IOSR Journal Of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 16, Issue 1 Ser. I (Jan. – Feb. 2024), PP 55-58
www.Iosrjournals.Org

Analysis Of The Effectiveness Of Diagnostic Laboratory Walls On The Rate Of Exposure To X-Ray Radiation

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Abstract—
Research has been conducted on the analysis of the effectiveness of the walls of the ATRO Bali diagnostic laboratory as a barrier to radiation exposure rates both primary and secondary radiation in preventing and minimizing radiation hazards, for radiation workers, staff, and the community inside and outside the laboratory. The radiation safety program in the use of X-ray aircraft has been regulated in Perka Bapeten No. 8 of 2011 concerning quality assurance of building designs that must meet the dose-limiting requirements for radiation workers of 0.57 mR per hour and for the general public of 0.03 mR per hour. From the results of measurements and calculations of radiation exposure rates on one primary wall, two scattering secondary walls, and one leaking secondary wall obtained values of 1.166 × 10-7 mR / hour, respectively; 1,668 × 10-7 mR/h; 2,237 × 10-7 mR/h; and 7,839 × 10-8 mR/h. When compared to Perka Bapeten, the wall is quite effective in resisting the rate of exposure to primary radiation and secondary radiation so it is declared quite safe. This is also reinforced by a statistical test of one sample test for all walls showing results that are still safe according to NBD Bapeten.

Keywords— *Radiation, Wall effectiveness, Radiation protection*

Date of Submission: 12-01-2024 Date of Acceptance: 22-01-2024

I. INTRODUCTION

Radiation is the emission of energy in the form of waves or particles emitted by radiation sources or radioactive substances [1]. Radiation is used in industry, agriculture, transportation, and health. The use of ionizing radiation in the health sector as X-rays is used to diagnose the presence of a disease in the form of anatomical images of the body shown in radiographic films [2]. Radiation has benefits and causes radiation effects. The effects of radiation can have an impact on receiving excessive exposure doses to workers and the community. Radiation is emitted from the radiation source in all directions so that the closer the body is to the radiation source, the greater the radiation exposure received. Partial radiation exposure will be scattering radiation when it hits the material. This scattering radiation will increase the amount of radiation dose received [3]. The effort to protect these workers is to use radiation protection. Radiation protection that must be applied includes distance, time, and radiation resistance. The distance of workers is expected to be as far as possible from the radiation source, the shortest possible time in the radiation area, and for radiation containment must use personal protective equipment (PPE) and take shelter behind a wall during exposure [4]. Radiation containment is divided into two, namely source anchoring and structural anchoring. Source anchors are integrated with X-ray equipment while structural anchors are divided into two, namely primary radiation anchors that protect against useful rays and secondary radiation anchors that protect against scattering secondary radiation and leaking secondary radiation [5]. Based on Perka Bapeten No. 8 of 2011 concerning radiation safety in the use of X-ray aircraft regarding the building design quality assurance program, the dose limit value must meet the requirements for radiation workers, namely 10 mSv per year or 0.2 mSv per week equivalent to 0.57 mR per hour and for the community of 0.5 mSv per year or 0.01 mSv per week equivalent to 0.03 mR per hour [6].

To prevent and minimize radiation hazards, research is needed on the rate of exposure to X-ray radiation on the walls of the ATRO Bali diagnostic laboratory room to protect radiation workers, staff, and students considering that radiation is odorless and invisible but harmful to health and safety. Continuous radiation exposure can cause health problems to death [7].

II. RESEARCH METHODS

The research was carried out at the Academy of Radiodiagnostic and Radiotherapy Engineering (ATRO) in Bali. The tools used in this study were X-ray aircraft brand medical Instrument System (MIS) type MXHF-1300R, surveymeter brand Fluka, and meter. The first step taken for measuring the dose of radiation exposure indoors and outdoors is to determine the primary radiation retaining wall (A), the scattering secondary radiation retaining wall (B and D) and the leaking secondary radiation retaining wall (C). The primary radiation retaining wall is divided into three measurement points with a distance of 138.7 cm marked with A1, A2, A3 (indoors) and A1', A2', A3' (outdoors). The scattering secondary radiation retaining wall is each divided into four points with a distance of 137.5 cm marked with B1, B2, B3, B4 and D1, D2, D3, D4 (indoors), while outdoors is marked with B1', B2', B3', B4' and D1', D2', D3', D4'. For the retaining wall of leaking secondary radiation is divided into three points by a distance of 138.7 cm namely C1, C2, C3 (indoors) and C1', C2', C3' (outdoors). The division of measurement points indoors and outdoors is shown in Figure 1 and Figure 2.

