Dosimeter Co-Card Alarm X-ray Radiation Dosage Monitoring Instrument

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Abstract. One type of radiation which is widely used in the field of radiodiagnostic is ionizing radiation. This radiation is a type of radiation with the source of radiation from X-ray devices used in many medical purposes such as Roentgen. Besides giving benefits, radiation has an adverse effect on health when it exceeds specified dose limit. Monitoring radiation doses for most hospitals in Indonesia use passive dosimeters that monitored every month. Dosimeter Co-Card Alarm (DOSCA) is an innovative instrument that combines the application of surveymeter as a gage of dose velocity and dose meter as a gage of radiation dose simultaneously and directly with component advanced electronic in occupational safety and health efforts in the radiation field. At function test in radiology of RSI PDHI Yogyakarta use comparison instrument brand BliT made in China, which is controlled by voltage that starts from 50kV until 90kV, 65mA and 0,08s. The average result of the difference in value obtained between BliT and DOSCA is 0.03μSv. Then the function test in CV. Sehat Sejahtera using voltage 60kV with 5mAs and 10mAs showed the average result of the difference by 0,01µSv. The results of testing instrument showed that DOSCA were able to detect X-ray radiation well.

1. Introduction
Radiation is the release of energy emitted by radiation sources in form of particles or electromagnetic waves without the need for a medium. One type of radiation that is widely used in the radiodiagnostic field is ionizing radiation [1][2]. This radiation is a type of radiation from X-ray devices used for various types of medical diagnostic needs such as x-rays scanner (Roentgen) and another various benefits. In addition to providing beneficial effect on its utilization, radiation also has harmful effect on human health if it is not aware of the required dose limit value [3][4].

Based on the Decree of the Head of Bapeten Number 4 of 2013, the dose limit value for effective doses received by radiation workers or radiographers is an average of 20 mSv per year in a 5 year period, so that the accumulated dose must not exceed 100 mSv [5][6]. The negative effects took place if the radiation received by the radiographer exceeds the specified dose limit, known as somatic effect and genetic effect. Somatic effects are effects that are felt directly by the radiographer because of receiving the radiation [7][8]. While the genetic effect is the effect felt by the offspring. Moreover, radiation can also cause cell changing as a stochastic effect and even cell death as a deterministic effect. Stochastic effects, are the effects of radiation that occur after a quiet period (latent period), such as cancer and leukemia. Deterministic effects, namely the effects felt by someone several moments later after the exposure of radiation that exceeds the dose, such as infertility, cataracts, burns and others [9][10]. The results of the study on the atomic bomb victims of Hiroshima and Nagasaki based on data from the Life
Span Study (LSS) have shown that the risk of death increased significantly due to 22% radiation at 1 Gy, 47% cancer incidence at 1 Gy, 31% leukemia deaths at 1 Gy, and occurrence of several diseases such as hypertension, thyroid gland, uterine myoma and others [11][12].

Radiation is also invisible matter that cannot be felt or known of its existence because human beings do not have the five senses that are capable of detecting the presence of radiation. Therefore, for the work safety a radiographer is attempted to receive minimum radiation dose, through monitoring by radiation measuring device continuously while being in the radiation field. The radiation monitoring tool used by radiographer is a dosimeter. Dosimeters work by detecting radiation in accumulation, the value of the radiation dose received is summed with the value of the radiation dose that has been previously encountered. Dosimeters used by radiographers must be small and light so that they will not be burden while being in the radiation field. Dosimeters widely used by radiographers in several hospitals are pocket dosimeters imported from outside Indonesia with relatively expensive prices.[13][14]

The advantage of pocket dosimeters compared to other types of dosimeters are that they are lightweight and practical to use when in the radiation field. The weakness is that it cannot display information on the dose received directly because it requires additional equipment (reader) to read the results of the doses that have been received and require high accuracy for reading needle deviations [13][15].

Based on the above problems, DOSCA (Dosimeter Co-Card Alarm) tool is designed as innovation of a tool that combines surveymeter technology as a dose rate reader and dosimeter as a portable, lightweight radiation dose reader and using advanced electronic components that are easily available in Indonesian market. DOSCA also has several advantages from the previous tool, which is the monitoring information on the value of received radiation doses that can be seen directly through OLED display (Organic Light Emitting Diode) that do not require backlighting so that it saves power for the lighting, moreover its equipped with a long-term dose value storage system using EEPROM facility (Electrically Erasable Programmable Read-Only Memory) on the Atmega328p chip which function is to perceive and evaluate doses that have been received periodically and a safety system for radiographers using buzzers and LEDs (Light Emitting Diode) that serving as an indicator of radiation received by detector is added.

2. Literature Review

2.1. TLD (Thermoluminisence Dosimeter)

The research of Wahyuningsih and Sri Suliyanto (2009) with the title "Evaluation of Radiation Exposure to External Doses Received by Radiation Workers" has been aimed to measure the radiation dose received by workers using dosimeter TLD, where the readings are by heating luminance cells [16]. Radiation dose data received by workers have been monitored per week and then taken to produce average data per month and averaged to produce data per year. The radiation dose recorded by the dosimeter TLD have been read using additional equipment in the laboratory, namely the TLD reader. This is certainly not effective and efficient because it requires a long time to read which can endanger the health and safety of the radiographer.

