Evaluation of Typical Dose Rate Values, Maximum Dose Rate in Air and Dose Rate in Surface Image Intensifier (II) in Dual Function Fluoroscopy (FL)

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Abstract. This study aims to determine the value of the typical dose rate, the maximum dose rate in the air and the dose rate on the surface of Image Intensifier (II) in 3 types of dual function Fluoroscopy (FL). This study used a dual function Fluoroscopy, X-Ray safe multimeter, Pb plate, Cu plate, and phantom perspek. Typical dose rate measurement were carried out by placing a multimeter X-Ray of phantom perspek of a thickness of 18 cm, so that the examination table distance from the detector was 18 cm and source distance from image of 96 cm according to normal patient position. Measuring the maximum dose rate in the air is done by placing the detector at distance of 300 mm above the examination table, placing the Pb 2 mm below the collimator, the exposure is carried out at the maximum automatic kVp. Measuring the dose rate of the surface Image Intensifier (II) is done by placing the detector above II, the Cu plate with a thickness of 2 mmCu is affixed to the surface of the collimator and the exposure is carried out on the automatic kVp. Typical dose rate to test results from FL (A) and FL (C) with the same size II are 35 cm while FL (B) sized II is 23 cm. The results of the tipical dose rate test for FL (A), FL (B), and FL (C) are 11.428 mGy/minute, 11.712 mGy/minute and 12.518 mGy/minute, respectively. All results of the testing of the typical dose rate test results from FL (A), FL (B), and FL (C) remain below the maximum value of 17 mGy/minute as required by BAPETAN Regulation No. 2 in 2018.

1. Introduction

Typical dose rates testing, maximum dose in air and dose rate on the surface Image Intensifier (II) is very important for us know where this test aims to determine exposure to radiation doses received by patients when conducting Fluoroscopy (FL) examinations. Exposure to ionizing radiation is known to cause deterministic effects that have a dose threshold value that can be avoided by seeking to receive a dose by someone below the threshold dose. The stochastic effect that is caused is not possible at all avoided that needs to be done is that every act giving radiation exposure should lead to a reaction in the occurrence of stochastic impacts by striving so that the reception of radiation doses is always below the threshold dose. The risk of using ionizing radiation is also part of the National Hospital Accreditation standard, which is a patient-focused service standard to improve patient quality and safety with a risk management approach at the hospital [1, 2, 3, 4].

In general, radiation doses are known to be related to the absorption of a certain amount of radiation energy in the volume section of the tissue. The amount of dose that is directly related to the biological effects that can be caused is the amount that is limited by the amount of energy absorbed...
from radiation by biological tissue, or the energy delivered by ionizing radiation to the material. The energy delivered by ionizing radiation to a material with a volume of \( V \) and mass of \( m \) is limited as

\[
e = (R_m)u - (R_k)u + (R_m)c - (R_k)c + \sum Q
\]

with \((R_m)u\) is the energy emitted by uncharged radiation that enters \( V \), \( \sum Q \) is the net energy that comes from the stationary mass in \( V \), \((R_k)u\) is the energy emitted by all uncharged radiation leaving \( V \), \((R_m)c\) is the energy carried by all charged particles which enters \( V \), and \((R_k)c\) denotes the energy carried by charged particles coming out of \( V \). Limitation of absorbed dose \( D \) at point \( P \) in volume as

\[
D_p = \frac{dE}{dm}
\]

\( D_p \) is states the absorption dose value of point \( P \), \( \frac{dE}{dm} \) is the average amount of energy delivered into the volume section around the point \( P \), and \( dm \) is the mass of material in that part of the volume. SI units for absorbing doses are joules per kilogram \( (J kg^{-1}) \) with a special name gray \( (\text{Gy}) \). Absorption doses can be used for all types of ionizing radiation and all ingredients. The absorbency doses derivative with time is called the absorption dose rate

\[
\dot{D} = \frac{dD}{dt}
\]

A typical dose rate is a dose on the surface of the skin or ESD which is a measure of the radiation dose absorbed \( (\text{mGy}) \) by the skin when it reaches the patient. The maximum dose in the air is the maximum radiation exposure obtained in the air far away on the patient's skin surface. The dose rate for Image Intensifier \( (\text{II}) \) is the amount of radiation exposure to the surface of Image Intensifier \( (\text{II}) \) under the patient. The limitation values stated in BAPETEN Regulation No. 2 in 2018 is for the typical ESD rate is \( D_{\text{Typical}} = 17 \text{ mGy/minute} \), the maximum dose rate in air is \( D_{\text{max}} = 50 \text{ mGy/minute} \), and the absorption dose rate on surface \( \text{II} \) for diameter size \( \text{II} = 23 \text{ cm} \) which is \( 60 \mu\text{Gy/minute} \) and for diameter \( \text{II} = 23 \text{ cm} \), that is \( 90 \mu\text{Gy/minute} \) [5, 6, 7].

