IRPA 12

BUENOS AIRES - ARGENTINA - 19 / 24 OCTOBER 2008

12TH INTERNATIONAL CONGRESS OF THE INTERNATIONAL RADIATION PROTECTION ASSOCIATION

Topical Session TS 1.1.1
External Exposure to Ionizing Radiation

Keynote Lecture:

Recent Achievements in External Radiation Dosimetry

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Topical session: External Exposure to Ionizing Radiation

Keynote Lecture: Recent Advances in External Radiation Dosimetry

Objective:

Comment some of the most relevant activities and achievements since the last IRPA conference (Madrid, 2004).

Selected topics:

- Individual dosimetry:
  - Active/Passive Personal Dosimeters
  - OSL
  - Neutron dosimetry
  - Personal dosimetry in interventional radiology procedures
- Computational dosimetry
- 2007 ICRP Recommendations

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Active Personal Dosimeters

Active Personal Dosimeters proposed as a more convenient method for individual dosimetry than Passive Personal Dosimeters.

Active methods: direct dose readings

- Better assessment of doses in specific operations
- Optimization of working conditions and protection procedures.

It was considered APDs to replace PPDs.

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After more than a decade of use, APDs and PPDs peacefully co-exist

Some Personal Dosimetry Services have moved to APDs.
Common situation: APDs and PPDs are employed for the operation of services.

Both methods are useful and somewhat complementary for individual dosimetry.

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Table 3. Technical characteristics of APDs and TLDs for beta, gamma and neutron personal dosemeters compared with IEC 61526 requirements.

Characteristic	IEC 61526 requirement	Typical values for APD	Typical values for TLDs
Size	<250 cm^3	100 cm^3 (31/31)	15 cm^3
Mass	<200 g	80 g (31/31)	50 g
Mechanical resistance	±10%, 1.5 m hard-tiled surface	Some APDs do not pass the test (~26/31)	No problem
Environmental immunity	±10%, 100 V m^{-1} at 100 kHz–500 MHz and 1 V m^{-1} at 500 MHz–1 GHz	Old APDs used to have problems (~28/31)	No problem
Effective range of measurement	1 μSv–1 Sv	1 μSv–10 Sv (25/31)	10 μSv–1 Sv
Photon radiation fields (33 keV–2 MeV)	Dose equivalent, ±15%	(50 keV–2 MeV) (11/31)	33 keV–2 MeV
Beta radiation fields ($^{90}Sr/^{90}Y$, ^{204}Tl)	Dose equivalent, ±15%	(4/31)	$^{90}Sr/^{90}Y$ (90%) ^{204}Tl (70%)
Neutron radiation fields	−35 to +122% (100 keV–15 MeV −35 to 200% (0.025 eV–100 keV)	Only fulfilled in limited energy regions[10]	−50 to +100% in workplaces with field-dependent correction factors

In parentheses, the number of APDs from Table 1 that comply with the requirements are indicated

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Ginjaume, M., Bolognese-Milsztajn, T., Luszik-Bhadra, M., Vanhavere, F., Wahl, W. and Weeks A.. Overview of Active Personal Dosemeters for Individual Monitoring in the European Union. Radiat. Prot. Dosim. 125, 261-266 (2007). EURADOS WG 2.

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OSL

A passive method, has reached practical feasibility and commercial availability

TLD and OSL sister techniques similar processes but different stimulation method: OSL optical, TLD thermal.

OSL does not requires any heating, this is reported to be the origin of the reported advantages over TLD.

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Anyway, the comparison of the practical characteristics of both methods does not reveal a clear advantage of OSL overTLD.

OSL seems to offer slightly better characteristics, but the experience accumulated by TLD for decades is very satisfactory.

Both solid state methods will probably dominate in future the market of passive methods for personal dosimetry.

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Neutron dosimetry

Difficult dosimetry:
Strong energy dependence conversion factors fluence/absorbed dose
Practical neutron fields: broad energy distributions/photon contribution

None of the actual dosimeters can provide acceptable results in every field
For a precise dosimetry field correction factors/ realistic calibration needed

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EVIDOS EU project objective:

Perform comprehensive evaluation different personal and area dosimetry Methods in mixed n-γ fields of workplaces in the nuclear industry.

