Dosemeter Intercomparison Exercises (organised by EURADOS)

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AUSTRIAN RESEARCH CENTERS

List of international Intercomparisons

Organiser	year	# IMS	radiation	Dosim.	comment
IAEA	1988	20	photon	WB	Phase I
IAEA	1990	24	photon	WB	Phase II
IAEA	1997	??	photon	WB	“Type test”
IAEA	1998	23	photon	WB	"Simulated Workplace Field"
EURADOS	1998	26	photon	WB	"Simulated Workplace Fields"
EURADOS	1998	16	beta	WB	"Simulated Workplace Fields"
EURADOS	1998	8	beta	EXT	"Simulated Workplace Fields"
EURADOS	1998	17	neutron	WB	"Simulated Workplace Fields"
IAEA	1999	35	photon	WB	"Simulated Workplace Fields"
IAEA	2003	34	photon/ neutron	WB	Phase I
IAEA	2004	?	photon/ neutron	WB	Phase II (Simulated Workplace Fields
EURADOS/IAEA	2005	13	photon/beta	WB/APD	Reference And Workplace Fields
EURADOS/CONRAD	2007	6	photon	WB/APD	Interventional Radiology Fields
EURADOS/CONRAD	2007	24	photon/ beta	EXT	Reference And Workplace Fields
EURADOS	2008	72	photon	WB	Reference And mixed Fields
EURADOS	*2009*		*photon/beta*	*EXT*	*Reference And mixed Fields*
EURADOS	*2010*				
EURADOS	*??*				

Early intercomparisons

Radiation Protection Dosimetry
Vol. 96, Nos 1–3, pp. 143–150 (2001)
Nuclear Technology Publishing

IAEA INTERCOMPARISONS FOR INDIVIDUAL MONITORING OF PHOTON RADIATION 1987–1998

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INVITED PAPER

Abstract — In 1985 a technical committee set up by the IAEA formulated tasks to be performed in individual monitoring and recommended 'some type of personnel dosimetry activity'. Since 1987 several coordinated research projects have been performed within the Agency's Research Contract Programme concerning intercomparisons for individual monitoring. While the first intercomparison focused on the impact of the possible adoption of the new set of operational quantities introduced in ICRU Report 39 in 1985, later intercomparisons concentrated on the performance of personnel dosimetry services. In the last intercomparison, dosimetry services for nuclear power plants in IAEA Member States in Eastern Europe were given an opportunity to gain experience with the recommendations of the IAEA to use the operational quantity $H_p(10)$. This paper analyses whether the important tasks formulated in 1985 were actually solved. It summarises the various intercomparisons carried out between 1987 and 1998 and highlights some results.

