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MEASUREMENT OF ENTRANCE SKIN EXPOSURE (ESE) VALUE WITH VARIOUS TYPES OF FILTER MATERIALS ON MOBILE X-RAY MACHINE USING EXPOSURE FACTOR OF CHEST

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Abstract— Measurement of Entrance Skin Exposure (ESE) value with a variety of types of material filter on mobile X-ray machine has been done using exposure factor of chest examination. The type of filter used is aluminum (Al), copper (Cu), galvalum (AlZnSi), and zinc (Zn). The tube voltage is varied at 70, 73, 77, and 81 kVp, fixed current-flow 20 mAs, SSD distance 100 cm, and radiation area 10 cm x 10 cm. The result of measuring the consistency of X-ray tube voltage has the biggest error of 1.52%. The exposure factor used in chest examination, which is 80 kVp obtained by interpolation of data. The result of measuring ESE value with exposure factor of chest (lateral) using filter 0.5 - 1.5 mmAlZnSi; 0.5 - 1.5 mmZn; and 0.5 - 1 mmCu are within tolerable limits. Similarly, the ESE value measurement results with filters 1 - 3.5 mmAl; 0.5 mmCu; 0.5 - 1 mmAlZnSi; and 0.5 - 1 mmZn is still within tolerable limits. The half ESE value of the 80 kVp exposure factor can be reached using a 3.2 mmAl filter. This value is equivalent to using a 0.17 mmCu filter; 0.23 mmAlZnSi; or 0.23 mmZn.

Keywords— x-ray machine, ESE value, filter, HVL, multipurpose detector

I. INTRODUCTION

One radiology service is to use X-rays to support diagnostic and therapeutic processes. In X-ray imaging there is an ESE or Entrance Skin Exposure value, ie the measured exposure value at the center of the X-ray axis which is the center point of the region to be subjected to radiation. The ESE value is affected by the combination of targets (anodes) and filters used in the X-ray tube. Filter is a material designed to absorb X-rays selectively.

Filtration filters allow the removal of undesirable low-energy X-ray photons by adding a material that can absorb the primary beam. It can remove photons that can increase the radiation dose but do not affect the radiographic image [1]. In accordance with ALARA principles, with the use of filters can minimize dosage and optimize image quality. The entrance skin exposure to a patient should be measured directly or computed from the actual technique used [2]. Dose-area-product meters offer a rapid and accurate means to measure skin entrance exposure when the radiography field size is known[3]. During this time generally only used Al material as filter on X-ray plane. So in this research is done variation of type of filter material other than Aluminum material. The material is copper, galvalum, and zinc to determine its effect on ESE value by exposure factor of chest with a tube voltage of 80 kVp [4]. The purpose of this research is to know the type of filter material better than aluminum.

II. MATERIALS AND METHODS

Measurement of Entrance Skin Exposure is done at Training Center of Diponegoro University. The instrument used is the Polymobile Plus X-ray Polymobile Plus, the Multi Purpose Detector (MPD) brand Barracuda R100 type equipped with RS-232 serial interface electrometers and PDA handle QA Browser software using real-time HP brand RTD (real-time display). While the materials used as filter are aluminum (Al), copper (Cu), galvalum (AlZnSi) and zinc (Zn). Al filter consists of 0.5 thickness; 1, 1.5, 2, 2.5, 3, 3.5, and 4 mm. AlZnSi and Zn filters consist of thicknesses of 0.25, 0.5, 1, 1.5; and 2 mm. The Cu filter consists of thickness of 0.5, 1, 1.5, and 2 mm. Prior to ESE measurements, a consistency test of the output voltage of a mobile X-ray tube is tested. Variations in X-ray tube voltages tested: 70, 73, 77 and 81 kVp. ESE measurements were then made by varying the type of filter material, filter thickness and X-ray tube voltage (70, 73, 77 and 81 kVp). From the data interpolation determined the ESE value for four types of filter materials by exposure factor of chest examinations or at 80kV x-ray tube voltage.