2.2. Surveymeter

Based on research conducted by S. Rudi and Susilo (2013) with the title "Measurement of Radiation X-ray Aircraft Exposure in Radiodiagnostic Installation for Radiation Protection", monitoring radiation doses have received by radiographers using a surveymeter device[17][18]. This tool reads the dose rate on the radiation field before or after exposure using an analog system, the reading the dose information seen through the movement of the needle. The weakness of this tool is that it requires high accuracy on reading needle irregularities, is not portable, heavy and can only read the radiation dose rate.[19]

Based on the results of previous studies, the innovation of portable, practical, effective and efficient dosimeter tool that not only reads the radiation dose rates around but is equipped with a reading of the
dose value received by the radiographer directly while in the radiation field through a digital display was made. The radiation dose received while in the radiation field is as following equation (1).

\[ D = D_0 \cdot T \]  

Where:
- \( D \) = accumulated dose received by workers
- \( D_0 \) = dose rate in the radiation field
- \( T \) = duration of worker in the radiation field

The detector used as a radiation reader on DOSCA is Geiger Muller. The radiation exposing this detector is proportional to the intensity of the radiation received. The longer the radiographer is in the radiation field, the higher the radiation dose received according to the equation [7]

3. Methodology

3.1 Determining of Tool Features and Specifications

Determining the features and specifications of the tool at his stage determined the use of the main and supporting components. Moreover, it was needed to create a DOSCA work system which consists of: control system, radiation reading system and power system. The block diagram can be seen in Fig. 1

![Fig. 1 Overall Block Diagram](image)

3.2 Planning the Instrument Diagram

The design of the instrument was adapting the results of determining the features and specifications of the instruments that previously existed. The planning of the instrument design was expected optimally functional to detect X-ray device radiation as Fig. 2
3.3 Instrument Making

The making of the instrument was done at the UMY Electromedical Engineering Laboratory and CV. Sehat Sejahtera. The making of this DOSCA was through several processes, namely:

- Hardware design included designing a series of HV (High Voltage) DC (Direct Current) Generators, ATmega328p microcontrollers, equipped with modules for batteries recharge, OLED display circuit modules and detector stands which are then integrated into the box.

- The software design uses Arduino software to program the ATmega328p chip which gives commands to the hardware series to process the analog data output from the geiger muller detector into digital data then converts it to a dose value and displays using an OLED display as in Fig. 3.

3.4 Instrument Testing

Direct testing was carried out at the radiology of the RSHI PDHI Yogyakarta on July 09 2018 and CV. Sehat Sejahtera on July 12 2018 which had received the approval of various parties to ensure that this tool is functioning properly and in accordance to the expected goals. If the function test has obtained good results, then it can be proceeded to the next stage. The test method was by placing dosimeter at a distance of 100 cm below the collimator of the X-ray device. Schematic process of testing the tool as in Fig. 4.
3.5 Analysis

At this stage an analysis of the instrument regarding the efficiency, effectiveness, economic value and others would be carried out. This analysis aims to study whether this instrument still has deficiencies and can be implemented by the radiographer while on the radiation field.

4. Results and Discussion

Based on the test results obtained the radiation dose value data received by DOSCA as in Table I. Tests are carried out with the value (kV) changing while the value (mA) and (s) remain. The value (kV) is set from 50 kV to 90 kV with 65 mA and 0.08 s. The radiation dose read on DOSCA does not have much of differences from the BLiT used during the function test. At exposure of 50 kV the dosage value on DOSCA and BLiT read 0.01 µSv, then again with 60 kV the DOSCA read 0.02 µSv and BLiT read 0.04 µSv. Exposures of 70 kV the DOSCA read 0.02 µSv and at BLiT 0.06 µSv. At 80 kV the DOSCA 0.03 µSv and BLiT 0.07 µSv. Expose with a value of 90 kV the DOSCA reads 0.03 µSv and BLiT reads 0.09 µSv. In addition, the average difference in reading the dose value obtained between BLiT and DOSCA with 5 times test based on equation (2) which can be seen graphically in Fig. 5 where function test charts at PDHI Yogyakarta hospital

\[
\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \quad (2)
\]

\[
= \frac{0.16}{5} = 0.03 \mu Sv
\]

![Fig. 5 Function Test Charts at PDHI Yogyakarta Hospital](image)

**Table 1. Test Result of Instrument Function by changing kV, Fixed MA and Fixes s**

| Test | kV  | mA | s    | BLiT (µSv) | DOSCA (µSv) | Differences of BLiT and DOSCA (µSv) |
|------|-----|----|------|------------|-------------|-------------------------------------|
| 1    | 50  | 65 | 0.08 | 0.01       | 0.01        | 0.00                                |
| 2    | 60  | 65 | 0.08 | 0.04       | 0.02        | 0.02                                |
| 3    | 70  | 65 | 0.08 | 0.06       | 0.02        | 0.04                                |
| 4    | 80  | 65 | 0.08 | 0.07       | 0.03        | 0.04                                |
| 5    | 90  | 65 | 0.08 | 0.09       | 0.03        | 0.06                                |
the average difference that is not much different from the BLiT instrument which is 0.03 µSv as in Fig. 5. This occurs because of the differences in tolerance between the components used in BLiT and the components used in DOSCA and the difference in sensitivity of the detector used to detect X-ray radiation.

Function Test Result Graph obtained on CV. Sehat Sejahtera can be seen in Fig. 6 which does not have much differences from the results obtained on the testing at the RSHI PDHI Yogyakarta. The function test in CV. Sehat Sejahtera has a difference 0.01 µSv. It is proven that between the flash and DOSCA the difference value is still at the limit

5. Conclusion

The conclusion that can be drawn from the results of the application of the DOSCA instrument with a standard comparison tool of Chinese-made BLiT brands on X-ray radiation is good performance shown by the dosage values radiation DOSCA does not have much of differences from BLiT which has means difference of 0.03 µSv for the function test carried out at the Yogyakarta RSHI PDHI and 0.01 µSv for the function tests performed at CV. Sehat Sejahtera. The test results shows that DOSCA is able to detect X-ray device radiation well and could be implemented directly by the Radiographer patie

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