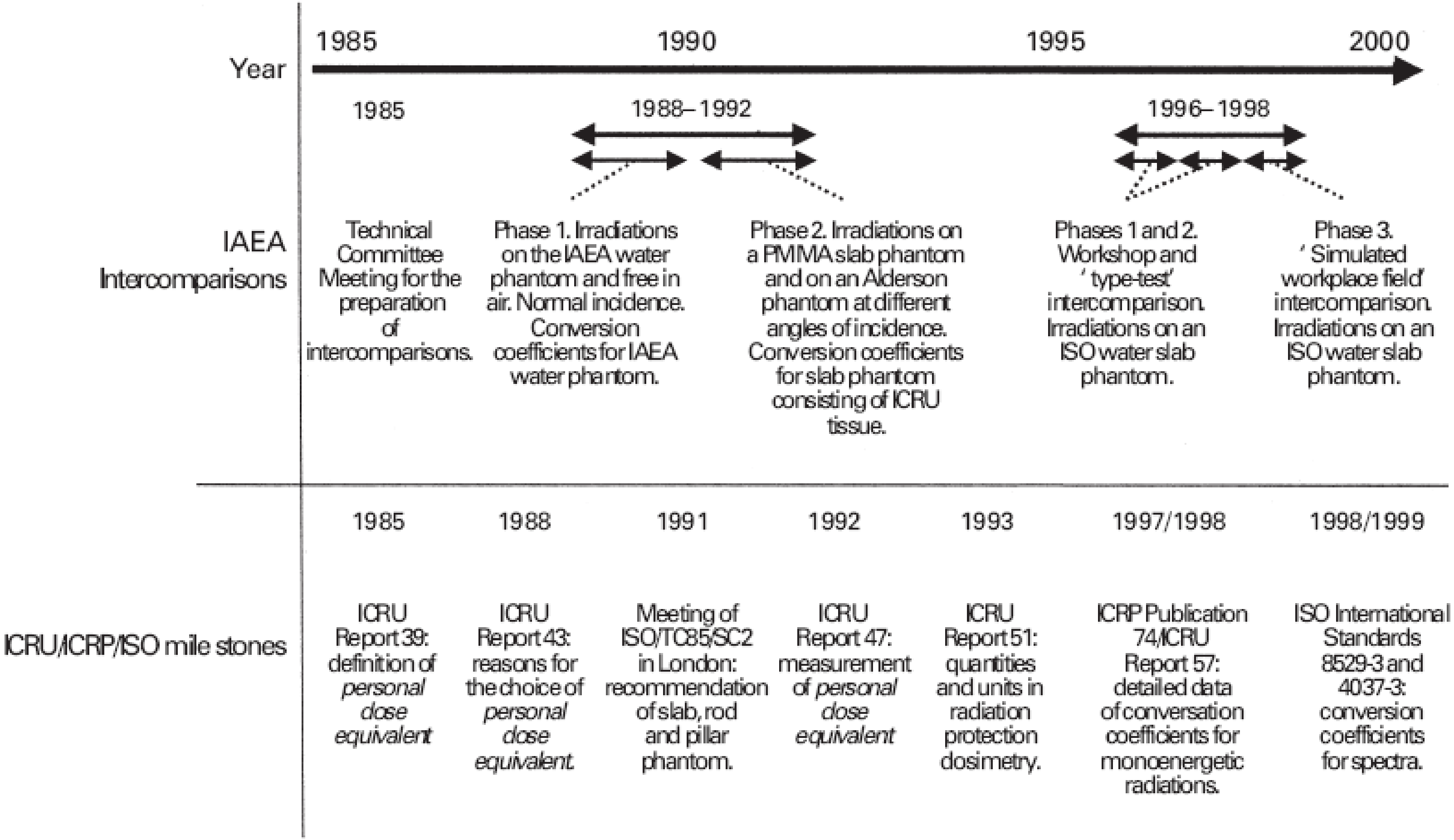

Figure 1. IAEA intercomparisons for individual monitoring and dosimetric milestones related to ICRU, ICRP and ISO between 1985 and 2000.

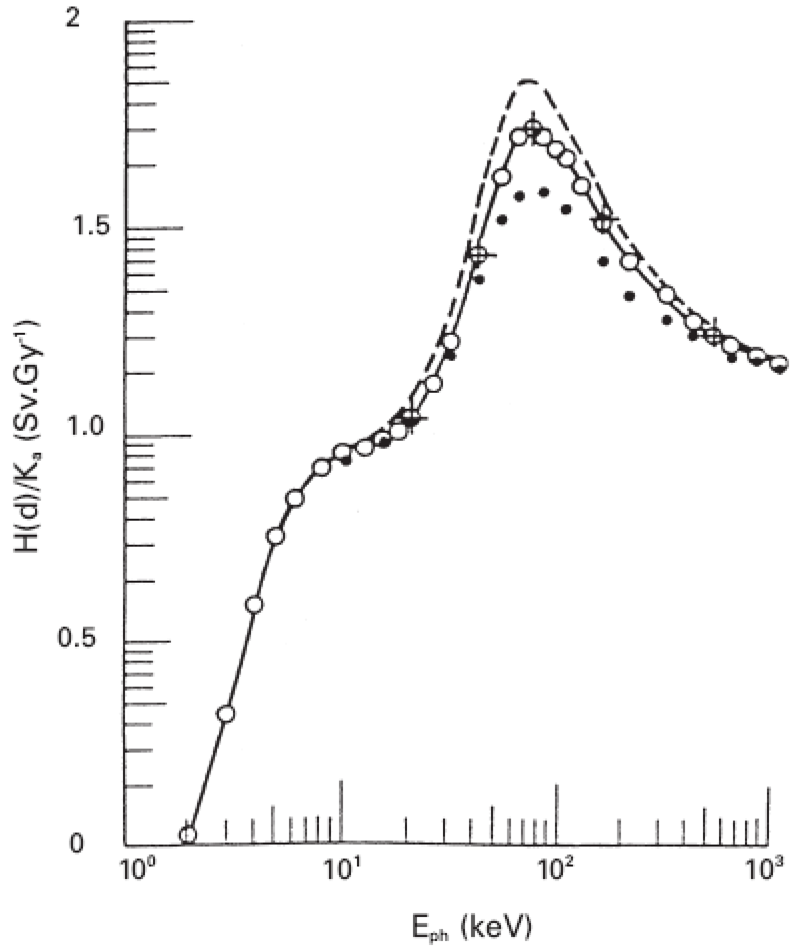

Figure 5. Conversion coefficient H(d)/K_a as a function of photon energy E_{ph} for different phantoms[16]. The depth d is 0.07 mm for the ICRU tissue slab phantom (○), the IAEA water phantom (+) and the ICRU sphere (●). For the PMMA slab phantom (- - -) d is 0.1 mm.

ISO 4037-3

INTERNATIONAL STANDARD

ISO 4037-3

First edition
1999-06-15

X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy —

Part 3:
Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence

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6.3.1 Use of phantoms

Measurements of the response as a function of radiation energy and direction of radiation incidence and calibrations of personal dosemeters should be carried out on a phantom that is suitable in view of the depth of measurement and of the type of dosemeter. As a rule, the depth of 0,07 mm will be applicable only for extremity dosemeters (see note below). For dosemeters worn on the fingers, the ISO rod phantom should be used and, for those worn on the wrist or the ankle, the ISO pillar phantom should be used. The ISO rod phantom is a PMMA cylinder of 19 mm diameter and a length of 300 mm. The ISO pillar phantom is a water-filled hollow cylinder with PMMA walls and an outer diameter of 73 mm and a length of 300 mm. The cylinder walls have a thickness of 2,5 mm and the end faces have a thickness of 10 mm. For dosemeters worn on the body to measure $H_p(10)$, a phantom of outer dimensions 30 cm × 30 cm × 15 cm with PMMA walls (front wall 2,5 mm thick, other walls 10 mm thick) filled with water and termed the ISO water slab phantom, should be used. When using reference radiations with a mean energy equal to or above that of the radionuclide ^{137}Cs, a solid PMMA slab of the same outer dimensions may be used.

