



Leakage Test of Conventional X-Ray Tube in Radiology Installation of Regional Hospital Prof. H. Muhammad Yamin, Sh

Cicillia Artitin^{1*}, Zaura Nofita², Nerifa Dewilza³, Chairun Nisa⁴

Baiturrahmah University Padang, West Sumatra, Indonesia

Corresponding Author: Cicillia Artitin: cicilliaartitin@atro.unbrah.ac.id

ARTICLE INFO

Keywords: Leak Test, X-ray Machine, Raysafe.

Received : 27, July

Revised : 20, August

Accepted: 25, September

©2026 Nofita, Artitin, Dewilza, Nisa (s): This is an open-access article distributed under the terms of the [Creative Commons Atribusi 4.0 Internasional](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

Quality Assurance, or QA, encompasses the overall management of a program to ensure excellence in medical care and ensure radiological health services. One component is Quality Assurance, or QC, which includes acceptance testing, routine performance monitoring, and error correction. The goal is to determine whether there are any leaks and whether the leak value exceeds the pass-through value set by BAPETEN (≤ 1 mGy/hour) for conventional X-ray machines. This quantitative research using an experimental method was conducted in the Radiology Unit of Prof. Muhammad Yamin, S.H. Pariaman Regional Hospital in June 2025. The exposure factor used was 102 kVp and 50 mA at a distance of 1 meter. The X-ray dose rate was measured using a Raysafe survey meter. The exposure process was repeated three times and then averaged. The average value was then subtracted from the background. The dose rate value was then calculated using the Leakage formula to determine the leakage value. In this study, the results of leakage on the right side were 8.316×10^{-4} , the front side was 9.174×10^{-4} , the left side was 5.742×10^{-4} , the top side was 1.353×10^{-3} and the bottom side was 1.1154×10^{-3} . The tube leakage value in this study was still in the category of passing test value ≤ 1 mGy/hour. Based on these results, it can be concluded that the conventional x-ray tube in the radiology installation of Prof. Muhammad Yamin, S.H. Pariaman Regional General Hospital experienced leakage but the value did not exceed the passing test value set by BAPETEN. Therefore, the right, front, left, top and back sides of the tube were declared safe.

INTRODUCTION

Quality Assurance or QA is the overall scope of the management program that is held to ensure medical excellence and ensure radiological health services. One part of QA is Quality insurance or QC, which is acceptance testing, routine performance monitoring, and error correction test evaluation. QA and QC are carried out to detect disorders early, reduce the rate of photo repetition and reduce the amount of radiation patients receive (Hidayah, 2021).

Each X-ray aircraft must be specified according to the safety of protective equipment with equipment, radiation, operational safety of patient protection, and compliance tests. Conformity tests are intended to ensure that the equipment used in diagnostic radiology procedures function correctly so that patients do not get unnecessary exposure, and implement a quality assurance program for diagnostic radiology (Hidayah, 2021).

Based on the Regulation of the Head of BAPETEN No. 2 of 2018, the Diagnostic Radiology X-ray Aircraft Conformity Test must be carried out by the permit holder for the use of diagnostic radiology x-ray aircraft. The conformity test is a series of testing activities to ensure that the X-ray device functions properly and reliably (BAPETEN, 2018). The results of this test must meet certain standards or tolerance limits so that they can be used as a guideline for facility owners to take the best steps, such as making repairs or replacing equipment that is no longer suitable (Carmelia, et al., 2023). Based on BAPETEN Regulation No. 2 of 2022, one of the conformity test parameters for General Radiography X-ray Aircraft is the tube container leak test, which has a $\leq$ test pass value of 1 mGy/hour (BAPETEN, 2022).

Leak tests on X-ray tubes are very important to find out if there is radiation leaking from areas where it shouldn't. In addition, this test aims to ensure that the equipment meets the set safety standards. Leak tests can also provide information about damage to certain equipment or components that need to be repaired or replaced. Performing these checks regularly will prevent more serious problems that can negatively impact the quality of X-ray images (Carmelia, et al., 2023).

Prof. H. Muhammad Yamin Regional General Hospital, SH is a class B hospital located in the city of Pariaman, West Sumatra. This hospital has a large number of patients. In the last 3 months, January, February and March 2025, the number of patient examinations at radiology installations reached 2,185 examinations. The average examination carried out at the radiology installation is 700 examinations per month.

