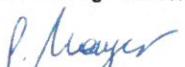


Certificate of Participation

in the EURADOS Intercomparison 2017 for whole body neutron dosimeters

Certificate number:	EURADOS-2017n-S015
Number of pages:	3
Date of Issue:	22 June 2018
Participating institute:	DOZIMED S.R.L. Atomistilor 407, 5th Floor, Flat 507, 77125 MAGURELE, ILFOV, Romania
Dosimetry system:	S015 (system code) - Harshaw 6600 TLD reader, 4-elements TLD card 6776 (LiF:Mg,Ti) + 8806 badge, ODA 48/2017, RENAR LI 1047/2015
Requested a priori information:	Yes
Intercomparison procedure:	<p>The EURADOS Intercomparison 2017 for whole body neutron dosimeters (IC2017n) was managed and co-ordinated on behalf of EURADOS by the WG2-Intercomparison Organization Group for neutron dosimetry (OGn). The OGn established the irradiation plan and announced the intercomparison, including the range limits of the doses and radiation qualities, in March 2017.</p> <p>On the application form candidate participants were asked to indicate details of the dosimeter, including its reference point. After completing subscription procedures the participant sent its dosimeters to the OGn coordinator (May/June 2017). Each participant provided 40 dosimeters: 28 dosimeters were irradiated, 8 were kept as spares and 4 were transit controls.</p> <p>The coordinator sent all dosimeters, along with the instructions to 2 irradiation laboratories. Each laboratory irradiated a certain number of dosimeters of each set of dosimeters according to the irradiation plan and then sent all the dosimeters back to the coordinator (October 2017).</p> <p>The coordinator then returned the dosimeters to the participant for assessment and indicated which dosimeters were not irradiated. The participant was instructed to follow normal routine procedures as much as possible. Those participants, who indicated a need to receive a priori information on the radiation fields for the evaluation procedure ('yes'), were provided the following description: (i) bare radionuclide source, and (ii) radionuclide source, significantly moderated. All other participants ('no') received no information on the radiation fields.</p> <p>The participant then sent the results of the dosimeter readings to the coordinator. Within one month after receiving the dosimeters, the participant had to submit the results in terms of $H_p(10)$ in an online response form provided by the Organization Group.</p> <p>After receipt of the participants' results, the coordinator sent the reference values for $H_p(10)$ together with detailed information on the radiation field used (April 2018).</p>
Number of participants:	32 Institutes participated in EURADOS IC2017n with a total of 33 systems.
Irradiation data:	See attached certificates of the irradiation laboratories Reference No.: N1531 (2016070332) Participant S015 PTB – 6.4-2017/35_S015
Intercomparison results:	See the table on page 2-3 of this certificate

On behalf of the IC2017n Organization Group:


 Dr. Sabine Mayer
Coordinator

On behalf of EURADOS:


 Prof. Dr. Werner Rühm
Chairperson

Result of the intercomparison

Certificate of Participation EURADOS-2017n-S015

ID code	Irradiation laboratory	$H_p(10)$ Reference value mSv	Radiation field	$H_p(10)$ Participant's value mSv	Remark of participant	Ratio (Participant's value/ Reference value)
S015-2017-1	NPL	1.50	Bare AmBe source at 0°	1.27		0.85
S015-2017-2	NPL	0.299	Bare Cf-252 source at 0°	0.38		1.27
S015-2017-3	NPL	1.50	Bare AmBe source at 0°	1.37		0.91
S015-2017-4	NPL	12.00	Bare Cf-252 source at 0°	12.79		1.07
S015-2017-5	NPL	1.501	Bare Cf-252 source at 0°	1.67		1.11
S015-2017-6	NPL	0.299	Bare Cf-252 source at 0°	0.37		1.24
S015-2017-7	NPL	1.50	Bare AmBe source at 0°	1.24		0.83
S015-2017-8	NPL	1.501	Bare Cf-252 source at 0°	1.59		1.06
S015-2017-9	NPL	12.00	Bare Cf-252 source at 0°	15.81		1.32
S015-2017-10	NPL	0.299	Bare Cf-252 source at 0°	0.45		1.51
S015-2017-11	NPL	1.50	Bare AmBe source at 0°	1.39		0.93
S015-2017-12	NPL	1.501	Bare Cf-252 source at 0°	1.69		1.13
S015-2017-13	NPL	1.500	Bare Cf-252 source at 45°	1.34		0.89
S015-2017-14	NPL	1.501	Bare Cf-252 source at 0°	1.82		1.21
S015-2017-15	NPL	0.299	Bare Cf-252 source at 0°	0.4		1.34
S015-2017-16	NPL		not irradiated			-
S015-2017-17	NPL	1.500	Bare Cf-252 source at 45°	1.57		1.05
S015-2017-18	NPL	12.00	Bare Cf-252 source at 0°	13.64		1.14
S015-2017-19	NPL		not irradiated			-
S015-2017-20	NPL	12.00	Bare Cf-252 source at 0°	13.21		1.10

