TYPE TEST INFORMATION OF THE NEW INSTADOSE PERSONAL DOSIMETER

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Abstract - Instadose™ is a small, rugged dosimeter based on patented direct ion storage technology. Instadose™ currently has accreditations in the United States (ANSI/HPS N13.11-2009), the United Kingdom through the Health and Safety Executive, the United Arab Emirates, Nigeria, New Zealand, and Australia. The technology eliminates the need for radiation workers to return their personal dosimeter to a processor. This is accomplished through the utilization of a computer's USB port and Internet access to read and record the individual's dose. Eliminating the need for shipping using the Instadose™ dosimeter not only decreases the amount of time a dosimetry administrator spends collecting and distributing personal radiation dosimeters, but also removes the variability introduced in the form of transit doses, without sacrificing the quality of their dosimetry programs. This paper discusses the in-depth type testing of the Instadose™ dosimeter.

Key Words: instadose, USB, internet, dosimeter

INTRODUCTION

The Instadose dosimeter is a small, rugged dosimeter based on patented direct ion storage technology. The Instadose dosimeter is currently NVLAP accredited for all photon test categories under ANSI/HPS N13.11-2009, in the United Kingdom under the Health and Safety Executive, in the United Arab Emirates, Nigeria, New Zealand, and Australia. The Instadose dosimeter was launched in June 2009 and continues to grow its client and country accreditation base. The technology provides radiation workers the ability to eliminate the need to return their personal dosimeter to a processor. This is accomplished by allowing any computer with internet access the ability to read and record the individual's doses using the computer's USB drive.

Dosimeter Theory: The Instadose dosimeter utilizes the Direct Ion Storage (DIS) for its radiation detection. DIS is a non-volatile analog memory cell surrounded by a gas filled ion chamber. DIS technology has been in use in personal radiation dosimeters for over 20 years, primarily in the DIS-1 dosimeter.

Test Data Review: Over the last couple years, many tests were conducted on the Instadose dosimeter. Many of the tests were conducted in accordance with the IEC 62387 standard, but some were conducted to ensure a positive customer experience. Tests include:

- Energy response tests
- Angularity response tests
- Response at various temperatures
- Drop Tests
- Computer USB Power tests
- Low Dose Tests
- Dose Rate Tests
- Dose Linearity

This paper will discuss the results of these tests.

Operational Experiences: Since the Instadose dosimeter utilizes a unique method for distribution of personal radiation exposure results by having the individual wearer perform the reading, there have been some operational nuances learned through the fielding of the Instadose dosimeter, to include:

- How to ensure users read their dosimeter
- User PC compatibility issues (i.e. firewalls, proxy servers, USB ports)
- Temperature effects on the Instadose dosimeter

A discussion of each will be highlighted.

DOSIMETER THEORY

The DIS technology utilizes a non-volatile analog memory cell surrounded by a gas filled ion chamber. For photon radiation, intial interactions take place in the wall material and secondary electrons ionize the gas inside the chamber. Dose is determined by taking the difference in charge from one read event to the next. Figure 1 below shows how the technology works:

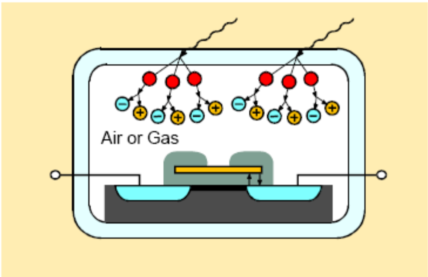


Figure 1 – DIS technology operations

The Instadose dosimeter in conjunction with the web-based software performs the calculations of dose and only the dose accumulated between two reads is reported. The overall cumulative dose is maintained, but not shown to the end user.

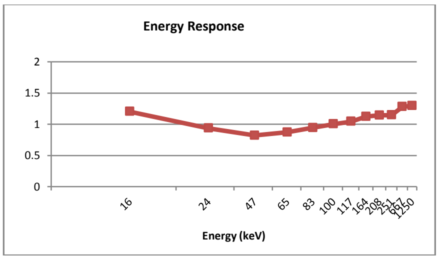
The Instadose dosimeter contains two ion storage chambers. The first chamber (DL) is used to accurately measure dose from 0.01 mSv to approximately 120 mSv cumulative dose. Doses exceeding 120 mSv are calculated using the second chamber (DH).