When these phantoms are employed as described above, no correction factors shall be applied to the reading of the instrument under test, due to possible differences in back-scatter properties between these phantoms and those of ICRU tissue.

Routine calibrations (see note in 3.2.11) need not always be performed on a phantom but may sometimes be done more simply, free in air, or with another type of radiation than that which the dosemeter is intended to measure. Such simplifications, if they are to be applied, shall be justified prior to their adoption by demonstrating that they lead to results identical to those from procedures described in this part of ISO 4037, or that any differences can be corrected for reliably. This may be done on the basis of the results of a type test.

Radiation Protection Dosimetry
Vol. 89, Nos 1–2, pp. 107–154 (2000)
Nuclear Technology Publishing

PERFORMANCE TEST OF DOSIMETRIC SERVICES IN THE EU MEMBER STATES AND SWITZERLAND FOR THE ROUTINE ASSESSMENT OF INDIVIDUAL DOSES (PHOTON, BETA AND NEUTRON)

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Received and accepted March 1 2000

Table 1. Number of services taking part in the tests by country and by radiation type.

EU code	Country	Photon	Beta whole-body	Beta extremity	Neutron	Total/ country	Services/ country
A	Austria	2	1	1	1	5	2
B	Belgium	1	1	1	—	3	1
CH	Switzerland	2	2	1	2	7	3
D	Germany	2	—	2	1	5	4
DK	Denmark	1	1	1	1	4	2
E	Spain	2	1	—	1	4	2
EL	Greece	1	—	—	2	3	2
F	France	4	2	1	4	11	5
FIN	Finland	2	1	—	1	4	2
I	Italy	1	1	—	1	3	1
IRL	Ireland	1	1	—	—	2	1
L	Luxembourg	1	—	—	—	1	1
NL	Netherland	1	1	—	—	2	1
P	Portugal	1	—	—	—	1	1
S	Sweden	1	1	—	—	2	1
UK	United Kingdom	3	2	1	3	9	5
Total		26	15	8	17	66	34

Detailed Information about used Dosemeters

Table 10. Continued.

(c) Extremity dosemeters (all of TLD type)

Code No	Dosemeter category	Detector	Detector thickness ($mg.cm^{-2}$)	Cover thickness ($mg.cm^{-2}$)	Calibr. reference radiation
1	Finger	LiF:Mg,Ti; TLD-100	100	40	Cs-137
2	Finger	LiF-7 Teflon	28	32	Co-60
4	Wrist	LiF:Mg,Ti; TLD-700	100	45	Co-60
5	Finger	LiF:Mg,Cu.P (MCP-Ns)	10	0.5	Co-60
6	Finger	LiF:Mg,Cu.P (MCP-Ns)	8	2	Cs-137
7	Finger	LiF:Mg,Cu.P (MCP-7s)	8	10	Cs-137
8	Finger	LiF-grains (75–106 μm)	5	3.5	Sr/Y-90
9	Wrist	LiF:Mg,Cu.P (1): MCP-Ns (2): MCP-7	 (1): 8 (2): 240	 (1): 1.5 (2): 86	 Cs-137 (a)

Radiation Protection Dosimetry
Vol. 96, Nos 1–3, pp. 159–165 (2001)
Nuclear Technology Publishing

EURADOS TRIAL PERFORMANCE TEST FOR PHOTON DOSIMETRY

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INVITED PAPER

Abstract — Within the framework of the EURADOS Action entitled *Harmonisation and Dosimetric Quality Assurance in Individual Monitoring for External Radiation*, trial performance tests for whole-body and extremity personal dosemeters were carried out. Photon, beta and neutron dosemeters were considered. This paper summarises the results of the whole-body photon dosemeter test. Twenty-six dosimetry services from all EU Member States and Switzerland participated. Twelve different radiation fields were used to simulate various workplace irradiation fields. Dose values from 0.4 mSv to 80 mSv were chosen. From 312 single results, 26 fell outside the limits of the trumpet curve and 32 were outside the range 1/1.5 to 1.5. Most outliers resulted from high energy R-F irradiations without electronic equilibrium. These fields are not routinely encountered by many of the participating dosimetry services. If the results for this field are excluded, most participating services satisfied the evaluation criteria.