IC2017n - EURADOS Intercomparison 2017 for whole body neutron dosimeters

Certificate of Participation EURADOS-2017n-S015					
ID code	Irradiation laboratory	$H_p(10)$ Reference value mSv	Radiation field	$H_p(10)$ Participant's value mSv	Remark of participant (Participant's value/ Reference value)
S015-2017-21	NPL		not irradiated		-
S015-2017-22	NPL		not irradiated		-
S015-2017-23	NPL		not irradiated		-
S015-2017-24	NPL		not irradiated		-
S015-2017-25	PTB	1.2	Cf-252 (D_2O moderated, 1 mm Cd)	1.48	-
S015-2017-26	PTB	1.5	Cf-252 (with additional 1.0 mSv of Cs-137)	1.71	1.23
S015-2017-27	PTB	1.2	Cf-252 (D_2O moderated, 1 mm Cd)	1.51	1.14
S015-2017-28	PTB		not irradiated		1.26
S015-2017-29	PTB		not irradiated		-
S015-2017-30	PTB	1	Cf-252 (D_2O moderated, 1 mm Cd) behind a shadow block	4.58	-
S015-2017-31	PTB	1.5	Cf-252 (with additional 1.0 mSv of Cs-137)	1.87	4.58
S015-2017-32	PTB	1.5	Cf-252 (with additional 1.0 mSv of Cs-137)	1.79	1.25
S015-2017-33	PTB		not irradiated		1.19
S015-2017-34	PTB	1.2	Cf-252 (D_2O moderated, 1 mm Cd)	1.31	-
S015-2017-35	PTB		not irradiated		1.09
S015-2017-36	PTB	1	Cf-252 (D_2O moderated, 1 mm Cd) behind a shadow block	4.52	-
S015-2017-37	PTB		not irradiated		4.52
S015-2017-38	PTB	1.2	Cf-252 (D_2O moderated, 1 mm Cd)	1.45	-
S015-2017-39	PTB	1.5	Cf-252 (with additional 1.0 mSv of Cs-137)	1.82	1.21
S015-2017-40	PTB		not irradiated		1.21



NATIONAL PHYSICAL LABORATORY

Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222



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Certificate of Calibration

Calibration of the personal dose equivalent delivered during irradiation of personal dosimeters with bare ^{252}Cf and $^{241}\text{Am-Be}$ radionuclide neutron sources

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

FOR:

Paul Scherrer Institut
Department of Radiation Safety and Security
OFLC/U101
5232 Villigen PSI - Switzerland

For the attention of Sabine Mayer

On behalf of IC2017n Participant S015

DESCRIPTION: Irradiation of personal dosimeters to accurately known neutron fluences, and hence dose equivalent values, with bare ^{252}Cf and $^{241}\text{Am-Be}$ radionuclide neutron sources at incident angles of either 0° or 45°

IDENTIFICATION: Each neutron dosimeter individually identified

BASIS OF MEASUREMENTS: ISO Standard 8529, *Reference neutron radiations – Part 1: (2001) Characteristics and methods of production, Part 2: (2000) Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field, Part 3: (1998) Calibration of area and personal dosimeters and determination of their response as a function of neutron energy and angle of incidence.*

DATE OF RECEIPT: 6th June 2017

DATES OF IRRADIATIONS: 25th July – 14th September 2017

Reference: N1531 (2016070332) Participant S015

Page 1 of 6

Date of issue: 31st October 2017

Signed: *David Thomas*

(Authorised Signatory)

Checked by: *GJ*

Name: Dr David J Thomas

on behalf of NPLML



This certificate is consistent with the capabilities that are included in Appendix C of the MRA drawn up by the CIPM. Under the MRA, all participating institutes recognise the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details see <http://www.bipm.org>).