With the frequency of use of the aircraft very often, it will affect the performance and function of the equipment. According to BAPETEN no. 2 of 2018, the certificate of conformity test for x-ray aircraft is only valid for four years. Meanwhile, at the Prof. H. Muhammad Yamin, SH Regional General Hospital, the conformity test was last carried out in 2018, and has not been carried out again for the past seven years. Which means that it has exceeded the validity period of the test for three years. So it is possible that there can be a leak in the tube. So this leak test is carried out to find out whether there is really a leak in the x-ray plane at the radiology installation of Muhammad Yamin, S.H. Leakage

test on the x-ray tube is a form of radiation protection to protect patients, workers and the environment from radiation hazards. Radiation protection according to BAPETEN is an action taken to reduce the damaging effects of radiation due to radiation exposure (BAPETEN, Regulation of the Nuclear Energy Supervisory Agency, 2020).

RESEARCH METHODS

This research is a type of quantitative research with experimental methods conducted at the Radiology of the Prof. Muhammad Yamin, S.H Pariaman Regional General Hospital in June 2025. The tools and materials used in this study include x-ray aircraft, Control panels, raysafe surveymeters, pb plates, stationery, Length measuring instruments, duct tape, and laptops.

The variables used in this study are the tube leakage test as an independent variable. And the results of tube house leakage as a bound or dependent variable. The data collection techniques used include literature studies, observation and documentation. Data was taken by positioning the surveymeter at a distance of 1 meter from five measurement points, namely left, right, front, back, and top of the x-ray tube. Then exposure was carried out with a voltage exposure factor of 102 kVp and a current of 50 mA, so that the dosage rate results from the surveymeter were obtained.

The data is then analyzed using quantitative techniques with experimental methods. The results of the raysafe surveymeter measurement are entered into the Leakage formula, namely:

$$\text{Leakage (L)} = \dot{X} \times (\text{mA}_{\text{con}}/\text{mA}_{\text{set}}) \times (1/1000) \text{ mGy/h}$$

Furthermore, the value of the tube leakage from the calculation results is compared to the value of passing the tube leakage test that has been determined by Bapeten. Based on BAPETEN Regulation No. 2 of 2022, one of the conformity test parameters on the General Radiography X-ray Aircraft is the tube container leakage test, which has a $\leq$ test pass value of 1 mGy/hour (BAPETEN, 2022).

RESULTS AND DISCUSSION

Research Results

A study has been conducted on the leakage test of conventional X-ray aircraft tubes of the Siemens brand with the Multi X fushion VA10 type based on BAPETEN (2020), using the Unfors Raysafe AB surveymeter at the radiology installation of Prof. H. Muhammad Yamin, SH, Pariaman Hospital. The test was carried out on five sides, namely right, front, left, top and rear at a distance of 1 meter from the X-ray tube to the surveymeter using a voltage of 102 kVp and a current of 50 mA. Exposure was carried out three times at each point.

The following results of the measurement of the radiation dose rate value are shown in table 4.1, and the highest reading value is in the upper position with 205.167 $\mu\text{Sv}/\text{hour}$. While the lowest is the left side with 86.967 $\mu\text{Sv}/\text{hour}$. Furthermore, this data can be used to determine radiation leakage.

Based on the measurement data of the dose rate value of each point in table 4.1, it can be seen that the largest value at the actual dose rate is at the top of 205.167 $\mu\text{Sv}/\text{hour}$ or 0.205 mGy/hour. From the measurement results, it is obtained that the leakage value is calculated by the formula:

$$\text{Leakage (L)} = \dot{X} \times (\text{mA}_{\text{con}}/\text{mA}_{\text{set}}) \times (1/1000) \text{ mGy/h}$$