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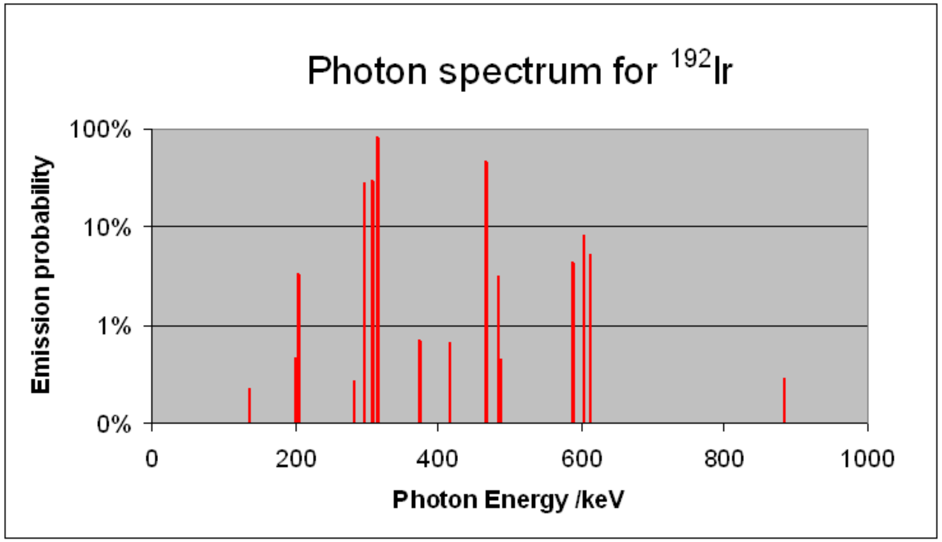
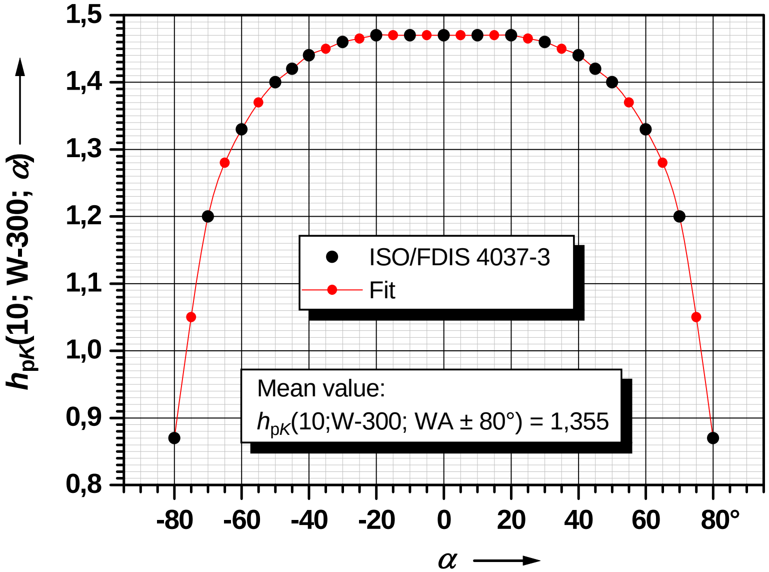
Radiation quality	Conversion coefficient h_{pK} (10) Sv / Gy	Standard uncertainty	Mean Energy keV
S-Ir (0°)	1,317 *	0,03	396
S-Ir (WA ± 80°)	1,262 *	0,035	396
W-80 (WA ± 80°)	1,523 *	0,025	57
S-Co (0°)	1,15	0,02	1250
R-F (0°)	1,12	0,029	6610
W-300 (WA ± 80°)	1,355 *	0,025	208
R-F (0°) without electronic equilibrium	1,41 *	0,086	6610