The DL chamber can detect 0.01 mSv changes in dose, but the DH chamber detects increments of 1.00 mSv.

TEST DATA REVIEW

Photon Energy Response Test

The dosimeter was tested from 16 keV to 1250 keV to determine the response over a wide spectrum of photon energies. All Instadose™ were irradiated to 5.0 mSv to the different energies and the response dose was compared to the expected response. The N-series x-ray's (N20, N30, N60, N80, N100, N120, N150, N200, N250, and N300) as well as Cs^{137} and Co^{60} were used for this analysis. Graph 1 below shows the response dose/delivered dose for each photon energy.



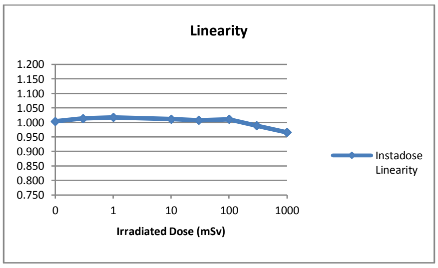
Graph 1 – Energy Response

The response in graph 1 is normalized to a 100 keV photon. With the web application this can be adjusted based on the wearers known photon energy. Overall, the results were very promising for a single element dosimeter.

Linearity Response Test

Linearity of the Instadose dosimeter was tested to ensure that accumulated doses responded linearly. If the dose results become sub-linear or supra-linear throughout the dose range a more complex dose calculation would be required to accurately assess personal dose.

Graph 2 below shows the results of the linearity test. The irradiated doses were: 0.10 mSv, 0.30 mSv, 1.0 mSv, 10.0 mSv, 30.0 mSv, 100 mSv, 300 mSv, and 1000 mSv. All but the last two highest dose values were determined with the DL chamber result.



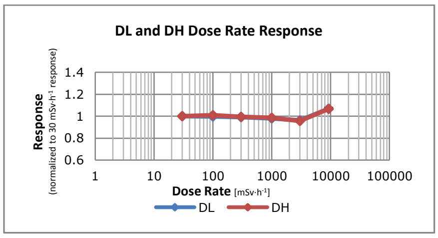
Graph 2 – Linearity

The results of the linearity were very good. The small decrease at the higher doses were taken from the DH element.

Dose Rate Test

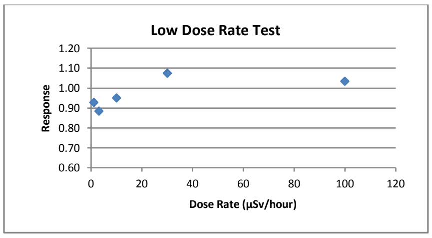
There were two tests for dose rate independenc, a high dose rate test performed directly by Mirion Technologies and a low dose rate test performed by an independent entity. Both tests used Cs^{137} as the source of radiation.

The high dose rate test tested instadose rates from 30 mSv/hour up to 10,000 mSv/hour. The results of the test are displayed in Graph 3.



Graph 3 – High Dose Rate Test

The low dose rate test verified dose rates from 1.1 µSv/hour to 100 µSv/hour. Results of the low dose rate test are shown in Graph 4 below.



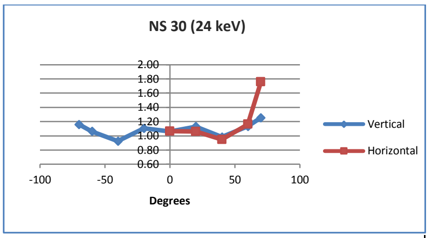
Graph 4 – Low Dose Rate Test

Both graph 3 and 4 indicate that instadose is fairly independent for dose rates.

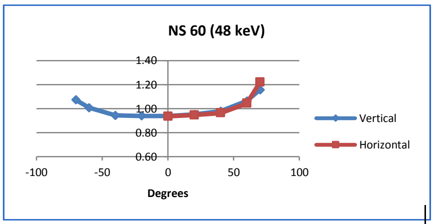
Angularity Test

The Instadose dosimeter was tested to three N-series x-ray energies to verify the angular responses. N30, N60, and N80 techniques were used and normalized to Cs^{137} at a zero degree angle. Both directions of the vertical plane were tested since the geometries of each direction would be slightly different. However, only one direction of the horizontal plane was tested since the dosimeter is isotropic on the horizontal axis.