Particular attention to develop fluence/dose equivalent conversion factors as function of energy spectra and directional dependence

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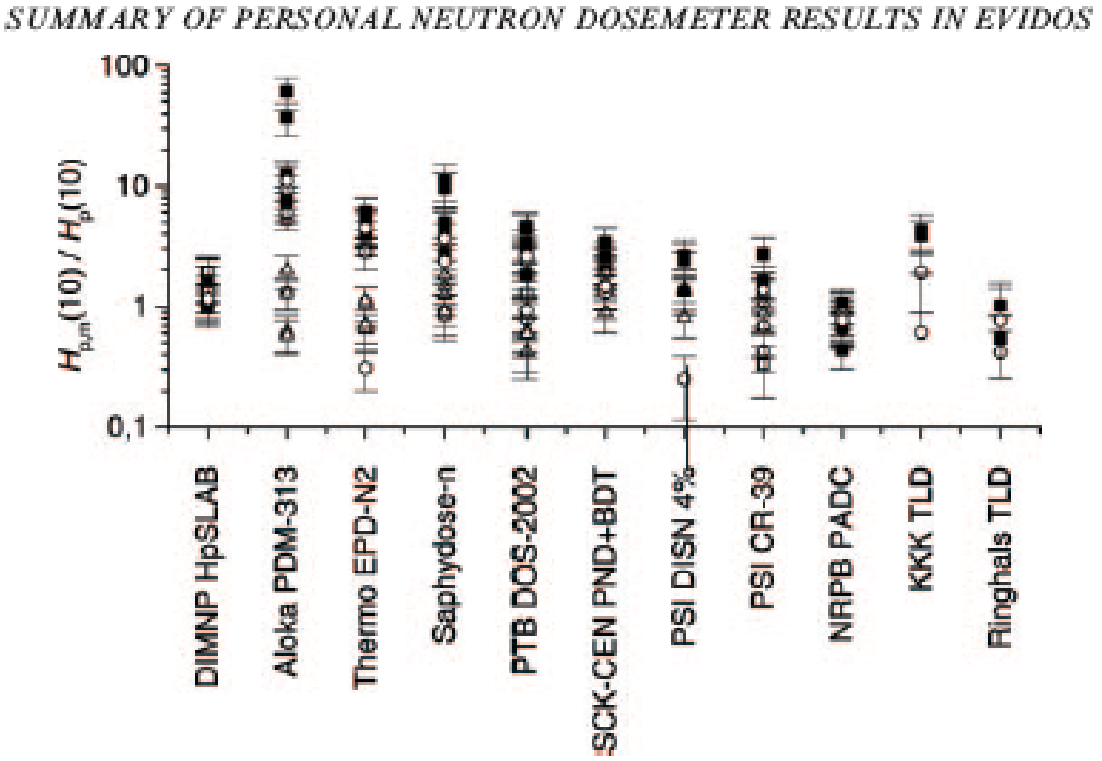

Figure 1. Response of different personal dosemeters in the simulated workplace field CANEL (□), the reactor fields (■), the fields at transport casks (○) and the fields at the fuel facility Belgonucléaire (△).

L., Luszik-Bhadra, M., Bolognese- Milsztajn, Boschung, M., Coeck, M., Curzio, Derdau, D., D'Errico, F., Fiechtner, A., Kyllönen, J.E., Lacoste, V., Lievens, B., Lindborg, Lovefors Daun, A., Reginatto, M., Schuhmaker, H., Tanner, R. and Vanhavere, F. Summary of Personal Neutron Dosemeters Results Obtained Within the EVIDOS Project. Radiat. Prot. Dosim. 125, 293-299 (2007).

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Personal Dosimetry in interventional radiology

The readings of personal dosimeters should provide reasonably good estimates of effective dose, E, and so of risks incurred by radiation workers.

Interventional radiology procedures: significant doses, non-uniform exposures. Direct readings from a personal dosimeter placed on the torso not adequate.

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Interventional radiology procedures: significant doses, non-uniform exposures. Direct readings from a personal dosimeter placed on the torso not adequate.

Not clear where the personal dosimeter (dosimeters) should be placed and what dose value registered.

Above protective apron important E overestimation, below underestimation.

Both should be avoided:
Underestimation: inadequate insufficient protection,
Overestimation: if excesive dose limits can be falsely reached. Unnecessary problems for workers and for the efficiency of the service.

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Lack of consensus on the dosimetry for the medical staff in interventional radiology: single or double dosimetry, different correction algorithms….