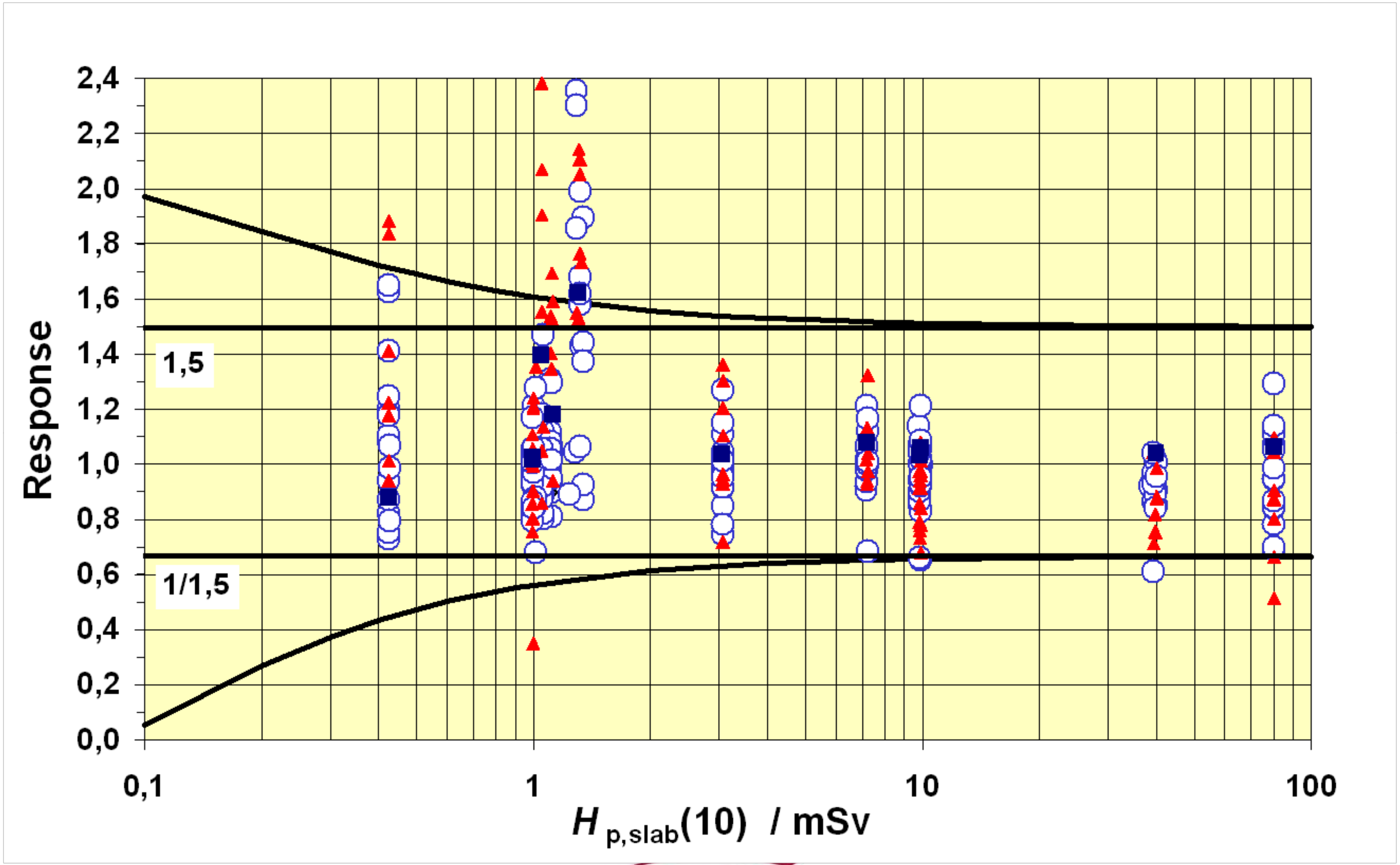


EURADOS Performance test

EURADOS
Performance test

IAEA (2x)
Performance test

Results


2,4
2,2
2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
Response
1,5
1/1,5
0,1
1
10
100
H p,slab(10) / mSv

Trumpet curve				
type	datapoints	outliers	outside limits	inside limits
TLD (PT)	204	10	4,9%	95,1%
Film (PF)	96	15	15,6%	84,4%
Glass (PV)	12	1	8,3%	91,7%
All	**312**	**26**	**8,3%**	**91,7%**

1/1,5 to 1,5 range				
type	datapoints	outliers	outside limits	inside limits
TLD (PT)	204	10	4,9%	95,1%
Film (PF)	96	21	21,9%	78,1%
Glass (PV)	12	1	8,3%	91,7%
All	**312**	**32**	**10,3%**	**89,7%**

Radiation Protection Dosimetry
Vol. 96, Nos 1–3, pp. 175–182 (2001)
Nuclear Technology Publishing

EURADOS TRIAL PERFORMANCE TEST FOR PERSONAL DOSEMETERS FOR EXTERNAL BETA RADIATION

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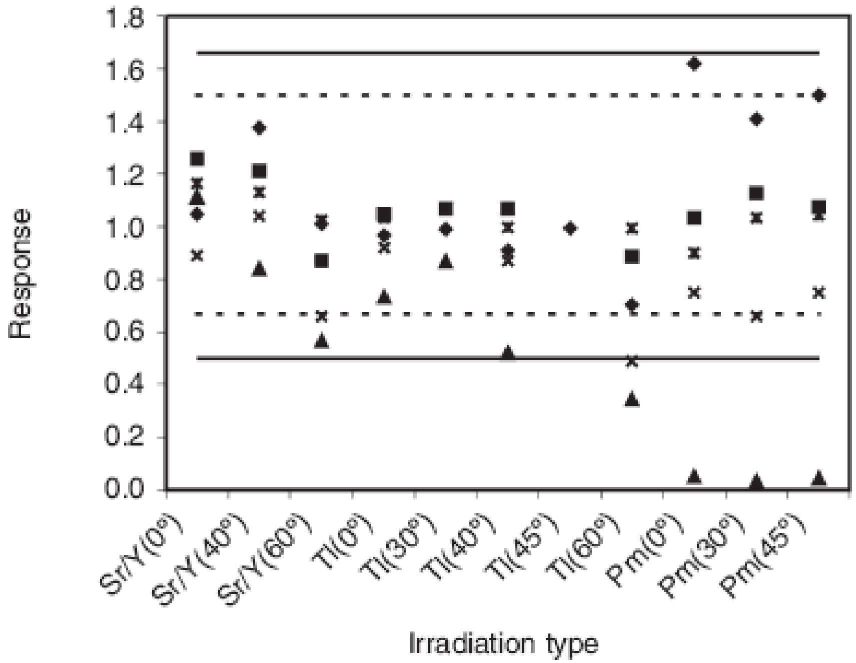
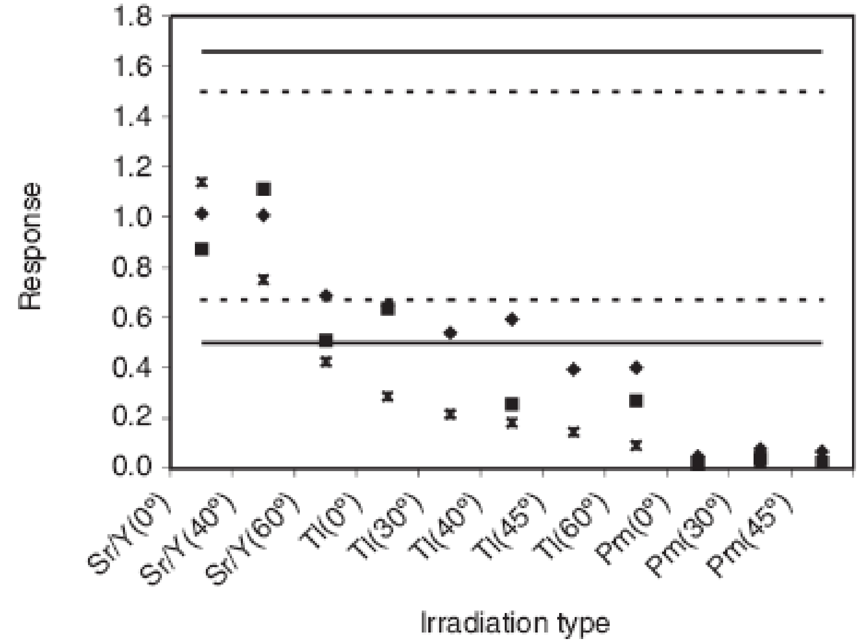
INVITED PAPER