III. RESULTS AND DISCUSSION

Consistency of X-ray Tube Voltage Without filter

Before the x-ray tube is used for further research it is necessary to test the consistency of X-ray tube output voltage first. Based on table 2 it can be seen that the consistency value of the output voltage of the mobile X-ray tube is still below the tolerance limit of ± 10% so the mobile X-ray is still good.

Table 2. Value of Tube Voltage Consistency without Filter

kVp-set	kVp- output Average	Error (%)
70	69,32	-0,97
73	72,26	-1,02
77	75,83	-1,52
81	80,09	-1,13

ESE value with thickness variation

In figure. 3 to figure. 6 it is seen that for the same thickness and tube voltage the ESE values of the four types of materials are not the same. The value of ESE for Al is the largest compared to the other three types of filters. This is because Alumunium has the smallest density of the masses of AlZnSi, Zn, and Cu types, so that the absorption of X-ray beam is not as much as other filter materials. For chest examination generally used exposure factor of 80 kVp tube voltage, so that the value of that voltage used in measurement of ESE value with variation of Al, Cu, AlZnSi, and Zn. The ESE value at 80 kVp tube voltage for each filter type is obtained from the interpolation on the graph between the magnitude of the tube voltage to the ESE value. Table 3 shows the ESE value on 80 kVp tube voltage with material type variation and filter thickness.

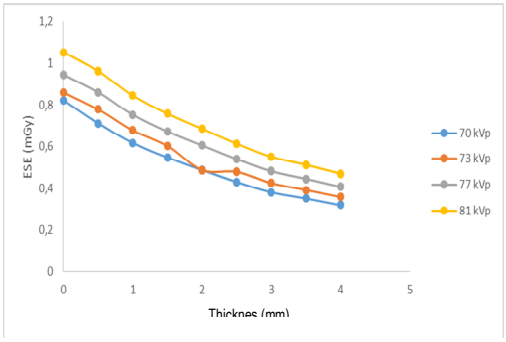

Figure 3. ESE value with Al thickness variation

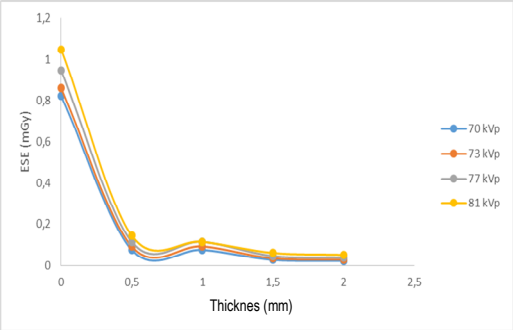

Figure 4. ESE value with Cu thickness variation

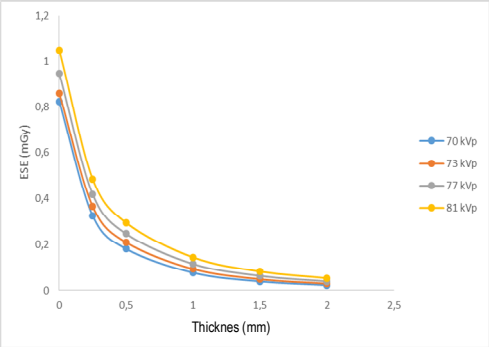

Figure 5. ESE value with AlZnSi thickness variation

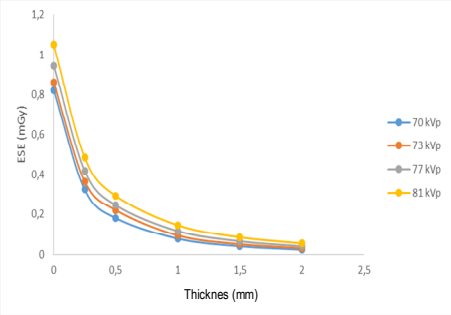

Figure 6. ESE value with Zn thickness variation

Table 3. ESE value at 80 kVp tube voltage

Thickness (mm)	ESE			
	Al filter (mGy)	Cu filter (mGy)	AlZnSi filter (mGy)	Zn filter (mGy)
0	1,02	1,02	1,02	1,02
0,25	-	-	0,47	0,47
0,5	0,94	0,14	0,28	0,28
1	0,82	0,11	0,14	0,14
1,5	0,74	0,06	0,08	0,08
2	0,67	0,05	0,05	0,05
2,5	0,59	-	-	-
3	0,53	-	-	-
3,5	0,5	-	-	-
4	0,45	-	-	-

