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# DOSIMETRIC PERFORMANCE OF INSTADOSE DOSIMETER IN PERSONNEL EXTERNAL DOSIMETRY

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ABSTRACT

**Background:** Instadose dosimetry system is gaining popularity and becoming widely acceptable in most hospitals competing with the most commonly used Thermolumniscence and film badge dosimeters in personal radiation monitoring.

**Objective:** In this study, the dosimetric performance test of Miron instadose in radiodiagnosis and radiotherapy for in vivo measurements was evaluated to determine its dosimetric accuracy and reliability with respect to badge homogeneity, reproducibility, linearity and fading of dosimeters to continuous x-ray beams exposure.

**Methods:** The instadose dosimeter badges were serially irradiated to high doses of radiation under controlled conditions with GE x-ray facility (GE haulum with model number XR 6000 and Serial number S0S09084. Manufactured 2009) and readings of absorbed doses were obtained from a Portable Computer (PC) with internet access. The quantities measured are personal dose equivalents; Hp (10), Hp (3) and Hp (0.07) (all in mSv) representing deep, eye lens and shallow doses respectively. The readings were tabulated, presented and calculations were performed to determine the tests performance based on the criteria of International Electrotechnical Commission standard.

**Results:** Results showed 9% of badge homogeneity, 7.2% and 3.3% collectively and separately respectively for badges reproducibility test, 6.5% averaged for linearity and 0.0% in fading/stability performance test.

**Conclusion:** Miron instadose performance tests conducted were compared with the performance criteria of the International Standard on TL Dosimetry System for Personal Monitoring 'IEC 1066 standard' and were found to satisfy the criteria of the standard, thus, recommending the dosimeters for official personal monitoring of radiation under clinical settings (radiodiagnosis and radiotherapy).

## INTRODUCTION

Radiation dosimeters exhibit several desirable characteristics, but not all dosimeters can satisfy all characteristics [1]. Dosimeter choice must therefore, be made judiciously, taking into account the requirements of the measurement situation [2]. Radiation dosimetry is used for radiation protection principles and is normally applied to occupationally exposed radiation workers, where there is expected irradiation without exceeding regulatory levels [3]. Other significant areas are medical dosimetry, in which the required absorbed treatment dose and any other absorbed collateral dose is monitored, and in environmental dosimetry, like monitoring of radon in buildings [4].

A dosimeter or a radiation dosimeter can be described as an instrument or a device used measuring or evaluating, directly or indirectly, the radiation exposure, absorbed/equivalent dose, dose rates, kerma and other quantities associated to ionizing radiation [1,5]. A dosimeter and its reader are called a dosimetry system.

The instadose is a simple, rugged and small lightweight passive dosimeter that operates based on the principle of proprietary direct ion storage technology [6,7]. The new technology gives radiation staff accurate measurement of radiation dose including exact long term radiation exposure tracking. A memory chip (built in) records each user's ID through fixed and unique serial code assigned to the card holder. The dosimeter holders have the ability to view their modified radiation dose at a time using a computer with internet access [8,9]. Readings from a portable computer (PC) are permitted by a universal serial bus (USB) compatible detector. When a staff obtains instadose meter, the first thing to do is to register at; www.instadose.com. At the time of the registration procedure, the instadose client and driver are installed on the owners' PC and the meter is activated for use. If the user desires to view a result they simply visit the website and log-in to the user account, after plugging the instadose to a universal serial bus port and click 'Read Device'.

Accumulated dose recorded on instadose is processed via a proprietary computer mathematical algorithm [1,6]. It is an automated data transfer that minimizes the chance of human error and misidentification. After a complete processing of data, a graphical representation of the currently received dose will display on the screen [10]. Some of the characteristics of instadose design that makes it an appropriate dosimeter include; it's lightweight and small in design, photon energy response of 5 keV - 6 MeV, dose reading online by user, it has a minimum reportable Dose of 0.03 mSv, it has a range of useful dose 0.03 mSv - 5 Sv [8,11].

The findings of this research have provided performance indices that will serve as a baseline data to Radiographers, Radiologists, Medical physicists and Oncologists in judicial use of Instadose dosimeter.

## MATERIALS AND METHOD

### Materials

#### I. Instadose dosimeter system (Miron Instadose meters, USB and PC)

The detectors are manufactured by Miron Technologies Inc. USA as shown in Plate 1. It has a badge type of 18 - Hard Ring 31 - ID1 and 19 - MeasuRing® 37 - ID+. It measures and stores the amount of x-radiation produced by the X-ray machine at a given distance. Measured doses are obtained by connecting the meter via USB to a PC with internet access and logging into the meter account.