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Continuation Sheet

IRRADIATIONS

Irradiations of the personal neutron dosimeters provided by EURADOS IC2017n participant S015 were performed in the low-scatter facility in the Chadwick Building at the UK National Physical Laboratory. The dosimeters were irradiated to accurately known neutron fluence values. From these fluences, personal dose equivalent values, $H_p(10)$, were determined using internationally accepted fluence to dose equivalent conversion coefficients. Irradiations were performed using techniques recommended by the International Organization for Standardization (ISO)^[1].

Irradiations were performed using a bare ^{252}Cf radionuclide neutron source at 0° and 45° , and a $^{241}\text{Am-Be}$ radionuclide neutron source at 0° , mounted at the centre of the irradiation area in the low-scatter facility. All irradiations were performed using a $30\text{ cm} \times 30\text{ cm} \times 15\text{ cm}$ ISO water phantom. The dosimeters were mounted on the phantom exactly as supplied by the customer. The dosimeters were attached to the surface of the phantom using double-sided tape and then secured using single-sided tape.

All irradiations were performed at a fixed distance of $75.0 \pm 0.2\text{ cm}$ between the centre of the radionuclide neutron source and the centre of the front face of the phantom.

The neutron fluence rates were determined by absolute neutron source emission rate measurements, performed in the NPL manganese sulphate bath. The anisotropy factors for the source encapsulations had been previously determined at NPL using precision long counter measurements. 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.

For the 0° irradiations, four dosimeters were mounted as illustrated in Figure 1. This rotationally-symmetric arrangement ensured that any variation in radiation field due to beam divergence would be the same across every dosimeter. Also shown is an electronic personal dosimeter, which was used as a reference monitor during the irradiation.

NATIONAL PHYSICAL LABORATORY

Continuation Sheet



Figure 1: Rotationally symmetric arrangement employed for the irradiations of groups of four dosimeters.

For the 45° irradiation, two dosimeters were mounted on the axis of rotation, i.e. in line with the electronic personal dosimeter shown in Figure 1.

RESULTS

Table 1 quotes the nominal exposure, dosimeter numbers, source-to-phantom distance (measured from the centre of the source capsule to the centre of the front face of the phantom) and the neutron personal dose equivalent that the dosimeters received (subject to the above assumptions).

NATIONAL PHYSICAL LABORATORY

Continuation Sheet

FLUENCE TO DOSE EQUIVALENT CONVERSION COEFFICIENTS

The spectrum-averaged fluence to personal dose equivalent [2] conversion coefficient ($h_p(10, \theta)$) for bare ^{252}Cf has a value of 400 pSv cm 2 at $\theta = 0^\circ$ and a value of 389 pSv cm 2 at $\theta = 45^\circ$ [1]. The ($h_p(10, \theta)$) for $^{241}\text{Am-Be}$ at $\theta = 0^\circ$ has a value of 411 pSv cm 2 . These values have been derived using the spectra published in ISO 8529-1:2001 [3].

UNCERTAINTIES

The uncertainties have been treated as recommended in UKAS publication M3003 [4], and are given in Table 2. The standard uncertainties associated with the spectrum-averaged fluence to dose equivalent conversion coefficients, needed to convert fluence response to dose equivalent response, are $\pm 1\%$ for bare ^{252}Cf and $\pm 4\%$ for $^{241}\text{Am-Be}$ [5], and originate from uncertainties in the source spectra rather than uncertainties in the conversion coefficients, which are assumed to be exact.