From table 3 it is known that the smallest ESE values on the use of Cu filters and the largest ESE values on the use of the Al filter. Based on the reference [5] that ESE on chest examination (PA) with tolerance limit of 0.087 - 0.26 mGy then the use of AlZnSi filter and Zn filter with a thickness of 0.5 to 1.5 mm are within the tolerable range. For the use of Cu filters, the thickness of 0.5 - 1 mm is within the ESE chest tolerance limit (PA).

While ESE on chest examination (lateral) with tolerance limit 0,435 - 0,87 mGy. For the use of Al filter with a thickness of 1 - 3.5 mm, are within the limits of tolerance. For little X-ray absorption, it is better to use Al filter and for big X-ray absorption Cu filter can be used. The use of Al filter requires a thickness of 3 mm to reach the paro value. While the filter AlZnSi and Zn only needed 0.25 mm thickness to be able to reach the ESE paro value. This is due to the much lower density of Al than the three Cu filters, AlZnSi, and Zn

HVL on variations of filter material type

Based on the research data obtained by interpolation data with equation (2) to get the Half Value Layer (HVL) [6] and shown in table 4.

Table 4. The Half Value Layer (HVL) on Exposure Factor of Chest Inspection

kVp	Half Value of ESE (mGy)	HVL (mm)			
		Al	Cu	AlZnSi	Zn
70	0.41	2.84	0.15	0.21	0.21
73	0.43	3.00	0.16	0.22	0.22
77	0.47	3.16	0.16	0.22	0.22
80	0.51	3.20	0.17	0.23	0.23
81	0.53	3.27	0.17	0.23	0.23

$$HVL = \frac{\varepsilon_b LN\left(2\frac{D_a}{D_b}\right) - \varepsilon_a LN\left(2\frac{D_b}{D_a}\right)}{LN\left(\frac{D_a}{D_b}\right)} \quad (2)$$

Based on Table 4 it is known that an increase in the exposure factor of the X-ray tube voltage will lead to an increase in the half value of ESE. To achieve the ESE half-value at 80 kVp tube voltage. a 3.2 mm thick Al filter is required. The value will be equivalent to the use of Cu filters as thick as 0.17 mm. AlZnSi filter as thick as 0.23 mm. or a 0.23 mm Zn filter. Density of material filter influence on the absorption of X-ray intensity. Aluminum has the smallest density of 2.7 g / cm^3 so that the absorption of X-ray intensity by Aluminium filter is the least .While the Cu material has the density of 8.9 g / cm^3 and the largest among 3 other filter materials so that the intensity of x-rays which can be absorbed by Cu filter is the largest.

IV. CONCLUSION

From the research. it can be concluded that the ESE value with the chest examination factor (PA) is within the tolerance limit of 0.087 - 0.26 mGy using a 0.5 - 1.5 mmAlZnSi filter, 0.5 - 1.5 mmZn, and 0.5 - 1 mmCu. While ESE value with exposure factor of chest (lateral) is in tolerance limit 0.435 - 0.87 mGy by using filter 1 - 3.5 mmAl; 0.5 mmCu; 0.5 - 1 mmAlZnSi; and 0.5 - 1 mmZn. The half value of ESE of the 80 kVp exposure factor can be reached using a 3.2 mmAl filter. This value is also equivalent to using a 0.17 mmCu filter, 0.23 mmAlZnSi, or 0.23 mmZn. After doing this research. it can be taken some suggestion that is for research with variation of material type better use materials having density which is not much different. Materials Cu, AlZnSi, and Zn can be used as alternative filter materials other than Al material on X-ray machine filter.

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