**Plate 1:** Instadose Dosimeter [6]

#### ii. X ray Machine

GE HUALUM Medical Radiography X-ray Systems with Model number XR 6000, Serial number S0S09084 and frequency of 50/60Hz manufactured October 2009 was used for irradiating the Instadose meters. The components of this machine work in concert to create a beam of x-ray photons of well-defined intensity, penetrability, and spatial distribution.

**iii. Portable Computer**

SAMSUNG laptop computer with model number NP-N130 and Intel Atom inside made in China was used to access the absorbed doses by the instadose meters.

**Method of performance evaluation test of Miron instadose**

A series of control experiments were performed by exposing the Instadose to a range of doses at a focal distance of 1 meter. The quantities measured are personal dose equivalents; Hp (10), Hp (3) and Hp (0.07) representing deep, eye lens and shallow doses respectively. After each exposure, the dosimeters are connected to the PC via a USB port and connecting the system to internet and login to www.instadose.com.

The following response uniformity tests were conducted,

**i. Homogeneity of instadose dosimeter**

Eight (8) Instadose dosimeters were irradiated to the same level of radiation exposure factors (120kv:250mAs) under control conditions. The measurements of the readings were used to analyze the test criteria. Variation of readings for Instadose was evaluated using maximum and minimum values $D_{max}$ and $D_{min}$ as follows [12];

$$\frac{D_{max} - D_{min}}{D_{min}} \leq 30\% \quad \text{(equation 1)}$$

**ii. Reproducibility**

Five (5) instadose dosimeters were irradiated using 150kv:250mAs and their readings were obtained. This procedure is repeated three times to enable the evaluation of variations of readings for each dosimeter. The mean,

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \quad \text{(equation 2)}$$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad \text{(equation 3)}$$

Where $x_i$ : Reading of H*(d)

$\bar{x}$ : Average reading of H*(d)

$$\text{Co} - \text{efficient of variation} = \frac{\sigma_{n-1} \times 100}{\bar{x}} \quad \text{(equation 4)}$$

**iii. Linearity**

Five (5) dosimeters were irradiated to different exposure factors progressively (in order of increasing dose). The readings were compared to that of a reference dosimeter in order to evaluate percentage variation of readings. The deviation of measured dose from the irradiated dose was calculated using expression (5)

$$\frac{\text{Measured dose} - \text{Irradiated dose}}{\text{Irradiated dose}} \times 100$$

(equation 5)

**iv. Fading (Stability)**

Five (5) dosimeters were irradiated at different exposure cycles at an interval of 30 days, two weeks, 48hr, 24hr and 0hr chronologically. All dosimeters were read and normalized to the dosimeters irradiated on day 0. The fading of readings was evaluated.

**RESULTS**

The results of these tests were presented in tables and evaluated according to the established performance criteria, which are based on the fulfillment of the levels of accuracy and precision required for this type of service.

From the **homogeneity test**, the maximum and minimum values of dose evaluated were 22.96 mSv and 21.03 mSv as shown in Table 1. Substituting the evaluated values in equation 1, a factor of 0.09 was obtained representing 9% of percentage variation of readings. The mean of the evaluated doses and the standard deviation were 22.02 mSv and 0.02 mSv.

| S/No. | Instadose readings (mSv) | | |
|---|---|---|---|
| | Hp(10) | Hp(3) | Hp(0.07) |
| 1 | 22.29 | 22.29 | 22.29 |
| 2 | 22.96 | 22.96 | 22.96 |
| 3 | 21.90 | 21.90 | 21.90 |
| 4 | 22.00 | 22.00 | 22.00 |
| 5 | 22.49 | 22.49 | 22.49 |
| 6 | 21.03 | 21.03 | 21.03 |
| 7 | 22.24 | 22.24 | 22.24 |
| 8 | 21.21 | 21.21 | 21.21 |

The quantities of the instadose badge used are personal dose equivalent Hp(10) for deep dose, Hp(3) for eye lens and Hp(0.07) for shallow dose

In the **reproducibility test**, using the data obtained in Table 2, individual sensitivity responses were obtained in the range of 20.96 mSv to 22.96 mSv. The standard deviation,

**Table 2:** Sensitivity response variation of Instadose to three given irradiations and readings for Hp (10)

| S/No. | Readings obtained according to irradiation (mSv) | | |
|---|---|---|---|
| | 1st Irradiation | 2nd Irradiation | 3rd Irradiation |
| 1 | 22.96 | 22.49 | 22.24 |
| 2 | 21.90 | 21.03 | 20.96 |
| 3 | 22.24 | 22.90 | 22.49 |
| 4 | 22.29 | 22.00 | 21.90 |
| 5 | 22.49 | 22.24 | 22.03 |

In **linearity test**, using the data in Table 3, a graph of the average measured readings of the irradiations against the irradiated dose showed a linear correlation as shown in Figure 1.