REFERENCES

- [1] International Organisation for Standardisation. *ISO 8529: Reference neutron radiations – Part 3: (1998) Calibration of area and personal dosimeters and determination of their response as a function of neutron energy and angle of incidence.*
- [2] International Commission on Radiation Units and Measurements, Quantities and units in radiation protection dosimetry, Report 51, ICRU Publications, Bethesda, MD (1993).
- [3] International Organisation for Standardisation. *ISO 8529: Reference neutron radiations – Part 1: (2001) Characteristics and methods of production.*
- [4] UKAS, *The Expression of Uncertainty and Confidence in Measurement*, UKAS publication M 3003 Edition 3, UKAS, Feltham, UK (2012).
- [5] International Organisation for Standardisation. *ISO 8529: Reference neutron radiations – Part 2: (2000) Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field.*

NATIONAL PHYSICAL LABORATORY

Continuation Sheet

TABLE 1: Neutron personal dose equivalent at the reference distance for the irradiation of personal dosimeters using $^{241}\text{Am-Be}$ and ^{252}Cf neutron sources. The uncertainties are quoted with a coverage probability of approximately 95%

Nominal $H_p(10)$	Dosimeter Reference Number	Source - Phantom Distance*	NPL $H_p(10)$ (mSv)		
	S015/2017-01				
1.5 mSv	S015/2017-03	75.0	1.50	+/-	0.14
Am-Be	S015/2017-07				
0°	S015/2017-11				
	S015/2017-04				
12 mSv	S015/2017-09	75.0	12.00	+/-	0.58
Cf (bare)	S015/2017-18				
0°	S015/2017-20				
	S015/2017-05				
1.5 mSv	S015/2017-08	75.0	1.501	+/-	0.072
Cf (bare)	S015/2017-12				
0°	S015/2017-14				
	S015/2017-02				
0.3 mSv	S015/2017-06	75.0	0.299	+/-	0.015
Cf (bare)	S015/2017-10				
0°	S015/2017-15				
	S015/2017-13	75.0	1.500	+/-	0.072
1.5 mSv	S015/2017-17				
Cf (bare)					
45°					

*This figure represents the perpendicular distance from the centre of the source capsule to the centre of the front face of the phantom.

NATIONAL PHYSICAL LABORATORY

Continuation Sheet

Table 2: Percentage standard uncertainties associated with the determination of the personal dose equivalent at the reference distance.

Uncertainty component	Irradiation				
	$^{241}\text{Am-Be}$ 0° 1.5 mSv	^{252}Cf , 0° 12 mSv	^{252}Cf 0° 1.5 mSv	^{252}Cf 0° 0.3 mSv	^{252}Cf 45° 1.5 mSv
Type B (non-random)					
Reference irradiation distance*	± 0.55%	± 0.55%	± 0.55%	± 0.55%	± 0.55%
Source emission rate (MnSO_4 bath) (includes component for half-life)	± 0.69%	± 0.53%	± 0.53%	± 0.53%	± 0.53%
Source anisotropy correction	± 0.25%	± 0.26%	± 0.26%	± 0.26%	± 0.26%
Timing	± 0.06%	± 0.02%	± 0.15%	± 0.74%	± 0.14%
Scatter	± 2.0%	± 2.0%	± 2.0%	± 2.0%	± 2.0%
$H_p(10,\theta)$ conversion coefficient	± 4.0%	± 1.0%	± 1.0%	± 1.0%	± 1.0%
Total Standard Uncertainty Components added in quadrature	± 4.6%	± 2.4%	± 2.4%	± 2.5%	± 2.4%
Expanded uncertainty ‡	± 9.1%	± 4.8%	± 4.8%	± 5.0%	± 4.8%

* The figures quoted for the uncertainty in the reference irradiation distance includes a sensitivity factor of 2, taking into account the inverse square dependence of the neutron fluence rate on the distance between the source centre to reference point.

‡ Obtained by multiplying the total standard uncertainty by a coverage factor $k=2$. (This provides an uncertainty estimate for a coverage probability of approximately 95%).



Bericht *Report*

Irradiation of whole body dosemeters in neutron reference fields at PTB in the framework of the EURADOS intercomparison 2017 of neutron dosimeters IC 2017n

Applicant:
EURADOS e. V.
Working Group 2 "Harmonisation of individual monitoring"
Attn. Sabine Mayer, Paul Scherrer Institut (PSI)
European Radiation Dosimetry Group
Ingolstädter Landstraße 1
85764 Oberschleißheim
Germany

For:
IC2017n Participant S015

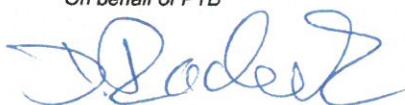
Date of irradiation:
2017-06-02 to 2017-07-10

Anzahl der Seiten: 8
Number of pages:

Geschäftszeichen: **PTB - 6.4-2017/35_S015**
Reference No.:

393 00B o

Im Auftrag
On behalf of PTB


Dr. D. Radeck

Siegel
Seal



Im Auftrag
On behalf of PTB


S. Koch

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1. Irradiation conditions

This report deals with the irradiation of ten whole body dosemeters in neutron reference fields at PTB in the framework of the EURADOS intercomparison 2017 of neutron dosimeters IC2017n.

