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iM 2015

New generation of dose estimation algorithm for multi-element passive dosemeter

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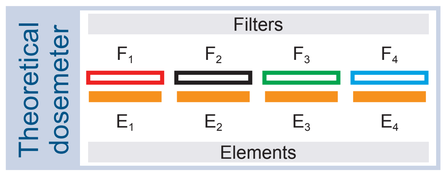
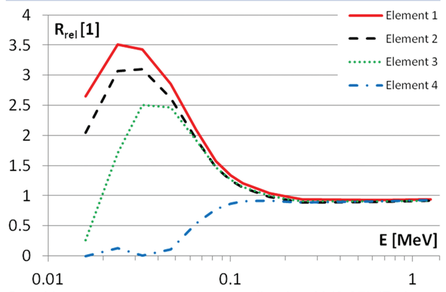
STATE-OF-THE-ART

Basic principle of a multi-sensitive element passive dosemeter





Sensitive element response normalized to $H_p(0.07)$ (R_{rel}) for the theoretical dosemeter as a function of photon energy

Intrinsic sensitive element response modulation

↓

Exposure conditions reconstruction possible

↓

Personal dose equivalent estimation

Most common type of personal dose equivalent estimation algorithm

Linear algorithm:

- Single linear equation on the whole rated energy-angular range

$$H_p(d) = \sum_{i=1}^{N} a_i(d)\, e_i$$

N=number of sensitive elements
e_i= measurement for the i^{th} sensitive element
$a_i(d)$=coefficient for the i^{th} element and the quantity $H_p(d)$

		Linear	Linear with decision points
Advantages	Easy to use/understand	x	
	Additivity of response	x	
	Adapted to dosemeter with highly energy dependent sensitive material		x

Linear algorithm with decision points:

- Multiple linear equations possible
- Choice depending on defined conditions

Example:

$$if\,(condition\,1)\; H_p(d) = \sum_{i=1}^{N} a_i(d)\, e_i$$

$$if\,(condition\,2)\; H_p(d) = \sum_{i=1}^{N} b_i(d)\, e_i$$

		Linear	Linear with decision points
Drawbacks	Dosemeter specific	x	x
	Optimization required	x	x
	May generate instabilities		x

MONTE-CARLO ALGORITHM (MCA)

SPECIFICATIONS

Universal algorithm:

- Shall be useable for all multi-element dosemeters

Results provided compliant with EN 62387-1:2012*:

- Development started for the new LANDAUER dosemeter and compliance with the european transcription of the standard given above (see poster 03.180)

norme européenne — NF EN 62387-1 Mai 2012
norme française — Indice de classement : C 19-113
ICS : 13.280

New LANDAUER dosemeter

* International standard defining performance requirements for dosimetry systems

BASIC PRINCIPLES

Dosemeter sensitive element measurements

MCA

Dosemeter Response Database (DRD)

Pattern reconstruction with Monte-Carlo based numerical method

Iterative process

Pattern reconstructed on DRD

$H_p(d)$ + Estimated exposure conditions

International patent: WO 20141191957 A1

MAIN CHARACTERISTICS

Advantages:

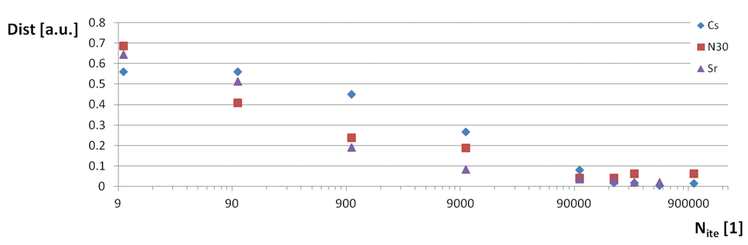
- Improved stability: not a decision - point algorithm
- Dosemeter independent algorithm: all dosemeter specific information contained in DRD
- Modular algorithm: possibility to assess dose with different DRD configurations
- Basic spectroscopy (energy/angle, particle type)
- Estimation of dose components possible

Drawback:

- By hand calculations impossible (Monte-Carlo method)

PERFORMANCES / STRESS TEST

CONVERGENCE



- The quantity Dist is an estimate of the distance between the results $H_p(10)$ and $H_p(0.07)$ given by the algorithm and the reference values $H_p(10)_{ref}$ and $H_p(0.07)_{ref}$:

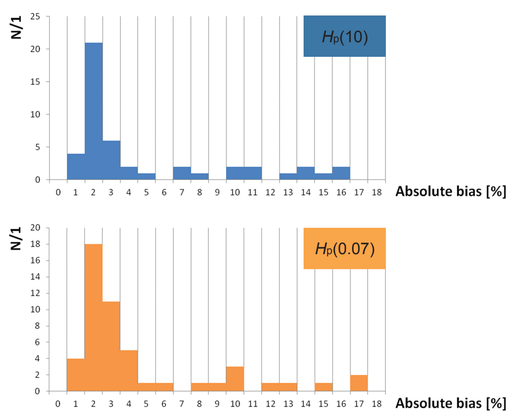
$$Dist = \left[\alpha \left(\frac{H_p(10)_{ref}}{H_p(10)} - 1 \right)^2 + \left(\frac{H_p(0.07)_{ref}}{H_p(0.07)} - 1 \right)^2 \right]^{1/2}$$

α = 1 for photons α = 0 for beta

- The variable N_{ite} is the number of iterations used to estimate $H_p(10)$ and $H_p(0.07)$
- The convergence zone starts at $N \approx 1 \times 10^5$

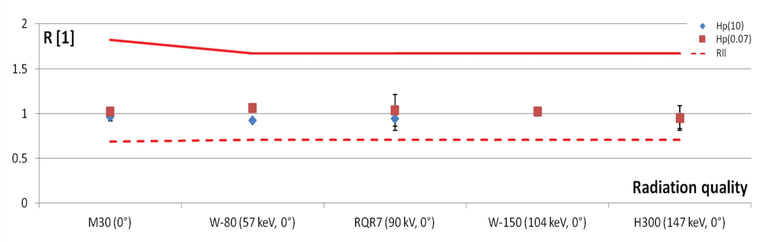
GN case experimental data has been used for this study.

STABILITY



- Absolute bias calculated between dose estimation for noisy measurements and references
- 10% Gaussian noise (k=2) added randomly to sensitive element measurements
- Radiation qualities considered: photons from 16 keV to 6 MeV, beta (^{85}Kr, ^{90}Sr/^{90}Y) ; angle of incidence in [-60°;60°]
- **Mean bias < 7.7 %**

RESPONSE TO UNKNOWN RADIATION QUALITIES



- Ratio R of estimated dose to conventional true value for $H_p(10)$ and $H_p(0.07)$
- R_{II} and R_{uI} are the lower and upper acceptable limits defined in the IEC 62387-1:2012
- The error bars are statistical only (k=1)
- Radiation qualities used are not in the DRD (dosemeter response database)
- **All ratios well inside the standard acceptable limits**

CONCLUSIONS

- **Successfull development of a UNIVERSAL dose estimation algorithm**
- **Algorithm patented**
- **Stress tests show: fast convergence, high stability and adaptability of the algorithm**
- **Algorithm already successfully used for IEC 62387-1:2012 compliance of the new LANDAUER dosemeter (see poster 03.180)**