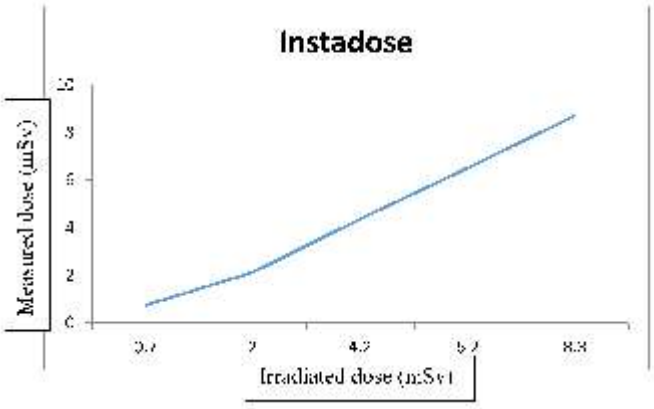


**Figure 1:** Linearity of Instadose dosimeters for Hp (10)

Also, the percentage deviation of measured dose from the irradiated dose was calculated using equation 5 and was found to be between 3.8% and 6.5%.

**Table 3:** Linearity of responses from Instadose for dose range of 0.7 mSv to 8.3 mSv in air

| Irradiated dose (mSv) | Measured dose (mSv) for Instadose |
|---|---|
| 0.7 | 0.74 |
| 2.0 | 2.50 |
| 4.2 | 4.66 |
| 6.2 | 6.50 |
| 8.3 | 8.70 |

The results of the fading (stability) check, has revealed that there was no any significant fading over the storage period. The evaluated loss of signal value was found to be less than 2%. Thus, the IEC 1066 requirement, which is 10% for 90 days under standard test conditions, is met.

Table 4, summarizes the instadose performance test results and compared the results to the IEC 1066 standard.

Table 4: Summary and comparison of results of Instadose dosimeter characteristics performance evaluation

| Evaluation | IEC 1066 Performance criteria for TLD | Results obtained for Instadose |
|---|---|---|
| Badge Homogeneity | The difference between the maximum and minimum evaluated values should not exceed 30% | 9% |
| Reproducibility of Badges | The co-efficient of variation should not exceed 7.5% for each dosimeter separately and all dosimeters collectively | 3.3% separately 7.2% collectively |
| Linearity | The dosimeters response variation should not be more than 10% over the range of 0.1 mSv to 1 Sv | 6.5% |
| Stability | Evaluated values of dosimeters shall not differ from the conventional values by more than 10% for 90 days at $25^0$ | 0.0% for 30 days at $25^0$ |

## DISCUSSION

The response uniformity check was performed based on the tests methods of International standard on Thermoluminescent dosimetry system for personal monitoring published by the International Electro technical Commission (IEC) standard (IEC 1066).

The result values for homogeneity are far below the recommended value by IEC 1066 standard (0.3),

this shows that the Miron instadose has a very good homogeneity. This may be due to the custom material made of the dosimeter (semiconductor). Reproducibility values demonstrate that the requirement of the IEC 1066 standard (7.5%) is met [12]. Linearity and fading performance values also indicate that the IEC 1066 standard requirement has been met.

In general, the performance test results are in tandem with Garzón *et al.* (2018) in their study to verify the performance of Miron Instadose dosimeter for interventional radiology and cardiology application under clinical x-ray field conditions [6] and Bappah *et al.* (2019) in the evaluation of the performance of TLDs in in vivo dosimetry [2]. It also tallies with Nguyen *et al.* (2001) and Daniel *et al.* (2000) in their studies differently to evaluate the performance of Direct Ion Storage (DIS) dosimeter and TLD respectively based on the test recommended by the IEC 1066 standard [13,14].

## CONCLUSION

The performance of Instadose dosimeter system has been studied under clinical conditions. The dosimeters were evaluated based on the criteria of IEC 1066 standard for personal monitoring. The results of the tests carried out were homogeneity, reproducibility, linearity and stability which have shown that, Miron instadose have a good performance and has pass the entire tests requirement carried out. Based on the result of this study, Instadose dosimeter is recommended for routine personal x-radiation monitoring in both radiodiagnosis and radiotherapy.

### Declaration

There is no conflict of interest in connection with this research study.

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