Results (Beta irradiation)





Sr/Y(0°) Sr/Y(40°) Sr/Y(60°) Tl(0°) Tl(30°) Tl(40°) Tl(45°) Tl(60°) Pm(0°) Pm(30°) Pm(45°)

Radiation Protection Dosimetry
Vol. 96, Nos 1–3, pp. 167–173 (2001)
Nuclear Technology Publishing

EURADOS TRIAL PERFORMANCE TEST FOR NEUTRON PERSONAL DOSIMETRY

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INVITED PAPER

Abstract — This paper reports on the results of a neutron trial performance test sponsored by the European Commission and organised by EURADOS. As anticipated, neutron dosimetry results were very dependent on the dosemeter type and the dose calculation algorithm. Fast neutron fields were generally well measured, but particular problems were noted in the determination of intermediate energy fields and large incident angles, demonstrating the difficulties of neutron personal dosimetry. Of particular concern from a radiological protection point of view was the large number of results underestimating personal dose equivalent. A considerable over-response was noted in a few cases.

Results (neutron irradiation)

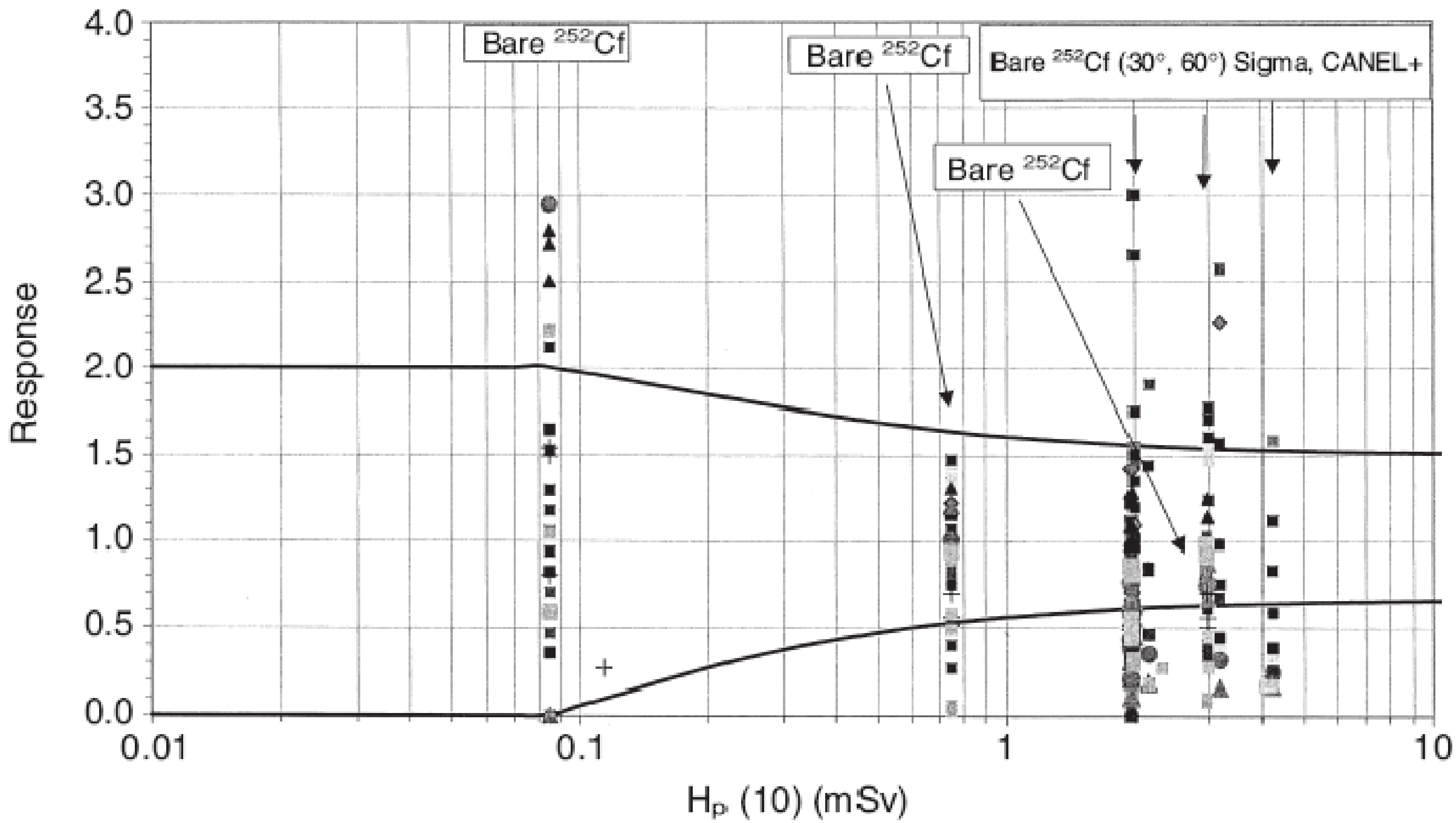

Figure 4. Trumpet curves for corrected results.