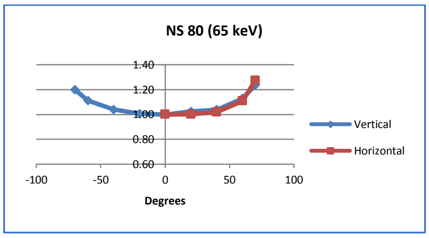
Graphs 5, 6, and 7 show the results of the angularity tests.



Graph 5 – N30 Angle Response



Graph 6 – NS60 Angle Response



Graph 7 – NS80 Angle Response

At angles the instadose performed very well and is better than most dosimeters in use today.

Temperature Test

Two temperature tests were performed to verify the response of instadose in high and low temperature environments.

The first test was conducted to determine how the instadose would report doses if placed in hot and cold environments. The test was conducted by irradiating three groups of 10 instadose to 3 mSv with Cs^{137} photons. Group 1 (reference group) was kept at room temperature, group 2 was placed in an oven set at 40 degrees C, group 3 was placed in a chamber at -20 degrees C. Each group was left for seven days in their respective environments. Following the seventh

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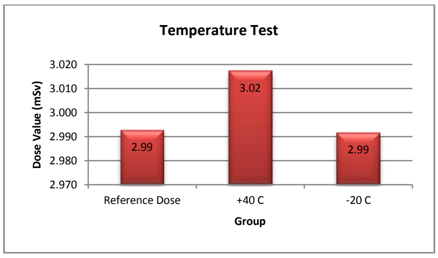
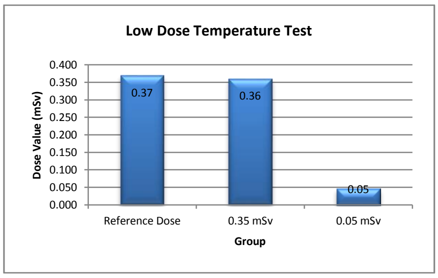
day, all groups were removed form their respective test environments and allowed to stabilize to normal room temperature. Once stabilized the dosimeters were then read. The average results of the readings are shown in graph 8.



Graph 8 – Temperature Test

The second temperature test was to just 40 degrees C, but was performed at a lower dose value. The same protocol was used as the first temperature test. There was a reference group exposed to 0.35 mSv, a test group exposed to 0.35 mSv, and another test group exposed to 0.05 mSv. These three groups were placed in a 40 degree C environment for seven days. Following the seventh day, all groups were removed form their respective test environments and allowed to stabilize to normal room temperature. Once stabilized the dosimeters were then read. Graph 9 shows the results of this second temperature test.



Graph 9 – Low Dose Temperature Test

Based on the two studies, temperature has little effect on instadose. Since these tests required stabilization of instadose to room temperature, more studies will be done to determine how dose is effected if it is read other temperatures.

Low Dose Testing

Since most personal dosimetry wearers are exposed to very low doses, a test at low dose was performed. A Cs^{137} beam irradiator was used that has a dose rate of 8.35 mSv/hour. It should be noted that at these low doses the potential uncertainty in delivered dose obtained from the irradiator could have significant influence on the outcome of this test.

The test consisted of irradiating the same 10 instadose to dose values of 0.01 mSv, 0.03 mSv, 0.05 mSv, 0.1 mSv, 0.2 mSv, and 0.25 mSv. The instadose were irradiated to the dose value, read, and then irradiated to the next dose value until all dose levels were complete.

Table 1 shows the results of the low dose test.

Irradiated Dose (mSv)	0.01	0.03	0.05	0.1	0.2	0.25
Average Dose	0.009	0.026	0.053	0.096	0.197	0.251
Standard Deviation	0.008	0.002	0.001	0.001	0.0003	0.0003
Min	0.001	0.009	0.044	0.062	0.189	0.236
Median	0.009	0.026	0.053	0.1	0.196	0.251
Max	0.025	0.036	0.064	0.11	0.207	0.264

Table 1 – Low Dose Test

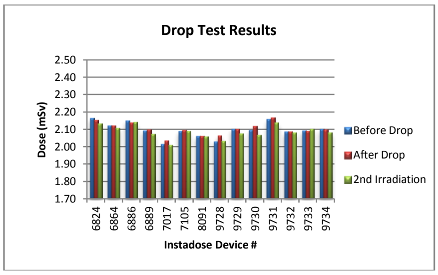
Based on the results of table 1, the instadose dosimeter performs very well at low doses.