The uncertainty stated in this report is the expanded measurement uncertainty obtained by multiplying the standard uncertainty by the coverage factor $k = 2$. It has been determined in accordance with the "Guide to the Expression of Uncertainty in Measurement" (GUM) [1]. The value of the measurand then normally lies, with a probability of 95%, within the attributed coverage interval.

The irradiations were performed in a low scattering room ($7 \text{ m} \times 7 \text{ m} \times 6.5 \text{ m}$) of PTB in a height of 3.25 m above the floor. For the irradiations, reference radiation fields from a ^{252}Cf neutron source were used in accordance with [2-4]. The irradiation conditions at PTB are listed in Tab. 1.

Tab. 1: Irradiation conditions at PTB for the EURADOS neutron intercomparison IC2017n.

Neutron source	Angle	Distance / cm	Number of dose-meters	$H_{p,ins}(10)/H_p(10) / \%$	$H_p(10) / \text{mSv}$
^{252}Cf	0°	75	4	2.24 ± 0.32	$1.50 \pm 0.06 *$
^{252}Cf (D ₂ O mod., 1 mm Cd)	0°	75	4	2.40 ± 0.40	1.20 ± 0.11
^{252}Cf (D ₂ O mod., 1 mm Cd) behind a shadow block	iso-tropic	170	2	100	1.00 ± 0.15

*: Additional irradiation with photons of a ^{137}Cs source ($H_p(10) = 1 \text{ mSv}$).

The measurement quantity is the neutron personal dose equivalent $H_p(10)$. This quantity was calculated from the fluence of the direct and the inscattered neutrons and the mean fluence-to-personal-dose-equivalent conversion coefficients $h_{p\phi,\text{dir}}(10; \alpha)$ and $h_{p\phi,\text{ins}}(10; \text{isotropic})$. The value $h_{p\phi,\text{dir}}(10; 0^\circ)$ for ^{252}Cf is taken from [4]. The value $h_{p\phi,\text{dir}}(10; \alpha)$ for the moderated ^{252}Cf source takes into account that the PTB moderator differs slightly from the ISO moderator [5]. The mean fluence-to-dose-equivalent conversion coefficients for the inscattered neutrons $h_{p\phi,\text{ins}}(10; \text{isotropic})$ have been determined from the spectral distribution of the scattered neutrons measured with the PTB Bonner-sphere spectrometer [6] and the monoenergetic fluence-to-personal-dose-equivalent conversion coefficients in accordance with [7]. The contribution of inscattered neutrons to the neutron personal dose equivalent is listed in Tab. 1 for each irradiation condition. The fluence-to-personal-dose-equivalent conversion coefficients as used are listed in Tab. 2. The spectral neutron fluence rate in the three reference fields is shown in the figures Fig. 2 to Fig. 4.

The first two irradiations were performed on an ISO water phantom (size: 30 cm x 30 cm x 15 cm). The distance between the centre of the neutron source and the centre of the front face

of the phantom was 75 cm. Four dosimeters were attached to the front surface of the phantom on an area of about 20 cm x 20 cm. Dosimeters from different participants were mixed. For the irradiations behind a shadow block, a PMMA phantom was used. It was directed with its side face towards the source and four dosimeters were fixed on each of the 30 cm x 30 cm faces of the phantom, see Fig. 1. Thus, eight dosimeters were irradiated together. The dosimeter ID codes and the corresponding irradiation conditions are given in Tab. 3.

Tab. 2: Fluence-to-personal-dose-equivalent conversion coefficients for the direct and the in-scattered neutron contribution.

