PERKA BAPETEN No 9, 2011. As per the BAPETEN No. 09 Year 2011 and Western Australia Standard, that the HVL for each voltage on the X-ray plane. The general radiography tested in this study is still within the permitted minimum range.

Results of HVL values are shown in Table 3 at a voltage of 90 kVp, 20 mAs. In thickness without attenuator Tin (Sn) results that surface dose of skin is 0.685 mGy, then given Tin (Sn) thickness attenuator 0.05 mm, measuring result of 0.306 mGy. Furthermore, there is no reduction in the thickness of the lead attenuator (Sn) because it is not possible to obtain the thickness of the Tin attenuator (Sn) below the size of 0.05 mm Tin (Sn).
From Figure 3 concluded that by using Tin attenuator (Sn) at 50 kVp the required tin (Sn) is 0.05 mm thick but no value of half values is obtained from the initial value, at 60 kVp the attenuator of Tin (Sn) is as thick as 0.05 mm but no value of half the value of the initial value, for the 70 kVp voltage obtained by Tin attenuator 0.05 mm, but did not get the value of half the value of the initial value, at a voltage of 81 kVp obtained thickness of tin (T) mm did not get the value of half the value of the initial value and at a voltage of 90 kVp obtained thick tin (T) attenuator 0.05 mm did not get the value of half the value of the initial value. So from HVL measurements using attenuator (Sn) for 50 kVp to 90 kVp voltage cannot be obtained half the value of initial value, meaning that attenuator is not suitable as attenuator for HVL measurement in X-ray plane.

4. Conclusion
Measurements of HVL by Aluminum (Al) at the University of Sumatera Utara Hospital, still within the minimum limit in accordance with the BAPETEN No. 09 Year 2011 and Standard Western Australia, then the three types of attenuators, the best attenuators for Half Value Layer (HVL) for X-ray plane are Aluminum (Al) and Copper (Cu). The type of Tin type (Sn) is not suitable as an attenuator to measure HVL on an X-ray plane at a voltage of 50 kVp up to 90 kVp.

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