Drop Test

Drop testing was performed to ensure that if an instadose was dropped from a distance of one meter that it will still be able to accurately report dose that was currently stored on the dosimeter as well as future doses.

The test consisted of irradiating 14 Instadose dosimeters to 2.0 mSv using Cs^{137}. Since the reading process does not remove dose, each dosimeter was initially read to obtain a baseline value. Following the initial read, each dosimeter was dropped from a height of one meter onto a hard surface. After the drop, the dosimeters were read again to ensure each still recorded the original 2.0 mSv dose value. Finally each dosimeter was irradiated again to another 2.0 mSv and immediately read to verify the acceptance of new dose.

The results of the drop test are shown in Graph 10.

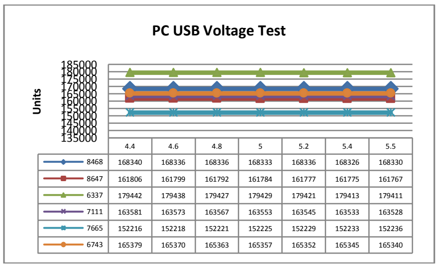


Graph 10 – Drop Test

Dropping the Instadose dosimeter at 1 meter should not cause problems with dose response.

PC USB Voltage Test

Instadose dosimeters are read using a USB port on any standard computer or laptop that has internet access availability. Since USB ports have changed slightly through the various revisions, a test to ensure that variances in USB voltage from computer to computer would not affect the dose calculation was performed. The test used six instadose and a computer that was set up to allow us to vary the voltage on the USB port in use. Voltages were varied from 4.4 volts to 5.5 volts. The raw data was analyzed at the different voltages to ensure the value did not substantially change. Graph 11 shows the results of this test.



	4.4	4.6	4.8	5	5.2	5.4	5.5
8468	168340	168336	168336	168333	168336	168326	168330
8647	161806	161799	161792	161784	161777	161775	161767
6337	179442	179438	179427	179429	179421	179413	179411
7111	163581	163573	163567	163553	163545	163533	163528
7665	152216	152218	152221	152225	152229	152233	152236
6743	165379	165370	165363	165357	165352	165345	165340

Graph 11 – PC USB Voltage Test

Operational Experiences

Ensuring Wearers Read Their Instadose

The concept of Instadose dosimetry in personal radiation monitoring was a new concept that requires adaptation of the end user (dosimeter wearer). Previous dosimetry programs involved the distribution and collection of dosimeters. Following collection, the dosimeter would be sent to a laboratory for reading and analysis. This followed with a report that indicated the wearer's dose. This process has been in use in radiological industries for several decades; however, the wearer was not able to obtain immediate feedback regarding their dose during the time period the dosimeter was used to monitor their exposure. Instadose dosimeters allow the wearer to read their dosimeter at any time and does not require collection and submittal to a laboratory for analysis.

The one shortfall to this concept is how to best 'train' the wearer to read his or her own dosimeter within the periodicity specified by that wearer's dosimetry administrator. Automatic email reminders was implemented in an effort to remind wearers to read their instadose. If an administrator wants his/her employees to read their instadose badge every 30 days, an email reminder is sent to the wearer to remind them when the 30 day time comes up.

This implementation has greatly increased the number of wearers who read their instadose at the correct times based on their program set up.

User PC Compatibility Issues

Initially server firewalls and other information security practices and procedures posed problems with the instadose web application and reading an Instadose dosimeter. The Instadose dosimeter software has been developed that is allowed communications through firewalls and the like. These developments have resulted in very few continuing issues.

Temperature Effects on Instadose

Based on the test data above, temperature has very little effect on an Instadose dosimeter, when it is read at room temperature. During dose calculations with the web application, temperature readings are taken from the Instadose dosimeter to ensure that temperature is within about 12 degrees C from room temperature, if not an error message is given to the wearer to allow stabilization of the instadose prior to reading. Once stabilized to room temperature and read, the dose is accurate as indicating by temperature testing previously mentioned.

Conclusions

Instadose dosimeters brings personal dosimetry into the 21st century. It eliminates the need for shipping services and allows the wearer to perform a reading at any time and obtain immediate feedback regarding their exposure.

The results of the type test data in this paper show that Instadose dosimeters perform just as well, if not better than other personal dosimetry in use today.