# Comparative Study of the Absorbed Dose of Secondary Shiled Wall Elements in a Digital Radiography Room

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***Abstract***- Most hospitals in Indonesia have already been provided with the digital radiography room in their radiology installation rooms. This room utilizes the lowest X-ray level to diagnose, and this kind of radiation, if not well-managed, will become one of the hospital's pollutant sources namely the danger of radiation exposure. Related to the room's design, the government, by means of the Ministry of Health Regulation No. 1014 of 2008 and the Chairman of Nuclear Energy Supervisory Agency Regulation No. 8 of 2011, requires the brick wall with 25 cm thickness, 2.2 g/cm3 density, and 2 meters height from the floor or equal to 2 mm lead layer (Pb), which serve as the room's partition (the secondary shield). However, in its implementation, most of shielding partition wall designs in hospitals' digital radiography rooms use the 15 cm half brick wall coated with 2 mm lead layer (Pb).

There is no recent research in the absorbed dose of each secondary shield forming element. Therefore, the following research has become important because it strives to determine the absorption percentage of each secondary shield wall element in the digital radiography room.

This research employed the measurement method, using a survey meter from the digital radiography device on a scale of 1 to 1, and the secondary shield thickness calculation method.

The measurement and calculation in this research has acquired the absorption percentage from the radiation dose rate reaching the surface of the secondary shield wall for the half brick wall (10.91%); for the half brick wall, the frame and the supporting partition (14,72%); and for the half brick wall, the partition frame, the 2mm lead layer (93,62%).

***Index Terms***- X-ray radiation, the absorbed dose rate, the secondary shield wal

## I. INTRODUCTION

The radiology installation has become the hospital's vital part for supporting the activities of other installations. Every hospital's medical measure always starts this installation. The radiology installation has three main divisions: the diagnosis division (including the use of ultra-sonic diagnosis, fluoroscopy, and others), the therapy division, and the nuclear medicine division. The installation utilizes the radiation of radioactive substances in the lowest level namely the ionizing radiation from the X-ray device. In diagnostic radiology, the instruments with the biggest radiation are digital radiography and CT-san, but the most frequently used instrument is the digital radiography where most hospitals, public health centers, and clinics have this instrument. However, the X-ray beam from the instrument can cause damage to living cells, so precise and careful covering for the entire room is extremely important.

or the room design guidance, the government has issued two regulations namely the Ministry of Health Regulation No. 1014 of 2008 and the Chairman of Nuclear Energy Supervisory Agency Regulation No. 8 of 2011. These official rules require the building of a partition wall (the secondary shield). This wall, furthermore, is made of bricks having thickness 25 cm and density 2.2 g/cm3, and it is equal to 2 mm lead layer (Pb) at the height of 2 meters from the floor. What happens in reality is that in designing the partition wall for their digital radiography room, most hospitals use 15 cm half brick walls coated with 2mm lead (Pb). Related to this partition wall, there is no recent research in the absorbed dose of each secondary shield forming element.

This research has great significance due to its effort to determine the percentage of absorption rate from each forming element of the secondary shield wall in every digital radiography room.

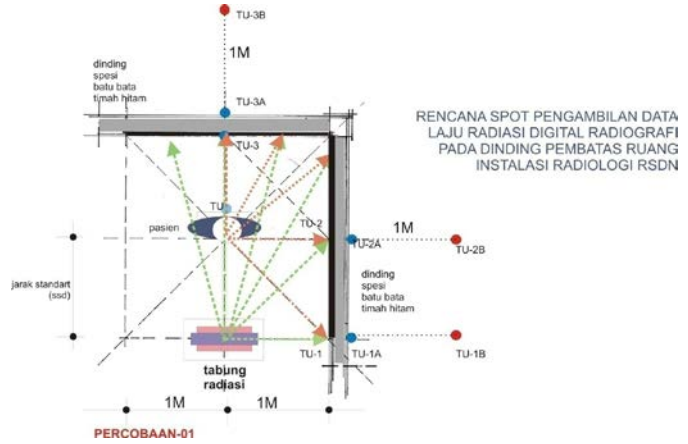
## II. THE RESEARCH METHOD

This research used the measurement with survey meter from the digital radiography in a room model with a scale of 1:1 and the calculation method of the secondary method shield.