2. Materials and Methods
This study used a dual function upper tube Fluoroscopy (FL) type, non-invasive multimeter, Pb plate, Cu plate and phantom perspek. Typical ESD measurement is done by placing a non-invasive multimeter above phantom perspek of a thickness of 18 cm, so that the distance from the examination table with the detector is 18 cm and the source distance from the image (SID) is 96 cm according to the normal patient position then automatic exposure, recording the value dose on the multimeter. Measuring the maximum dose rate in the air is done by placing the detector at a distance of 30 cm above the examination table, placing Pb 2 mm above II, exposure carried out at the maximum automatic kVp, recording the dose value of the multimeter. The measurement of absorbing dose rate of the surface Image Intensifier \( (\text{II}) \) was carried out by placing the detector above II, Cu plates with a thickness of 2 mmCu were affixed to the surface of the collimator and exposures were carried out on automatic kVp, recording the dose values on the multimeter [8, 9, 10, 11].

3. Results and Discussion
The results of the Fluoroscopy (FL) test were obtained by direct measurement using a non-invasive X-ray multimeter with five exposures and then calculated the average value and the standard deviation value of each tool. The results of this measurement are compared with the passed test value specified in BAPETEN Regulation No. 2 in 2018 [12].

3.1 Typical dose rate test
The results of a typical dose rate test using phantom PMMA perspek with a thickness of 20 cm. The results of the typical dose rate test can be seen in table 1.
### Table 1. Typical dose rate values

| Fluoroscopy (FL) Unit | Size II (cm) | Average (mGy/Min) | STDEV | Test pass value (mGy/Min) |
|-----------------------|--------------|-------------------|-------|--------------------------|
| FL (A)                | 35           | 11,428            | 0,020 |                          |
| FL (B)                | 23           | 11,712            | 0,023 | D_tipikal 17             |
| FL (C)                | 35           | 12,518            | 0,025 |                          |

Typical dose rate testing on FL (A) and FL (C) with the same size II is 35 cm while FL (B) size II is 23 cm. The results of testing the typical ESD dose rate for FL (A), FL (B) and FL (C) are 11.428 mGy/minute, 11.712 mGy/minute, and 12.518 mGy/minute, respectively. All results of the typical dose test are still within the test escape limit, which is 17 mGy/minute as required in BAPETEN Regulation No. 2 in 2018 [12].

### 3.2 Maximum dose rate test in the air

The maximum dose rate test in the air is the placement of a non-invasive multimeter detector 30 cm above II without using the phantom extension. The detector is placed on the edge of II. The results obtained from the maximum dose rate test in the air obtained data in Table 2.

#### Table 2. Maximum dose rate in the air

| Fluoroscopy (FL) Unit | Size II (cm) | Average (mGy/Min) | STDEV | Test pass value (mGy/Min) |
|-----------------------|--------------|-------------------|-------|--------------------------|
| FL (A)                | 35           | 7,998             | 0,001 | D_max 50                 |
| FL (B)                | 23           | 11,402            | 0,018 |                          |
| FL (C)                | 35           | 4,311             | 0,006 |                          |

Table 2 shows the value of the maximum dose rate in the air of each FL is very varied from the maximum value on FL (B) is 11.402 mGy/minutes, while the minimum value occur to FL (C) is 4.311 mGy/minutes. As for FL (A), the maximum dose rate in the air is 7.998 mGy/minutes. All results of testing the maximum dose rate in the air are still below the test pass value required by BAPETEN which is 50 mGy/minutes [12].

### 3.3 Absorption rate test on the surface Image Intensifier (II)

The dose rate test of surface II was used as a parameter related to the quality of fluoroscopy images using a Cu 1.5 mm filter. The multimeter detector is placed on the surface of the edge II. The results of the dose rate test of the surface of Image Intensifier (II) obtained data in Table 3.