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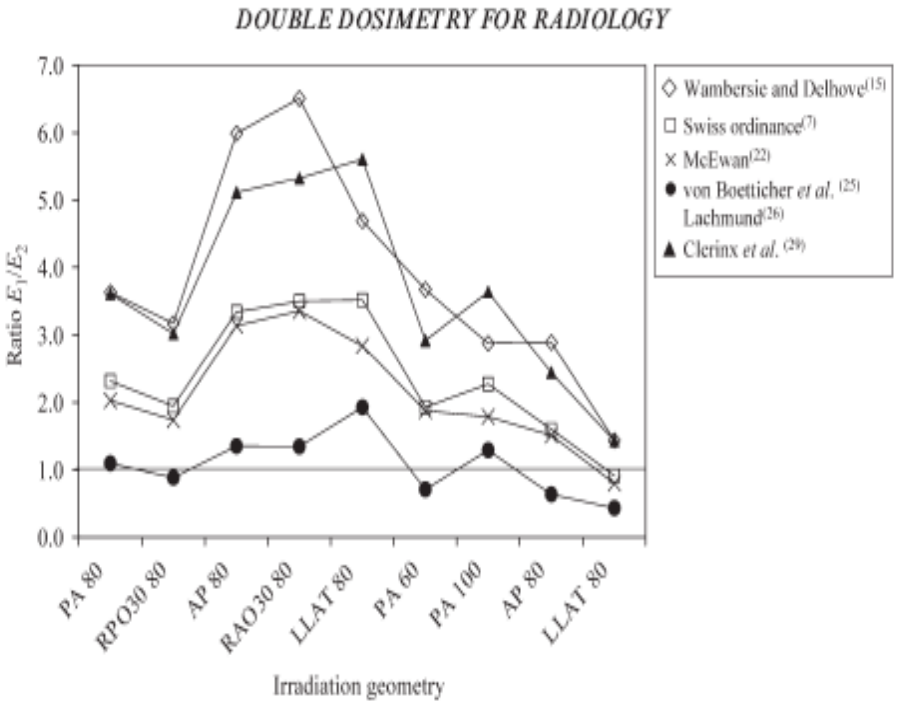

Figure 1. Ratio E_1/E_2, i.e. the effective dose calculated by the algorithm divided by the effective dose obtained from the MC calculation, for the various *double* dosimetry algorithms in the clinical cases considered and calculated by Siiskonen *et al.*[28].

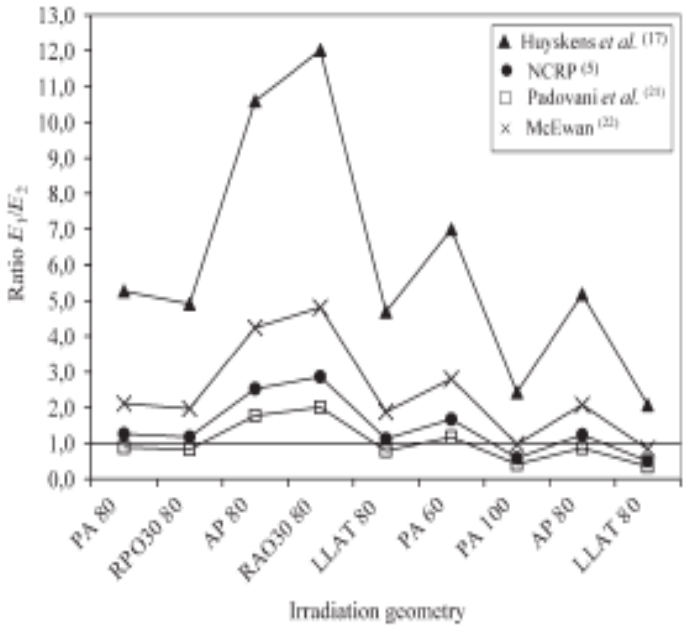

Figure 2. Ratio E_1/E_2, i.e. the effective dose calculated by the algorithm divided by the effective dose obtained from the MC calculation, for the various *single* dosimetry algorithms in the clinical cases considered and calculated by Siiskonen *et al.*[28].

Järvinen, H., Buls, N., Clerinx, P., Jansen, J., Miljanic, S., Nikodemová., Ranogacec-Komor, M. and D'Errico, F. Overview of Double Dosimetry Procedures for the Determination of the Effective Dose to the Interventional Radiology Staff. Radiat. Prot. Dosim. 129, 333-339 (2008).

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Computational dosimetry

Computational methods are playing a progressively more important role in practically every area of radiation dosimetry.

Monte Carlo methods together with mathematical phantoms of human body permit to calculate dose distributions in organs and tissues in an ample range of geometries and radiation fields.
Simulation of detector response: great help to develop new dosimeters.

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Radiation protection: the possibility of estimating effective or organ equivalent dose, starting from field quantities, a major advance.

Patient dosimetry: calculate accurate dose distributions and the contribution of scattered radiation. Photoneutrons in radiotherapy treatments with high energy photons.

Micro and nanodosimetry: distribution of energy deposition events in tissue volumes comparable to cellular dimensions.

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ICRP 2007 Recommendations

Annex B describes the dosimetry system for radiation protection.
Basically remains as in ICRP 60. Only some changes in the radiation weighting factors and tissue weighting factors.

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Effective Dose is defined only for regulatory purposes to demonstrate compliance with dose limits and for dose record.

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Not adequate for:

- ✓Assessment of causation of cancer/ tissue reactions
- ✓Assessment of doses associated to medical treatments
- ✓Retrospective assessment of occupational doses if a "limit or constraint" could have been exceeded.
- ✓In this case more appropriate to make specific individual estimates of dose and risk: absorbed dose and adequate values of RBE.

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THANKS FOR YOUR ATTENTION!!