The measurement of the radiation dose rate was conducted with the Phantom Thorax as the replacement of the patient.

The coating of the shield wall was done in stages. First, the half brick wall was plastered, and then it was coated by lead (Pb). Next, the wall was perfected by covering all holes of the lead coated wall without gaps. After that, the panel frame filler was added as a part of the room interior design.

The placing of measuring points at the room model of digital radiography installation can be seen in the picture 1.




Picture 1

The Blueprint for the Model and the Placing of Measuring Points in the Undip Training Center Installation
Source : private documents

In the initial phase, the measurement of the measuring points was done in the condition where the half brick wall was plastered with its total thickness is 15 cm. The following picture is the description of the measurement results.

TABEL HASIL PENGUKURAN LAJU DOSIS RADIASI
MODEL RUANG DIGITAL RADIOGRAPHY

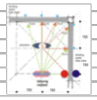
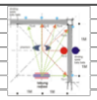
| No | JENIS PEMBATAS RUANG DAN TITIK UKUR | S | KV | mAs | LAJU DOSIS RADIASI (mSv/h) Latar | Penyinaran | Pasca | TITIK UKUR | FAKTOR KALIBRASI | SERAPAN LAJU DOSIS (%) | RATA2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | DINDING TEMBOK SETENGAH BATA | | | | | | | | | | |
| 1 |  | 120 | 96 | 4 | 0.086 | 2.31 | 1.152 | | 1.09 | 8.35 | |
| | | | | | | | 0.092 | | | | |
| | | | | | | | 0.086 | | | | |
| | | | | | 0.066 | 2.117 | 0.092 | | | | |
| | | | | | | | 0.066 | | | | |
| 2 |  | 120 | 96 | 4 | 0.086 | 4.101 | 0.072 | | 1.09 | 6.85 | 10.91 |
| | | | | | 0.092 | 4.169 | 0.082 | | | | |
| | | | | | | 4.248 | | | | | |
| | | | | | 0.117 | 3.957 | 0.117 | | | | |
| | | | | | | 3.957 | | | | | |
| 3 |  | 120 | 96 | 4 | 0.066 | 0.97 | 0.086 | | 1.09 | 17.53 | |
| | | | | | | 1.02 | 0.066 | | | | |
| | | | | | | 1.17 | 0.06 | | | | |
| | | | | | 0.04 | 0.8 | 0.04 | | | | |
| | | | | | | 0.8 | 0.04 | | | | |

Table 1

The Measurement Results of the Radiation Dose Rate on Measuring Points of the Brick Wall Installation Model and 15 cm Plaster
Source: Measurement Results

In table 1, the 96 kV Rontgen mobile device (4 mAs), in which the radiation dose rate on measuring points is parallel to the phantom, has the radiation intensity level as many as 4.248 mSv/hour. Meanwhile, for the measuring points parallel to the device, the intensity level is 2.31 mSv/hour and for the measuring points behind the shield, the intensity level is 1.17 mSv/hour. Thus, it can be concluded that the scatter dose rate is still above the allowed scatter dose rate, and it is dangerous for users during the radiation process.

The measurement result of the measuring points outside the room and parallel to the phantom is 3.957 mSv/hour while the measuring points outside of the room and parallel to the position of the Rontgen mobile tube is 2.117 mSv/hour. On the other hand, the measuring points outside of the room and behind the shield area are 0.8 mSv/hour. The three results of measurement outside the room are still above the allowed radiation dose rate, so it is dangerous for the users if they are continuously exposed.

The absorbed dose of the plastered half brick wall parallel to the phantom is 6.85%. In addition, the absorbed doses in the position both parallel to the mobile Rontgen device and behind the shield area are 8.53% and 17.53% respectively. The average absorbed dose of the plastered half brick wall is 10.91%.

The measurement of the points on the half brick wall with plaster and the partition panel frame in order to get the result of the absorbed dose was described in the table 2 below.