Neutron source	$h_{p\phi,\text{dir}}(10;0^\circ)$ / (pSv·cm ²)	$h_{p\phi,\text{ins}}(10;\text{isotropic})$ / (pSv·cm ²)
²⁵² Cf (D ₂ O mod., 1 mm Cd)	114.8 ± 7.2	13.7 ± 1.7
²⁵² Cf	400 ± 8	50 ± 7

2. Results

Tab. 3: Information on the irradiations of whole body dosemeters at PTB in the framework of the EURADOS neutron intercomparison IC2017n for participant S015.

ID code	$H_p(10)$ / mSv	Neutron source	Date of irradiation
S015-2017-25	1.20 ± 0.11	^{252}Cf (D_2O mod., 1 mm Cd)	07.06.2017
S015-2017-26	1.50 ± 0.06	^{252}Cf (with additional 1.0 mSv of ^{137}Cs)	19.06.2017
S015-2017-27	1.20 ± 0.11	^{252}Cf (D_2O mod., 1 mm Cd)	07.06.2017
S015-2017-28		not irradiated	
S015-2017-29		not irradiated	
S015-2017-30	1.00 ± 0.15	^{252}Cf (D_2O mod., 1 mm Cd) behind a shadow block	26.06.2017
S015-2017-31	1.50 ± 0.06	^{252}Cf (with additional 1.0 mSv of ^{137}Cs)	19.06.2017
S015-2017-32	1.50 ± 0.06	^{252}Cf (with additional 1.0 mSv of ^{137}Cs)	19.06.2017
S015-2017-33		not irradiated	
S015-2017-34	1.20 ± 0.11	^{252}Cf (D_2O mod., 1 mm Cd)	07.06.2017
S015-2017-35		not irradiated	
S015-2017-36	1.00 ± 0.15	^{252}Cf (D_2O mod., 1 mm Cd) behind a shadow block	26.06.2017
S015-2017-37		not irradiated	
S015-2017-38	1.20 ± 0.11	^{252}Cf (D_2O mod., 1 mm Cd)	07.06.2017
S015-2017-39	1.50 ± 0.06	^{252}Cf (with additional 1.0 mSv of ^{137}Cs)	19.06.2017
S015-2017-40		not irradiated	

3. Figures

Fig. 1: Illustration of the irradiation conditions of whole body dosemeters on a PMMA phantom in a ^{252}Cf (D_2O mod., 1 mm Cd) reference field behind a shadow block.

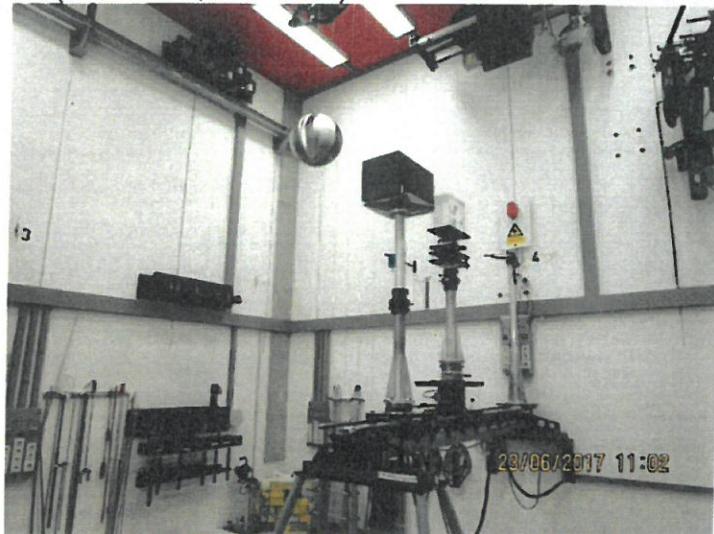


Fig. 2: Spectral neutron fluence rate of the direct and inscattered contribution and the total spectral neutron fluence rate (without phantom) at 75 cm distance for the ^{252}Cf source.

