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ELECTRONICS PERSONAL DOSEMETER (EPD-N) TEST AND EVALUATION REPORT

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Engineering Science and Technology Division

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Executive Summary

Three electronic personal dosimeters (EPD-N) manufactured by Siemens, serial numbers 0635, 0658, and 0683, were tested at the Radiation Calibration Laboratory for an evaluation of their response to neutron, gamma and x-ray radiation. Designed to provide real-time neutron and photon dosimetry, the EPD-N is capable of estimating and displaying neutron and gamma dose components separately for a range of energies from 50 keV to 7 MeV for photon and 0.025 eV to > 10 MeV for neutron.

All tests were conducted using the factory calibrations. A technical representative of the manufacturer indicated that site-specific calibrations are required as factory settings are calibrated for the lowest neutron energy limit of 0.025 eV. This raises concerns about the reliability of these devices in measuring neutrons when calibrations are made for a specific site radiological characterization then used at another site.

1. Introduction

Three electronic personal dosimeters (EPD-Ns) manufactured by Siemens (S/Ns: 0635, 0658, 0683) were tested at the Radiation Calibration Laboratory to evaluate their response to neutrons, gamma, and x-ray radiations. The EPD-N is designed to provide real-time neutron and photon dosimetry. It is capable of estimating and displaying neutron and gamma dose components separately for a wide range of energies (50 keV to 7 MeV for photon, and 0.025 eV to > 10 MeV for neutron). The manufacturer's published specifications are shown in Attachment A of this report. The purpose of this effort is to evaluate the performance of the EPD-N device as a candidate for personal dosimeter use at Oak Ridge National Laboratory.

Tests were performed using the factory calibration. All tests were conducted with the units mounted on a 40 cm x 40 cm x 15 cm Plexiglas phantom to simulate actual application conditions of the dosimeters. Response of the EPD-Ns to neutron radiation was evaluated using ^{252}Cf, where measurements were made for thermal and fast neutrons using a polyethylene sphere as a moderator.

The gamma response was evaluated for two different energy levels using ^{137}Cs and ^{60}Co. X-ray photon response was evaluated at two different energies, 117 keV (beam code # H150), and 51 keV (beam code # M100).

2. Neutron Test

The response to thermal neutrons was tested using a ^{252}Cf source moderated with a polyethylene sphere. The units were exposed to dose equivalent rates in the range of 10-120 mrem/hr. At 10 mrem/hr, response of the three units was very low with readings changing from 0-2 mrem/hr. At 50 mrem/hr the response remained low with readings changing between 0-4 mrem/hr. At 120 mrem/hr, all three units went into alarm. Meaningful readings could not be determined due to erratic indications.

Conclusions: All three units failed to measure neutrons, moderated and un-moderated, when exposed to ^{252}Cf at various exposure rates. Follow up discussions with a technical representative of the manufacturer (Siemens) indicated that a site-specific calibration is required. According to the technical representative, all EPD-Ns are typically calibrated for the lowest energy limit, 0.025 eV. This raised some concerns about the validity of these devices to measure neutrons reliably when calibrated according to a specific site radiological characterization and then used at another site.

3. Gamma Test Using ^{137}Cs

The units under test were exposed to gamma radiation from a ^{137}Cs source. The source exposure rates and the response are listed in Table 1. Gamma-neutron cross talk measurements were also performed using the same source at one exposure rate only.

Conclusions: All three units appear to function satisfactorily in performing gamma measurements at various exposure rates. However, some gamma-neutron cross talk was detected when the units were switched to neutron mode while exposed to the ^{137}Cs at one exposure rate. The results are shown in Table 2.

4. Gamma Test Using ^{60}Co

A gamma test was also performed using ^{60}Co at three different exposure/dose rates. Test results are shown in Table 3.

Conclusions: All units appear to function satisfactorily considering the accuracy of the calculated exposure rate of the source and the conversion factor used to determine the dose rate.

5. X-ray Test

Response to x-ray radiation was performed for two beam energies. One of the beams is code M-100 with 51 keV and the other is H-150 with 117 keV. The dose rates for the x-ray beams were determined using ion chamber measurements. Results are shown in Table 4.

Conclusions: All units appeared to perform satisfactorily.

Table 1. Gamma measurement using ^{137}Cs

Source Dose Rate (mrem/hr)	EPD-N #1 (S/N 0635) Measured Dose Rate (mrem/hr)	EPD-N #2 (S/N 0658) Measured Dose Rate (mrem/hr)	EPD-N #3 (S/N 0683) Measured Dose Rate (mrem/hr)
303	300-340	300-350	290-320
503	500-550	470-590	470-580
1040	1000-1200	1000-1100	1000-1100
2505	2700-3000	2700-3000	2700-3000
8390	9300-9800	9500-10,000	9100-9500

Table 2. Gamma-Neutron cross talk measurement (^{137}Cs)

Source Dose Rate (mrem/hr)	EPD-N #1 (S/N 0635) Measured Dose Rate (mrem/hr)	EPD-N #2 (S/N 0658) Measured Dose Rate (mrem/hr)	EPD-N #3 (S/N 0683) Measured Dose Rate (mrem/hr)
1040	0-15	11-22	13-25

Table 3. Gamma test results for ^{60}Co

Source Exposure Rate/Dose Rate (mrem/hr)	EPD-N #1 (S/N 0635) Measured Dose Rate (mrem/hr)	EPD-N #2 (S/N 0658) Measured Dose Rate (mrem/hr)	EPD-N #3 (S/N 0683) Measured Dose Rate (mrem/hr)
75.8 / 77.9	97-100	92-100	100
561.9 / 577.24	600-700	660-740	630-740
2250 / 2311.43	2500-2700	2500-2700	2500-2700

Table 4. X-ray measurement results

	Calculated Dose Rate (mrem/hr)	EPD-N #1 (S/N 0635) Measured Dose Rate (mrem/hr)	EPD-N #2 (S/N 0658) Measured Dose Rate (mrem/hr)	EPD-N #3 (S/N 0683) Measured Dose Rate (mrem/hr)
H-150 Beam Mode	513	490-550	490-550	460-550
	1999	1800-2000	1800-2000	1800-2000
M-100 Beam Mode	3610	2600-3000	2600-3000	2800-3000
	8280	7500-7600	7500-7600	7500

APPENDIX A

EPD-N PUBLISHED SPECIFICATIONS

EPD-N PUBLISHED SPECIFICATIONS

- Real-time neutron and photon dosimetry
- Separate measurement and display of neutron and photon doses
- Sensitive to X and γ, and neutrons
- Multiple diode detectors
- Energy responses:
  - Photons: 50 keV – 7 MeV
  - Neutrons: 0.025 eV to > 10 MeV (thermal and intermediate)
- Lower limits of detection:
  - <1 μSv (100 μrem) γ, X
  - ~ 10 μSv (1 mrem) n
- Dose rate response:
  - Neutron: 1 mrem/h to > 100 rem/h
  - Gamma: 0 mrem/h to 400 rem/h
- Estimation of neutron dose from high-level, short-duration exposure

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