Development of a multi-sensitive element passive dosemeter based on OSL technology for IEC 62387 compliance

Brahim Moreno, Marc Million, Julien Ranouil, Jérôme Hahang.

LANDAUER EUROPE, Direction scientifique, 33 Avenue du Général Leclec, 92256 Fontenay-aux-Roses, FRANCE

CONTEXT

Why a new dosemeter?
- Evolution of standard for passive dosemetry
- Requirements: EN 62387-1:2012
- NF EN 62387-1:2012
- Will to improve range of compliance
- Standard evolution anticipated: start of the new dosemeter development in 2011

Requirements

Metrological requirements
- A least: compliant with the EN 62387-1:2012 standard
- At best: better metrological performances than those required

Design requirements
- Technology: Optically Stimulated Luminescence (OSL) with aluminum oxide (Al₂O₃)
- Number of sensitive elements: 4
- Dosemeter readable on existing readers
- No modification of the external appearance

DEVELOPMENT

Dosemeter developed by using Monte-Carlo technique

- Basic principle of a multi-sensitive element passive dosemeter
- Sensitive material response modulation by using filters

Sensitive element modelling
- Material: Granular structure: cubic grains of the same dimension for the binder and aluminum oxide
- Homogeneous structure: aluminum oxide with adapted density

Geometrical modelling and validation

- Badge: Aluminum for photons
- Aluminium oxide for beta

New design
- Filters closer to sensitive elements for better angular response
- Acceptable agreement between MC and experimental data

RESULTS

Dosemeter tested against European version of IEC 62387 by LNHB (the French national laboratory for ionizing radiation).

Energy dependency for photons

Energy range expected: 0.01 mSv to 10 mSv
- Beta: energy-angle dependency better than 14% (except one point at 33%)

Energy-angle dependency

- Beta: energy-angle dependency better than 14% (except one point at 33%)
- Photons: energy-angle dependency better than 13% (except one point at 19%)

CONCLUSION

Dosemeter declared compliant with EN 62387-1:2012 for photon and beta radiations on the following range by LNHB:
- Dose range: 0.05 mSv to 10 Sv for H(10) and H(0.07)
- Photons: mean energies from 16 keV to 6 MeV angle from -60° to 60° H/V
- Beta: mean energies 0.2 MeV to 0.8 MeV (18°Kr and 18°Sr/Y) angle -45° to 45° H/V

Dosemeter with high metrological performances
- Non-linearity below 5% over 6 decades
- Photon energy dependency better than 11% over three decades
- Photon angle dependency better than 13% (except one point at 19%)
- Beta energy-angle dependency better than 14% (except one point at 33%)

Presenting author: Brahim MORENO - bmoreno@landauer-fr.com

Numerous optimization and testing parameters
- Filter material
- Filter geometry
- Filter positioning
- Beam quality

No sizeable differences
- Simplest model chosen

Acceptable agreement between MC and experimental data

FILTERS

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<th>Material</th>
<th>Polyamide</th>
<th>Polyurethane</th>
<th>Polyethylene</th>
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<tbody>
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<td>Density [g/cm²]</td>
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Mandatory energy range (average energies)
- Beta: 0.8 MeV to 0.8 MeV
- Photons: 0.5 mSv to 10 mSv

Mandatory dose range expected
- Beta: 0.5 mSv to 10 mSv
- Photons: 0.5 mSv to 10 mSv

Abstract:
- Development of a multi-sensitive element passive dosemeter based on OSL technology for IEC 62387 compliance.

Due to the high sensitivity of the OSL material, it was chosen for the sensitive element.

Theoretical dosemeter

- New case (GN) for photons
- Aluminium oxide powder embedded in plastic
- Metal oxide (Al₂O₃) and aluminum oxide for beta

Experimental dosemeter

- Metal oxide (Al₂O₃) for photons
- New case (GN)

Comparison of the response for photons and beta

- Energy range expected
- Beta: 0.8 MeV to 0.8 MeV
- Photons: 0.5 mSv to 10 mSv

Experimental dosemeter

- Metal oxide (Al₂O₃) for photons
- Aluminium oxide with adapted density
- New case (GN)

Comparison of the response for photons and beta

- Energy range expected
- Beta: 0.8 MeV to 0.8 MeV
- Photons: 0.5 mSv to 10 mSv

Comparing the response of the dosemeter with the EN 62387-1:2012 standard.

- Energy range
- Beta: 0.8 MeV to 0.8 MeV
- Photons: 0.5 mSv to 10 mSv

Comparing the response of the dosemeter with the EN 62387-1:2012 standard.

- Energy range
- Beta: 0.8 MeV to 0.8 MeV
- Photons: 0.5 mSv to 10 mSv

Comparing the response of the dosemeter with the EN 62387-1:2012 standard.