1. **Right Side (A)** Leakage (L) = $0.126 \times (3.3/0.5) \times (1/1000) \text{ mGy/hr} = 8.316 \times 10^{-4} \text{ mGy/hr}$ On the right side there is a leakage of $8.316 \times 10^{-4} \text{ mGy/hr}$, it can be concluded that the right side is safe because it is still within the limit of the radiation leakage value of $< 1 \text{ mGy/h}$.
2. **Front Side (B)** Leakage (L) = $0.139 \times (3.3/0.5) \times (1/1000) \text{ mGy/h} = 9.174 \times 10^{-4} \text{ mGy/h}$ On the front side experiencing a leakage of $9.174 \times 10^{-4} \text{ mGy/hour}$, it can be concluded that the front side is safe because it is still within the limit of the radiation leakage value of $< 1 \text{ mGy/hour}$.
3. **Left Side (C)** Leakage (L) = $0.087 \times (3.3/0.5) \times (1/1000) \text{ mGy/hr} = 5.742 \times 10^{-4} \text{ mGy/hr}$ On the left side there is a leakage of $5.742 \times 10^{-4} \text{ mGy/hr}$, it can be concluded that the left side is safe because it is still within the limit of the radiation leakage value of $< 1 \text{ mGy/hr}$.
4. **Upper Side (D)** Leakage (L) = $0.205 \times (3.3/0.5) \times (1/1000) \text{ mGy/h} = 1.353 \times 10^{-3} \text{ mGy/h}$ On the upper side experiencing a leakage of $1.353 \times 10^{-3} \text{ mGy/hour}$, it can be concluded that the upper side is safe because it is still within the limit of the radiation leakage value $< 1 \text{ mGy/hour}$.
5. **Rear Side (E)** Leakage (L) = $0.169 \times (3.3/0.5) \times (1/1000) \text{ mGy/hr} = 1.1154 \times 10^{-3} \text{ mGy/hr}$ On the rear side experiencing a leakage of $1.1154 \times 10^{-3} \text{ mGy/hr}$, it can be concluded that the rear side is safe because it is still within the limit of the radiation leakage value of $< 1 \text{ mGy/hr}$.

Based on the data from table 4.1, the following is a table of the tube radiation leakage values obtained:

Table 4.2 X-ray Aircraft Tube Leak Calculation Results

Sides	Dosing rate – Background (mSv/h)	Dosing rate (mGy/h)	Leakage (L)	Test pass value (mGy/hour)
A (Right)	0,125733	0,126	$8,316 \times 10^{-4}$	< 1
B (Front)	0,139	0,139	$9,174 \times 10^{-4}$	< 1
C (Left)	0,086967	0,087	$5,742 \times 10^{-4}$	< 1
D (Top)	0,205167	0,205	$1,353 \times 10^{-3}$	< 1
E (Back)	0,169	0,169	1.1154×10^{-3}	< 1

DISCUSSION

The research was carried out with an exposure factor with a voltage of 102 kVp and a current of 50 mA. Perform the exposure and record the value read on the surveymeter. Exposure is carried out three times at each point starting from right, front, left, top and back. This applies to each side where the leakage value will be calculated. After the data is obtained, then move it to the measurement results table.

Based on the results of data processing, the leakage value for the right side was 8.316×10^{-4} mGy/hour, the front side was 9.174×10^{-4} mGy/hour, the left side was 5.742×10^{-4} mGy/hour, the upper side was 1.353×10^{-3} mGy/hour and the rear side was 1.1154×10^{-3} mGy/hour. This shows that there is a leak that occurred in the X-ray tube at the radiology installation of the Prof. Muhammad Yamin Regional General Hospital, S.H Pariaman. However, the leakage value in the X-ray tube is declared safe and not dangerous because it does not exceed the limit of radiation leakage value that has been set by BAPETEN (2022), which is ≤ 1 mGy/hour.

Based on the data in table 4.2, the highest leak value is found on the upper side, which is 1.353×10^{-3} mGy/hour or 0.001353 mGy/hour. However, this leak still does not exceed the tolerance limit value set by BAPETEN (2022), which is ≤ 1 mGy/hour.

The scattering of radiation at the top is secondary radiation that occurs due to the interaction of x-rays with the built-in filter of the x-ray tube. So most of the x-ray beams are scattered upwards. In the process of x-rays, some of the incoming photons are not absorbed but lose energy during interaction with the atoms that make up the tissue. This process is called scattering. This process occurs due to the interaction between diagnostic X-rays and matter, known as the Compton effect. The loss of energy of the incoming photon occurs when it ejects the outer shell electrons from the tissue atoms and changes direction. The electrons emitted are called Compton electrons or secondary electrons (Faubert, 2017).