The radiation dose rates at the measuring points parallel to the phantom has the radiation intensity level as many as 4.248 mSv/hour; while at the measuring points parallel to the device, the radiation intensity is 2.31 mSv/hour. In addition, for the measuring points behind the shield wall, the intensity level is 1.17 mSv/hour. These facts show us that the scatter dose rate is still above the allowed scatter dose rate. Therefore, it is still dangerous during the radiation process.

TABEL HASIL PENGUKURAN LAJU DOSIS RADIASI
MODEL RUANG DIGITAL RADIOGRAPHY

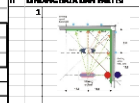
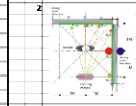
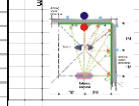
| No | JENIS PEMBATAS RUANG DAN TITIK UKUR | S | KV | mAs | LAJU DOSIS RADIASI (mSv/h) Latar | Penyinaran | Pasca | TITIK UKUR | FAKTOR KALIBRASI | SERAPAN LAJU DOSIS (%) | RATA2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| II | DINDING RUA DAN PARTISI | | | | | | | | | | |
| 1 |  | 120 | 96 | 4 | 0.086 | 2.31 | 1.152 | | 1.09 | 10.91 | |
| | | | | | | 2.31 | 0.092 | | | | |
| | | | | | | | 0.086 | | | | |
| | | | | | 0.066 | 2.058 | 0.092 | | | | |
| | | | | | | | 0.066 | | | | |
| 2 |  | 120 | 96 | 4 | 0.86 | 4.101 | 0.72 | | 1.09 | 8.52 | 14.72 |
| | | | | | 0.92 | 4.169 | 0.82 | | | | |
| | | | | | | 4.248 | | | | | |
| | | | | | 0.117 | 3.889 | 0.117 | | | | |
| | | | | | | 3.886 | | | | | |
| 3 |  | 120 | 96 | 4 | 0.066 | 0.97 | 0.086 | | 1.09 | 24.74 | |
| | | | | | | 1.02 | 0.066 | | | | |
| | | | | | | 1.17 | 0.06 | | | | |
| | | | | | 0.04 | 0.73 | 0.04 | | | | |
| | | | | | | 0.73 | 0.04 | | | | |

Table 2.

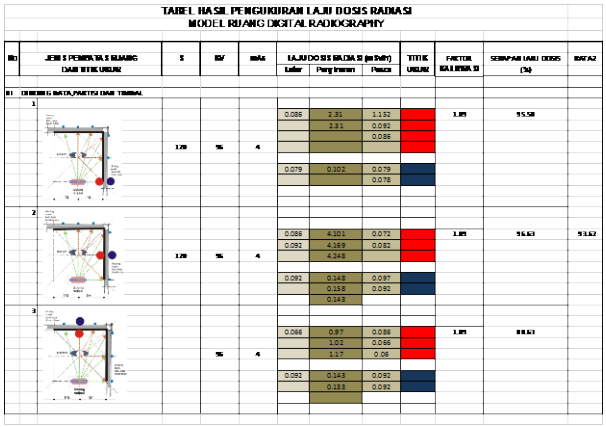
The Radiation Dose Rate Measurement Results of Measuring Points on the Brick Wall Installation Model with 15 cm Plaster and the Partition Panel
Source: Measurement Results

The measurement results of points outside the room are 3.889 mSv/hour (parallel to the phantom side), 2.058 mSv/hour (parallel to the mobile Rontgen tube device), and 0.73 mSv/hour (behind the shield). The number of the measurement results is still above the allowed radiation dose rate, and it is obviously still harmful for users if continuously exposed.

The absorbed doses of the plastered half brick wall with the partition panel are 8.52% (parallel to the phantom), 10.91% (parallel to the mobile Rontgen device), and 24.74% (behind the Rontgen device shield area). The average of the absorbed dose towards the radiation dose rate is 14.72%.

From both measurements, the absorbed dose of the partition panel area only is 4.52%

The measurement of points was conducted on the half brick wall with the plaster, the partition panel frame and the 2 mm lead coating with 2 meters height from the floor. This measurement's purpose is to determine both absorbed doses which is explained in the following table.



