



# Test Report

## RESULTS OF AN HSE PERFORMANCE TEST OF FAST NEUTRON PERSONAL DOSEMETERS

This test report is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This test report may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

**FOR:** Landauer Europe  
28 Bankside  
Station Approach  
Kidlington  
Oxford  
OX5 1JE

FAO: Chris Perks

**DESCRIPTION:** HSE fast neutron performance tests: PADC Personal dosimeters on an ISO water-filled phantom

**IDENTIFICATION:** Each dosimeter individually identified by service

**BASIS OF MEASUREMENT:** HSE *Measurement protocol for performance testing of dosimetry services for external, whole body fast neutron radiation. (June 2001)*

**DATES OF IRRADIATIONS:** 26<sup>th</sup> July – 1<sup>st</sup> August 2011

**DATE OF RECEIPT OF DOSIMETRY REPORTS:** 29th September 2011

**SOURCE USED:** <sup>241</sup>Am-Be

**Reference:** N1022 (2011030252)

Page 1 of 4

**Date of issue:** 17<sup>th</sup> October 2011

**Signed:**

(Authorised Signatory)

**Checked by:**

**Name:** Dr G C Taylor

on behalf of NPLML

# NATIONAL PHYSICAL LABORATORY

Continuation Sheet

## MEASUREMENTS

Irradiations of PADC personal dosimeters provided by Landauer Europe were carried out in the low-scatter facility in Building 47 at the National Physical Laboratory. Neutrons for the irradiations were produced using a radionuclide source mounted at the centre of the low-scatter area with the source capsule's axis of cylindrical symmetry orientated vertically.

The personal dosimeters were mounted directly on a water-filled 30 cm x 30 cm x 15 cm ISO phantom. The distance from the central axis of the source to the centre of the front face of the phantom was measured to be  $75.0 \pm 0.1$  cm.

The neutron fluence rates were determined by absolute neutron source emission rate measurements, performed in the NPL manganese sulphate bath. No correction was applied for neutron in- or out-scatter effects, the assumption being that, at this distance in the NPL low-scatter facility, the two effects are small and to some extent cancel each other. An additional uncertainty component was, however, included to allow for this. The total integrated neutron fluence was then derived from the fluence rate and the total irradiation time.

## RESULTS

Table 1 quotes the fluence to personal dose equivalent conversion coefficients used, the customer and the conventional true values for the dose equivalents, and the ratios of these numbers. Bias and relative standard deviations are presented for each dose equivalent rate group.

## FLUENCE TO DOSE EQUIVALENT CONVERSION FACTORS

The spectrum-averaged fluence to personal dose equivalent<sup>[1]</sup> conversion coefficient ( $h_p(10, \theta^\circ)$ ) for  $^{241}\text{Am-Be}$  now used at NPL has a value of  $411 \text{ pSv cm}^2$ <sup>[2]</sup> for AP irradiation, i.e.  $\theta = 0^\circ$ . It was derived using the  $^{241}\text{Am-Be}$  spectrum published in ISO 8529-1:2001<sup>[3]</sup>. Because the dosimeters were distributed over the face of the phantom, and the angle of incidence of the neutrons thus varied slightly from being exactly normal to the dosimeters, small adjustments to the values of ( $h_p(10, \theta^\circ)$ ) were made to allow for the variation with angle  $\theta$ .

## UNCERTAINTIES

The uncertainties have been treated as recommended in UKAS publication M3003<sup>[4]</sup>.

For each irradiation the uncertainty in the total fluence is dominated by uncertainties associated with the source emission rate, which in this case is approximately  $\pm 1.5\%$  at a confidence level of 95 %, assuming a coverage factor of  $k=2$ . This uncertainty also applies to the conventional true value, as the uncertainty component associated with the source spectrum in converting fluence to personal dose equivalent is omitted for the purposes of the performance test. A full uncertainty budget is available from NPL if required.

Reference: N1022

Page 2 of 4

Checked by: 



## REFERENCES

- [1] International Commission on Radiation Units and Measurements, *Quantities and units in radiation protection dosimetry*, Report 51, ICRU Publications, Bethesda, MD (1993).
- [2] International Organisation for Standardisation (ISO), *Reference neutron radiations – Part 3: Calibration of area and personal dosimeters and determination of their response as a function of neutron energy and angle of incidence*, International Standard ISO 8529-3 (1998).
- [3] International Organisation for Standardisation (ISO), *Reference neutron irradiations – Part 1: Characteristics and methods of production*, International Standard ISO 8529-1 (2001).
- [4] UKAS, *The Expression of Uncertainty and Confidence in Measurement*, UKAS publication M 3003 Edition 2, UKAS, Feltham, UK (2007).
- [5] HSE, *Statement on the Approval of Dosimetry Services*, Health and Safety Executive Publication (2004).

Reference: N1022

Page 3 of 4

Checked by: 

# NATIONAL PHYSICAL LABORATORY

Continuation Sheet

**TABLE 1: Results for the HSE fast neutron performance test for PADC personal dosimeters from Landauer Europe. The bias and relative standard deviation is calculated for each group of 5 dosimeters and for the complete set of 25 dosimeters.**

Dosimeter No.	Conversion Coefficient (pSv.cm <sup>2</sup> )	Customer H <sub>p</sub> (10) (mSv)	NPL H <sub>p</sub> (10) (mSv)	Di (ratio)	Group ratio	Bias (%)	Relative std deviation (%)	
1529696	410	0.90	0.81	1.11	1.061	6.1	6.3	
1529702	410	0.80	0.81	0.99				
1529704	410	0.80	0.81	0.99				
1529708	410	0.90	0.81	1.11				
1529717	411	0.90	0.82	1.10				
1529694	410	2.70	2.82	0.96	0.985	-1.5	1.6	
1529699	410	2.80	2.82	0.99				
1529709	410	2.80	2.82	0.99				
1529712	410	2.80	2.81	1.00				
1529714	411	2.80	2.84	0.99				
1529705	410	8.30	7.85	1.06	1.021	2.1	3.9	
1529706	410	7.50	7.85	0.96				
1529707	410	8.00	7.84	1.02				
1529711	410	8.20	7.83	1.05				
1529713	411	8.10	7.90	1.03				
1529701	410	17.30	16.71	1.04	0.963	-3.7	6.6	
1529710	410	16.60	16.69	0.99				
1529715	410	16.60	16.73	0.99				
1529703	410	15.20	16.73	0.91				
1529697	411	14.90	16.84	0.88				
1529700	410	42.30	44.91	0.94	0.898	-10.2	5.2	
1529698	411	38.20	45.31	0.84				
1529718	410	38.80	45.01	0.86				
1529716	410	40.20	44.95	0.89				
1529695	410	42.60	45.01	0.95				
Overall ratio					0.986			
						Overall bias %	-1.4	
							Overall relative std deviation %	7.3

\* Varies due to the angle of incidence

## CONCLUSION

The magnitude of the bias in the overall results is less than 20%.  
 The relative standard deviation in the overall results is less than 25%.  
 The magnitude of the bias for each group of 5 dosimeters is less than 20%.  
 The relative standard deviation for each group of 5 dosimeters is less than 25%.

**Based on these results the dosimetry service has achieved a Band A performance test<sup>[5]</sup>.  
 Band A represents a successful performance test.**

Reference: N1022

Page 4 of 4

Checked by: 