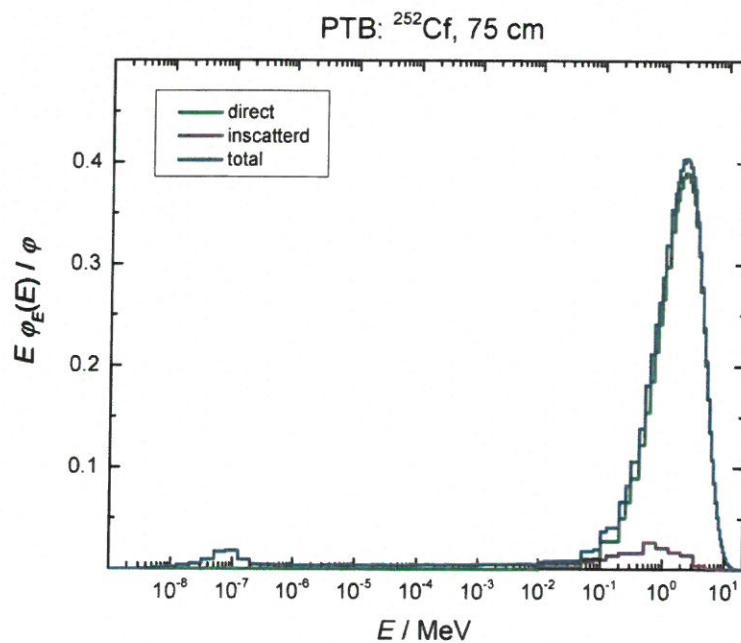


Fig. 3: Spectral neutron fluence rate of the direct and inscattered contribution and the total spectral neutron fluence rate (without phantom) at 75 cm distance for the ^{252}Cf (D_2O mod., 1 mm Cd) source.

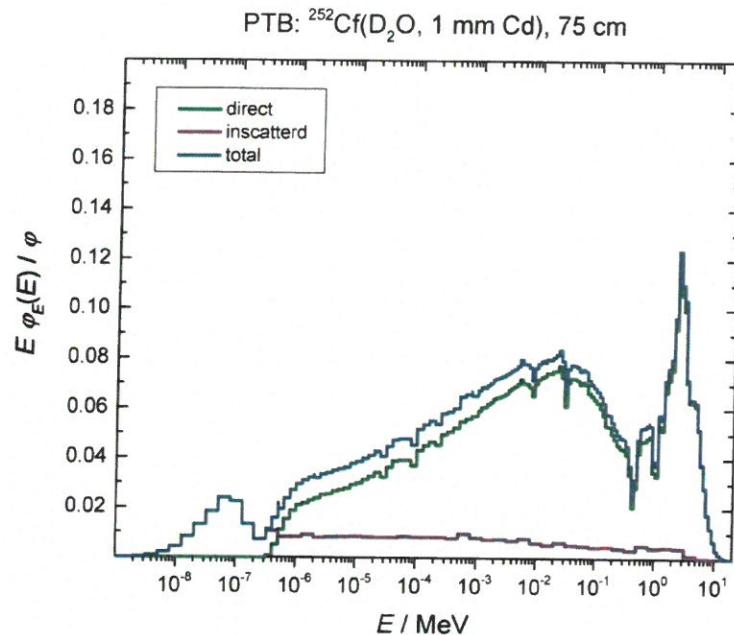
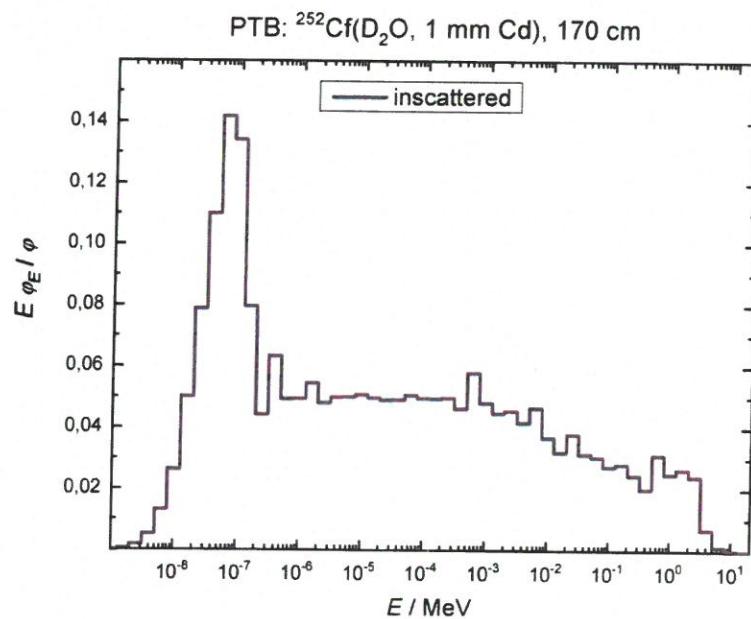


Fig. 4: Spectral fluence rate of the inscattered neutrons (without phantom) at 170 cm distance for the ^{252}Cf (D_2O mod., 1 mm Cd) source.