TABEL HASIL PENGUKURAN LAJU DOSIS RADIASI
MODEL RUANG DIGITAL RADIOGRAPHY

| No | JENIS PEMBATAS RUANG DAN TITIK UKUR | S | KV | mAs | LAJU DOSIS RADIASI (mSv/hj) Latar | Penyinaran | Pasca | TITIK UKUR | FACTOR KALIBRASI | SERAPAN LAJU DOSIS (%) | RATA2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| III | DIBELING BATA_PARTISI DAN TIMBAL | | | | | | | | | | |
| 1 | | 1,70 | 96 | 4 | 0,086 | 2,31 | 1,152 | | 1,09 | 95,58 | |
| | | | | | | 2,31 | 0,092 | | | | |
| | | | | | | | 0,086 | | | | |
| | | | | | 0,079 | 0,102 | 0,079 | | | | |
| | | | | | | | 0,078 | | | | |
| 2 | | 1,70 | 96 | 4 | 0,086 | 4,101 | 0,072 | | 1,09 | 96,63 | 93,62 |
| | | | | | 0,092 | 4,169 | 0,082 | | | | |
| | | | | | | 4,248 | | | | | |
| | | | | | 0,092 | 0,148 | 0,097 | | | | |
| | | | | | | 0,158 | 0,092 | | | | |
| | | | | | | 0,143 | | | | | |
| 3 | | | 96 | 4 | 0,086 | 0,97 | 0,086 | | 1,09 | 88,63 | |
| | | | | | | 1,02 | 0,066 | | | | |
| | | | | | | 1,17 | 0,06 | | | | |
| | | | | | 0,092 | 0,143 | 0,092 | | | | |
| | | | | | | 0,133 | 0,092 | | | | |

Table 3.

The Radiation Dose Rate Measurement Results of Measuring Points on the Brick Wall Installation Model with 15 cm Plaster, the Partition Panel, and Lead (Pb)
Source: Measurement Results

The dose rate of the measuring points parallel to the phantom is 4.248 mSv/hour. Meanwhile, the rates of the measuring points both parallel to the device and behind the shield wall are 2.31 mSv/hour and 1.17 mSv/hour respectively. These results show that the scatter dose rate is still above the allowed scatter dose rate, and certainly it is harmful for users throughout the radiation process.

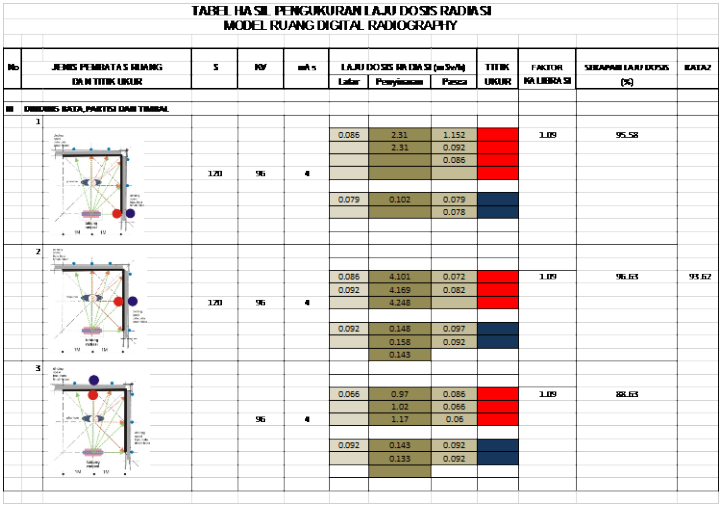
The points' measurement result, outside the room and parallel to the phantom position, is 0.158 mSv/hour. Furthermore, the other points' measurement results, parallel to the mobile Rontgen tube and behind the shield area, are 0.102 mSv/hour and 0.143 mSv/hour respectively. The aforementioned results are still above the allowed the radiation dose rate for the non-medical staffs, so it is still dangerous for users if continuously exposed. However, for the medical staffs, the rate of radiation dose is relatively below the required dose rate.

The absorbed rates of the plastered half brick wall with the partition panel coated with 2mm lead and parallel to the phantom, is 96.63%. Meanwhile, the other absorbed doses, parallel to the mobile Rontgen device tube and behind the shield area, are 95.58% and 88.63% respectively. Therefore, the average of the absorbed rates towards the radiation dose rate is 93.62%.