IAEA

IAEA-TECDOC-1564

Intercomparison of Personal Dose Equivalent Measurements by Active Personal Dosimeters

Final Report of a joint IAEA-EURADOS Project

EURADOS

IAEA

IAEA
International Atomic Energy Agency

November 2007

The IAEA in cooperation with EURADOS organized such an intercomparison in which most of the testing criteria as described in two internationally accepted standards (IEC61526 and IEC61283) were used. Additionally, simulated workplace fields were used for testing the APD reactions to pulsed X ray fields and mixed gamma/X ray fields. This is the first time that results of comparisons of such types are published, which is of great importance for APD end users in medical diagnostic and surgery X ray applications.

Nine suppliers from six countries in Europe and the USA participated in the intercomparison with 13 different models. One of the models was a special design for extremity dose measurements.

Radiation Protection Dosimetry (2008), Vol. 131, No. 1, pp. 67–72
Advance Access publication 30 August 2008
doi:10.1093/rpd/ncn230

EXTREMITY RING DOSIMETRY INTERCOMPARISON IN REFERENCE AND WORKPLACE FIELDS

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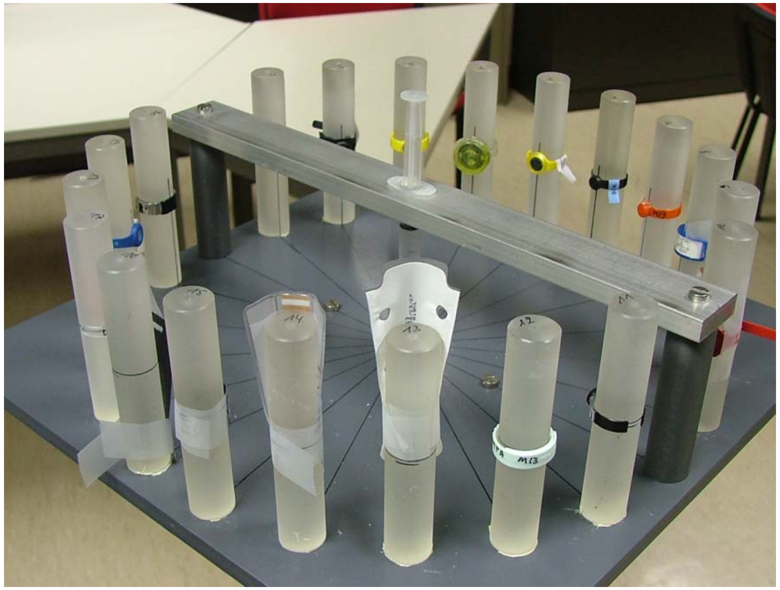
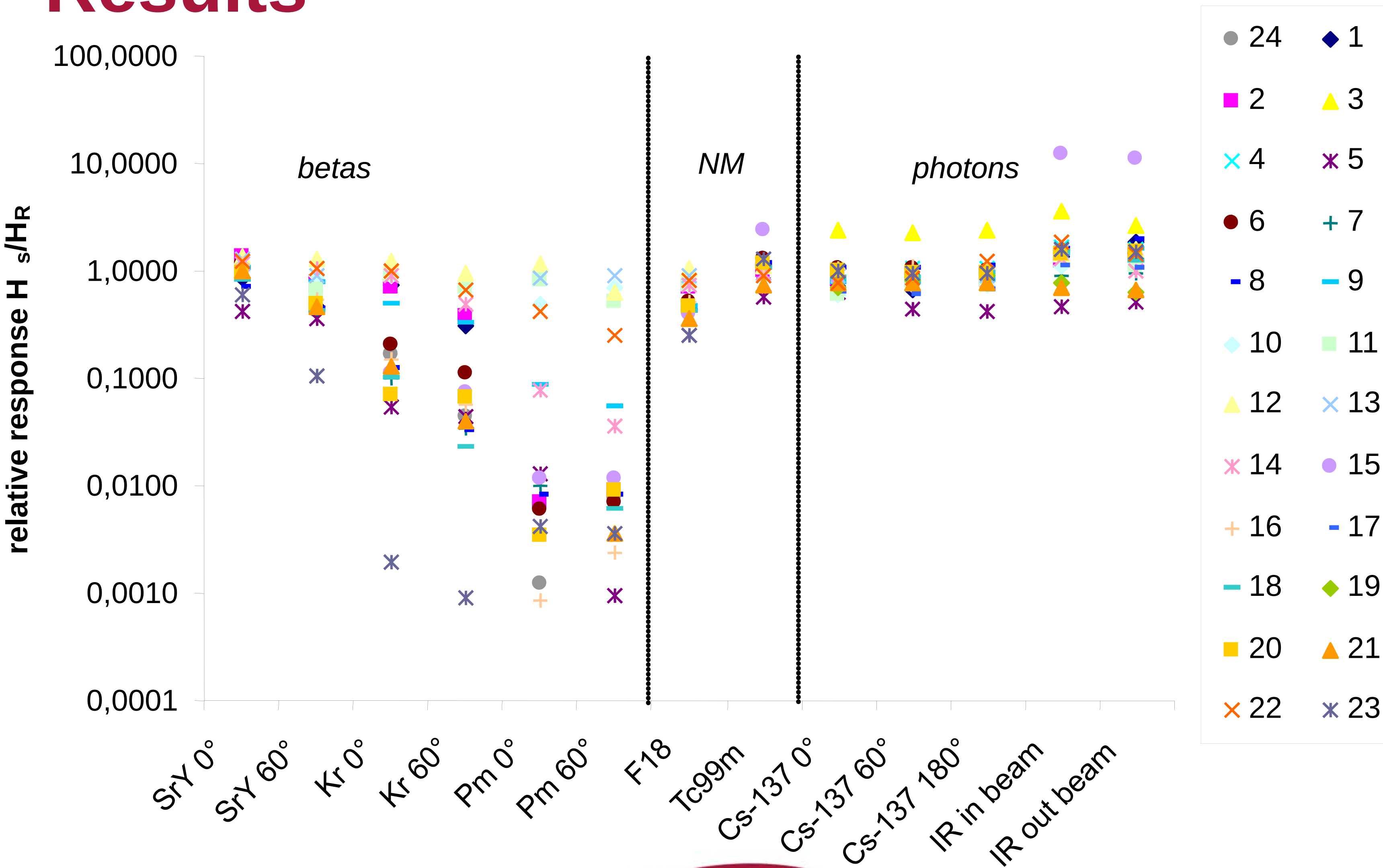
An intercomparison of ring dosemeters has been organised with the aim of assessing the technical capabilities of available extremity dosemeters and focusing on their performance at clinical workplaces with potentially high extremity doses. Twenty-four services from 16 countries participated in the intercomparison. The dosemeters were exposed to reference photon (^{137}Cs) and beta (^{147}Pm, ^{85}Kr and ^{90}Sr/^{90}Y) fields together with fields representing realistic exposure situations in interventional radiology (direct and scattered radiation) and nuclear medicine (^{99m}Tc and ^{18}F). It has been found that most dosemeters provided satisfactory measurements of $H_p(0.07)$ for photon radiation, both in reference and realistic fields. However, only four dosemeters fulfilled the established requirements for all radiation qualities. The main difficulties were found for the measurement of low-energy beta radiation. Finally, the results also showed a general under-response of detectors to ^{18}F, which was attributed to the difficulties of the dosimetric systems to measure the positron contribution to the dose.