Before measurement, the X-ray plane is turned on and a warming-up procedure is carried out. Next set the exposure factor with a voltage of 80 kV, a current of 200 mA within an exposure time of 0.060 s, then turn on the surveymeter in integral mode (accumulate the measured dose) and put it at the measurement point. Direct the X-ray tube to the primary wall, then expose it and record the dose of exposure. The above steps are also carried out for scattering secondary walls and leaking secondary with the direction of the tube on the primary wall.

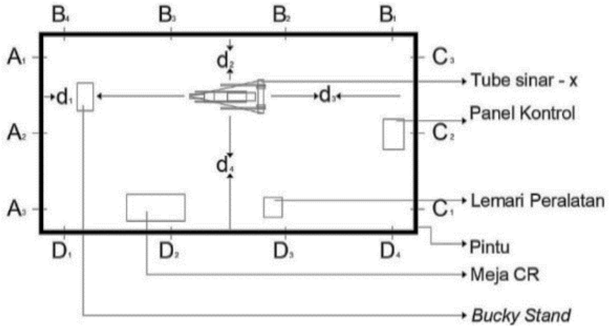

Figure 2.1. Measurement points in the room.

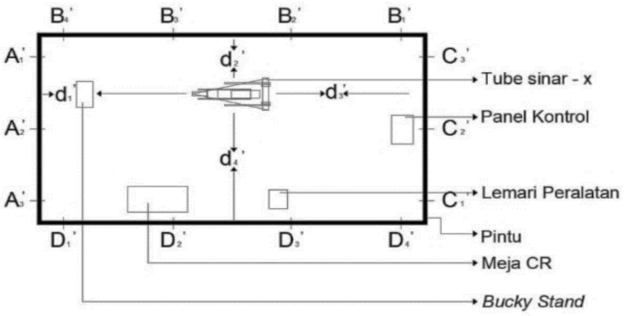

Figure 2.2. Outdoor measurement points.

III. PEMBAHASAN

The total use of the exposure factor in five weeks is 250 exposures with an exposure factor in the form of a total voltage of 17006 kV, a current of 43300 mA, and an exposure time of 26.936 seconds so that a workload of 3887.762666 mA minutes/week is obtained. The calculation of the value of the transmission factor or wall absorption in controlled and uncontrolled areas on wall A, wall B, wall C, and wall D will be reviewed as follows. The values of wall transmission factors B and D are calculated by taking into account the constants P, T, and a, where the P value is 0.01 R/week for uncontrolled areas. Furthermore, the value of T (occupancy factor) is determined based on the presence of a person behind walls B or D. In the ATRO Bali diagnostic laboratory the presence of a person is only occasionally behind the wall so that the value of T is chosen at 1/16 [12], and for the scattering angle value (a) based on the voltage used in the ATRO Bali diagnostic laboratory. The voltage used is 80 kV so it is between 70 kV and 100 kV see Table 3.1.

The value of the transmission factor for wall C is determined based on the value of constant P and T where the P value is 0.01 R / week for uncontrolled areas and the value of T is determined based on the presence of someone behind the wall C. In the ATRO Bali diagnostic laboratory because the presence of a person is not continuous, but relatively often so that the value of T is used by 1/4 [12].

Table 3.1. The calculation of the rate of radiation exposure in the room.