From the previous measurements, the absorbed dose of the 2mm lead area only is 78.90%

The measurement results on the half brick wall with the plaster, the partition panel frame, and the 2mm lead coating having height 2 meters from the floors without gaps, were conducted in order to determine the absorbed doses. The results of the measurements are described in the table 4.

The radiation dose rates at measuring points are 4.248 mSv/hour (parallel to the phantom) and 1.17 mSv/hour (both parallel to the device and behind). These phenomena show us that the scatter dose is still too high for the allowed scatter dose, and thus it is still hazardous for the users during the radiation process.



TABEL HASIL PENGUKURAN LAJU DOSIS RADIASI
MODEL RUANG DIGITAL RADIOGRAPHY

| No | JENIS PEMBATAS RUANG DAN TITIK UKUR | S | KV | mAs | LAJU DOSIS RADIASI (mSv/hj) Latar | Penyinaran | Pasca | TITIK UKUR | FACTOR KALIBRASI | SERAPAN LAJU DOSIS (%) | RATA2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| III | DIBELING BATA_PARTISI DAN TIMBAL | | | | | | | | | | |
| 1 | | 1,70 | 96 | 4 | 0,086 | 2,31 | 1,152 | | 1,09 | 95,58 | |
| | | | | | | 2,31 | 0,092 | | | | |
| | | | | | | | 0,086 | | | | |
| | | | | | 0,079 | 0,102 | 0,079 | | | | |
| | | | | | | | 0,078 | | | | |
| 2 | | 1,70 | 96 | 4 | 0,086 | 4,101 | 0,072 | | 1,09 | 96,63 | 93,62 |
| | | | | | 0,092 | 4,169 | 0,082 | | | | |
| | | | | | | 4,248 | | | | | |
| | | | | | 0,092 | 0,148 | 0,097 | | | | |
| | | | | | | 0,158 | 0,092 | | | | |
| | | | | | | 0,143 | | | | | |
| 3 | | | 96 | 4 | 0,086 | 0,97 | 0,086 | | 1,09 | 88,63 | |
| | | | | | | 1,02 | 0,066 | | | | |
| | | | | | | 1,17 | 0,06 | | | | |
| | | | | | 0,092 | 0,143 | 0,092 | | | | |
| | | | | | | 0,133 | 0,092 | | | | |

Table 4

The Radiation Dose Rate Measurement Results for Measuring Points on the 15 cm Brick Wall Installation Model, the Partition Panel, and the Lead (Pb) without any gap
Source: Measurement Results

The point measurement results outside the room and parallel to the phantom is 0.133 mSv/hour. On the other hand, the other measurement results of the points both parallel to the tube and behind the shield area are 0.113 mSv/hour. The results of the previous radiation dose rates measurement are still above the allowed rate for the non-medical staffs, so it will be harmful for them if they are continuously exposed. However, for the medical staffs, this radiation dose rate is relatively below the required rate.

The absorbed dose of the half brick wall; plastered with the partition panel, coated with 2mm lead without gaps and having position parallel to the phantom; is 96.87%. Moreover, the absorbed doses of the brick wall, both parallel to the tube and behind the shield area, are 95.11% and 90.34% respectively. The average of the absorbed dose towards the radiation dose rates of the half brick wall, the partition panel wall, and the 2 mm lead coating without gaps is 94.11%.
From the previously mentioned results, the absorbed dose of the 2 mm lead area without gaps is 79.39%

## III. CONCLUSIONS

- The partition wall of the digital radiography room consists of the plastered half wall + 2 cm lead (Pb) without gaps as tall as 2 meters and the HPL finishing panel frame
- The absorption percentage average of the radiation dose rate of the plastered brick wall +the HPL finishing panel frame +lead (Pb) without gaps (lab model) is **94,11**%

- The average of the absorption percentage of (2006). Penanggulangan Dampak the plastered brick wall (lab model) is **10.91**%
- The absorption percentage average of the plastered brick wall + the HPL finishing panel frame (lab model) is **14.72**%
- The average of the absorption percentage of the 2 mm lead coating (Pb) is **79,39**%

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