Results

H_p(0.07) [mSv]	*Radiation quality*	*Mean response*	*Response range*	*Nº services outside the trumpet curve*
8.2	^{90}Sr-^{90}Y, 0°	1.00	0.38 – 1.42	1/20
9.0	^{90}Sr-^{90}Y, 60°	0.63	0.03 – 1.30	10/20
10.3	^{85}Kr, 0°	0.45	0 – 1.31	12/20
11.0	^{85}Kr, 60°	0.29	0 – 0.95	15/20
5.8	^{147}Pm, 0°	0.25	0 – 1.34	15/20
8.3	^{147}Pm, 60°	0.16	0 – 0.95	16/20
10.1	^{18}F	0.55	0.02 – 1.08	13/20
4.2	^{99m}Tc	1.08	0.48 – 2.36	1/20
4.5	^{137}Cs, 0°	0.92	0.35 – 2.35	1/24
4.8	^{137}Cs, 60°	0.91	0.38 – 2.37	2/24
5.2	^{137}Cs, 180°	0.96	0.37 – 2.52	2/24
2.6	IR in beam	1.86	0.27 – 12.5	3/24
0.7	IR outside beam	1.86	0.21 – 11.7	3/24



Results


100,0000
10,0000
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0,0001
relative response H s/HR
betas
NM
photons
SrY 0°
SrY 60°
Kr 0°
Kr 60°
Pm 0°
Pm 60°
F18
Tc99m
Cs-137 0°
Cs-137 60°
Cs-137 180°
IR in beam
IR out beam
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Radiation Protection Dosimetry (2008), Vol. 129, No. 1–3, pp. 340–345
Advance Access publication 24 May 2008
doi:10.1093/rpd/ncn083

INTERCOMPARISON OF ACTIVE PERSONAL DOSEMETERS IN INTERVENTIONAL RADIOLOGY

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The use of active personal dosemeters (APD) in interventional radiology was evaluated by Working Group 9 (Radiation protection dosimetry of medical staff) of the CONRAD project, which is a Coordination Action supported by the European Commission within its sixth Framework Programme. Interventional radiology procedures can be very complex and they can lead to relatively high doses to personnel who stand close to the primary radiation field and are mostly exposed to radiation scattered by the patient. For the adequate dosimetry of the scattered photons, APDs must be able to respond to low-energy [10–100 keV] and pulsed radiation with relatively high instantaneous dose rates. An intercomparison of five APD models deemed suitable for application in interventional radiology was organised in March 2007. The intercomparison used pulsed and continuous radiation beams, at CEA-LIST (Saclay, France) and IRSN (Fontenay-aux-Roses, France), respectively. A specific configuration, close to the clinical practice, was considered. The reference dose, in terms of $H_p(10)$, was derived from air kerma measurements and from the measured and calculated energy distributions of the scattered radiation field. Additional Monte Carlo calculations were performed to investigate the energy spectra for different experimental conditions of the intercomparison. The results of this intercomparison are presented in this work and indicate which APDs are able to provide a correct response when used in the specific low-energy spectra and dose rates of pulsed X-rays encountered in interventional radiology.