#### Table 3. Absorption dose rate on surface II

| Fluoroscopy (FL) Unit | Size II (cm) | Average (μGy/Min) | STDEV | Test pass value (mGy/Min) |
|-----------------------|--------------|-------------------|-------|--------------------------|
| FL (A)                | 35           | 33,3              | 0,114 | 60                       |
| FL (B)                | 23           | 68,2              | 0,195 | 90                       |
| FL (C)                | 35           | 2,4               | 0,009 | 60                       |

From table 3 it can be observed that the value of the dose rate of surface II varies greatly from FL (B) having a maximum value is 68.2 μGy/minutes while FL (A) and FL (C) are 33.3 μGy/minute and 2.4 μGy/minutes, respectively. All the results of the dose rate testing for the surface of Image Intensifier (II) are still below the test pass value required by BAPETEN which is 60 μGy/minute for size II 23 cm and 90 μGy/minute for size II 23 cm [12].

### 4. Conclusion
The data obtained are as follows: Typical dose rate tests on FL (A) and FL (C) with the same size II which is 35 cm while FL (B) size II is 23 cm. The results of the typical dose rate test for FL (A), FL (B), and FL (C) are 11.428 mGy/minute, 11.712 mGy/minute, and 12.518 mGy/minute, respectively. All results of the testing of the Typical ESD dose rate are still within the test passes which are 17 mGy/minute as required by BAPETEN Regulation No. 2 in 2018. The value of the maximum dose rate in the air of each FL is very varied from the maximum value on FL (B) is 11.402 mGy/minutes, while the minimum value occur to FL (C) is 4.311 mGy/minutes. As for FL (A), the maximum dose rate in the air is 7.998 mGy/minutes. All results of testing the maximum dose rate in the air are still below the test pass value required by BAPETEN which is 50 mGy/minutes. The value of the dose rate for surface II varies greatly from FL (B) having a maximum value is 68.2 μGy/minutes while FL (A) and FL (C) are 33.3 μGy/minute and 2.4 μGy/minute, respectively. All results of testing the dose rate for the surface of Image Intensifier (II) are still below the test pass value required by BAPETEN which is 60 μGy/minute for size II 23 cm and 90 μGy/minute for size II 23 cm.

Acknowledgement
The author are grateful to Hasanuddin University, Faculty of Mathematics and Science and Department of Physics for support of this research.

References
[1] ICRP Publication 1991 Recomendations of the International Commission on Radiological Protection (Oxford: Pergamon Press)
[2] I Putu Susila, Ferry Sujanto, Istofa and Sukandar 2010 Prosiding Pertemuan Ilmiah Rekayasa Perangkat Nuklir PRPN-BATAN (Tangerang) 197-203
[3] J. F. Gabriel 1996 Fisika Kedokteran Edisi VII (Jakarta) ICRP Publication 60, Recomendations of the International Commission on Radiologica l Protection (Oxford: Pergamon Press)
[4] T. Jerrold, Bushberg, et. al 2002 The Essential Physics of Medical Imaging, Second Edition 231-232.
[5] M. Akhadi 2000 Dasar-Dasar Proteksi Radiasi (Jakarta: PT. Rineka Cipta)
[6] S. Wiriosimin 1995 Mengenal Asas Proteksi Radiasi (Bandung: ITB)
[7] L. Williams and Wilkins 2002 Physics of Medical Imaging, Second Edition (Philadelphia)
[8] Piranha 2013 Reference Manual English Version 5.5 A. Copyright 2001 (RTI Elektronics)
[9] Radiation Safety Act 1975 2000 Workbook 4: Major Fluoroscopic Equipment, Diagnostic X -Ray Equipment Compliance Testing (Australia: Health Department of Western Australia)
[10] N. Kumar 2018 Comprehensive Physics XII Laxmi Publications 1416
[11] N. Andreas 2010 Studi Metode Kalibrasi detektor Bilik Ionisasi Tipe Pensil Dengan dan Tanpa Kolimator (Depok) Skripsi Fakultas Matematika Dan Ilmu Pengahuan Alam
[12] BAPETEN 2018 Peraturan Kepala Badan Pengawas Tenaga Nuklir Nomor 2 Tentang Uji Kesesuaian Pesawat Sinar-X Radiologi Diagnostik dan Intervisional. Dokumen Teknis (Jakarta: Badan Pengawas Tenaga Nuklir.)