Then based on table 4.2, it can be seen that the leakage value of the x-ray tube on the right side is 8.316×10^{-4} mGy/hour is greater than the left side, which

is 5.742×10^{-4} mGy/h. This is because of the anode heel effects that occur from the perspective of the tube. Where the x-rays have a higher intensity on the cathode side with a reduced intensity towards the anode side. When electrons hit the target anode, x-rays are generated, but some of these X-rays are absorbed by the target material itself before exiting the tube, so the intensity of the X-rays going to the side of the tube anode will be weaker (Fauber, 2017).

In the study that has been conducted (Carmelia, et al., 2023), on the Siemens brand conventional X-ray tube at the Radiology installation of Mangusaada Hospital, there was also a leak on the side of the tube. However, the leakage value also did not exceed the threshold determined by BAPETEN (2022), which is ≤ 1 mGy/hour. The highest leakage in the study was on the right side of the tube.

This shows that on average, the x-ray tube does have leaks on each side. It's just that what needs to be considered is the value of the leak. Where the leakage value that still has not exceeded the threshold determined by BAPETEN can be declared safe. However, if the leak value has exceeded the threshold set by BAPETEN, it means that it is declared unsafe and needs to be repaired or followed.

Meanwhile, according to Indah Dewi and Dinanda (2020), the impact that occurs when the leakage value exceeds the specified limit is excessive radiation exposure, which causes several adverse effects in the form of hair loss and skin damage. In addition, the high dose of radiation received will also cause a drastic reduction in the number of lymphocytes.

CONCLUSION

1. After conducting research on the x-ray plane at the radiology installation of the Prof. Muhammad Yamin, S.H Pariaman Regional General Hospital, it can be concluded that there was a leak in the x-ray tube. From the measurement results, the leakage value for the right side was 8.316×10^{-4} mGy/hour, the front side was 9.174×10^{-4} mGy/h, the left side was 5.742×10^{-4} mGy/h, the upper side was 1.353×10^{-3} mGy/hour and the rear side was 1.1154×10^{-3} mGy/h.
2. It is known that after conducting research using a surveymeter and data processing with the Leakage (L) formula, the leakage values on the right, front, left, top and back sides of the tube were declared safe because the leakage value did not exceed the radiation leakage value limit set by BAPETEN (2022), which is ≤ 1 mGy/hour.

SUGGESTIONS

The researcher recommends that conformity tests be carried out regularly. Because the frequency of machine use is very often worried that it affects the quality of the tool. Based on BAPETEN regulation no. 2 of 2018, the conformity test certificate is only valid for 4 years after issuance.

THANK YOU

Thank you to the Head of the DIII Radiology Study Program, Vocational Faculty of Baiturrahmah University and the Radiology Installation of Padang Hospital for the support and support provided to complete this research.

REFERENCE

- BAPETEN. (2020). *Peraturan Badan Pengawas Tenaga Nuklir. Keselamatan Radiasi pada Penggunaan Pesawat Sinar-X dalam Radiologi Diagnostik dan Intervensional*. Jakarta, Indonesia: BAPETEN.
- BAPETEN. (2018). *Peraturan Badan Pengawas Tenaga Nuklir. Uji Kesesuaian Pesawat Sinar-X Radiologi Diagnostik dan Intervensional*. Indonesia: jdih.bapeten.go.id.
- BAPETEN. (2022). *Peraturan Badan Pengawas Tenaga Nuklir. Perubahan atas Peraturan Badan Pengawas Tenaga Nuklir Nomor 2 Tahun 2018 tentang Uji Kesesuaian Pesawat Sinar-X Radiologi Diagnostik dan Intervensional*. Indonesia: jdih.bapeten.go.id.
- Carmelia, Y., Sutapa, G. N., Pranditayana, I. N., Suryatika, I. B., Sumadiyasa, I. M., & Gunawan, A. N. (2023). Uji Kebocoran Tabung Pesawat Sinar-X Konvensional di Instalasi Radiologi RSD Mangusada. *Prosiding Seminar Keselamatan Nuklir*, 368-371.
- Fauber, T. L. (2017). *Radiographic Imaging and Exposure*. Missouri: Elsevier.
- Hidayah, N. (2021). Uji Kebocoran Tabung Pesawat Sinar-X Mobile di Universitas 'Aisyiyah Yogyakarta. *Naskah Publikasi*, 1-8.