Measurement Points	Exposure Rate A (mR/jam)	Exposure Rate B (mR/jam)	Exposure Rate C (mR/jam)	Exposure Rate D (mR/jam)
1	$2{,}705 \times 10^{-7}$	$1{,}093 \times 10^{-8}$	$0{,}437 \times 10^{-7}$	$1{,}892 \times 10^{-8}$
2	$0{,}394 \times 10^{-7}$	$2{,}738 \times 10^{-7}$	$0{,}952 \times 10^{-7}$	$0{,}716 \times 10^{-7}$
3	$2{,}185 \times 10^{-8}$	$1{,}367 \times 10^{-7}$	$0{,}476 \times 10^{-7}$	$0{,}874 \times 10^{-7}$

4	-	$2,184 \times 10^{-7}$	-	$1,288 \times 10^{-7}$
Average	$1,106 \times 10^{-7}$	$1,600 \times 10^{-7}$	$6,217 \times 10^{-8}$	$7,668 \times 10^{-8}$

This transmission factor value will then be used in the X-ray attenuation diagram to determine the minimum thickness of the concrete wall that must be used to avoid X-ray radiation leakage. Because the X-ray attenuation diagram does not show exactly the voltage of 80 kV which is the 80 kV voltage that is often used in student practicum at ATRO Bali, to determine the thickness of concrete on the laboratory wall, a voltage range between 70 kV to 100 kV is selected as stated in the X-ray attenuation diagram. From the graph in Figure 3.1 it can be seen that the wall thickness in the ATRO Bali laboratory is thicker than the recommended wall thickness based on calculations. The recommended maximum wall thickness based on calculations is 28.27 cm, this value is based on the maximum voltage used, which is 100 kV. In practice, the voltage usually used in student practicum is only 80 kV. So based on calculations, the existing laboratory wall with a thickness of 29 cm is effective and able to withstand exposure to X-ray radiation.

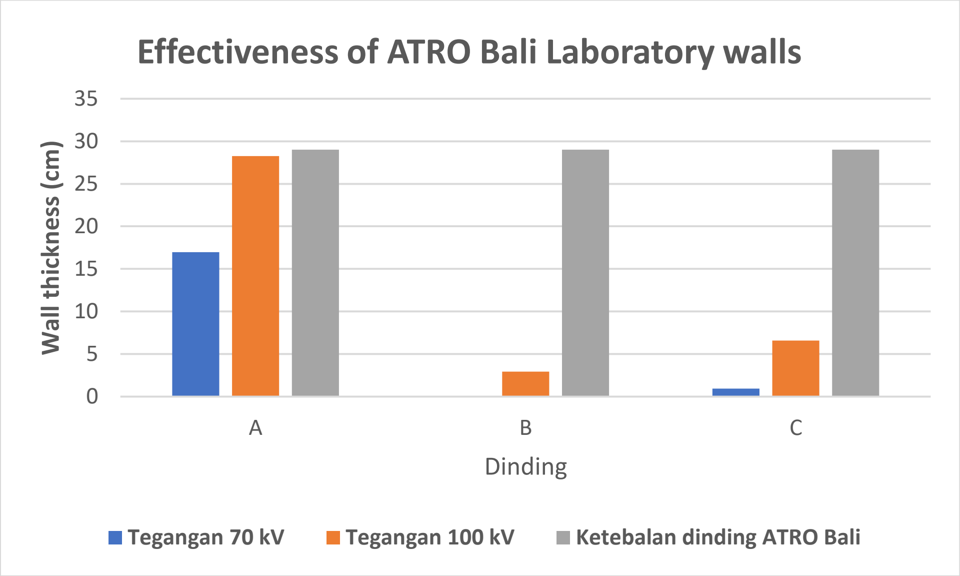

Figure 3.1 Effectiveness of ATRO Bali Laboratory walls at 70 kV and 100 kV voltages

IV. Conclusion

The calculation of the radiation exposure rate in the room is 1,106 × 10-7 mR/hour for wall A, 1,600 × 10-7 mR/hour for wall B, 6,217 × 10-8 mR/hour for wall C, 7,668 × 10-8 mR/hour for wall D and 0 mR/hour for all walls outside the laboratory room. The results of the calculation of the rate of radiation exposure indoors and outdoors compared to Perka Bapeten No. 8 of 2011 which stipulates NBD of 0.57 mR / hour for radiation workers and 0.03 mR / hour for the community, the existing walls are quite effective in resisting the rate of exposure to primary radiation and secondary radiation so that it is declared safe for radiation workers, non-radiation workers and the general public

ACKNOWLEDGMENTS

NLP Trisnawati thanks for funding this research from the fund DIPA PNBP Universitas Udayana TA-2022 following the Research Implementation Assignment Agreement Number: B/78.308/UN14.4. A/PT.01.03/2022, April 19, 2022

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