4. Bibliography

- [1] JCGM 100:2008, *Evaluation of measurement data – Guide to the expression of uncertainty in measurement* Joint committee for Guides in Metrology.
- [2] International Standard ISO 8529-1 (2001) *Reference neutron radiations – Part 1: Characteristics and methods of production*.
- [3] International Standard ISO 8529-2 (2000) *Reference neutron radiations – Part 2: Calibration fundamentals of radiation protection devices related to the basic quantities characterizing the radiation field*.
- [4] International Standard ISO 8529-3 (1998) *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*.
- [5] Jetzke, S. and Kluge, H. (1997) *Characteristics of the ^{252}Cf neutron fields in the irradiation facility of the PTB*, Radiat. Prot. Dosim. 69, 247.
- [6] Kluge, H., Alevra, A.V., Jetzke, S., Knauf, K., Matzke, M., Weise, K., and Wittstock, J. (1997) *Scattered neutron reference fields produced by radionuclide sources* Radiat. Prot. Dosim. 70, 327.
- [7] ICRP Publication 74 (1996) *Conversion Coefficients for use in Radiological Protection against External Radiation*, Ann. ICRP 26 (3-4).
- [8] Kluge, H. (1998) *Irradiation facility with radioactive reference neutron sources: Basic principles* PTB Report, PTB-N-34, ISBN: 3-89701-192-1.



Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

Seite 8 zum Bericht vom 2017-12-18
Page 8 of the Report dated 2017-12-18

Geschäftszeichen: PTB - 6.4-2017/35_S015
Reference No.: PTB - 6.4-2017/35_S015

Die Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig und Berlin ist das nationale Metrologieinstitut und die technische Oberbehörde der Bundesrepublik Deutschland für das Messwesen. Die PTB gehört zum Geschäftsbereich des Bundesministeriums für Wirtschaft und Energie. Sie erfüllt die Anforderungen an Kalibrier- und Prüflaboratorien auf der Grundlage der DIN EN ISO/IEC 17025.

Zentrale Aufgabe der PTB ist es, die gesetzlichen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI) darzustellen, zu bewahren und weiterzugeben. Die PTB steht damit an oberster Stelle der metrologischen Hierarchie in Deutschland. Die Kalibrierscheine der PTB dokumentieren eine auf nationale Normale rückgeführte Kalibrierung.

Dieser Ergebnisbericht ist in Übereinstimmung mit den Kalibrier- und Messmöglichkeiten (CMCs), wie sie im Anhang C des gegenseitigen Abkommens (MRA) des Internationalen Komitees für Maße und Gewichte enthalten sind. Im Rahmen des MRA wird die Gültigkeit der Ergebnisberichte von allen teilnehmenden Instituten für die im Anhang C spezifizierten Messgrößen, Messbereiche und Messunsicherheiten gegenseitig anerkannt (nähere Informationen unter <http://www.bipm.org>).



The Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig and Berlin is the National Metrology Institute and the supreme technical authority of the Federal Republic of Germany for metrology. The PTB comes under the auspices of the Federal Ministry of Economics and Energy. It meets the requirements for calibration and testing laboratories as defined in DIN EN ISO/IEC 17025.

The central task of PTB is to realize, to maintain and to disseminate the legal units in compliance with the International System of Units (SI). PTB thus is at the top of the metrological hierarchy in Germany. The calibration certificates issued by PTB document a calibration traceable to national measurement standards.

This certificate is consistent with the Calibration and Measurement Capabilities (CMCs) that are included in Appendix C of the Mutual Recognition Arrangement (MRA) drawn up by the International Committee for Weights and Measures (CIPM). Under the MRA, all participating institutes recognize the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details, see <http://www.bipm.org>).

