The quantity $H_p(3)$ need for reanimation?

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Radiation & Environment Measurement & Calibration
Aim

to provide background information about the dosimetric quantity $H_p(3)$

for better understanding and judgment of recent developments around this quantity
Outline

- Refresher: operational quantities for individual monitoring
- What is needed to put them into practice
- History of “patient” $H_p(3)$, from birth until recent developments
- Wrap-up
Limiting quantities

- Effective dose, $E$ (mSv)
- Equivalent tissue dose, $H_T$ (mSv)
- For quantifying limits to exposure from the radiation protection point of view
- Definition based on averaged organ doses in a person
- Therefore, not measurable
Operational quantities

- To provide measurable estimates for limiting quantities $E$ and $H_T$
- For external radiation exposure
- Based on “dose equivalent”, $H$
  - taking into account biological effectiveness different types of radiation
- Different definitions for
  - Monitoring workplaces and environment
  - Monitoring individuals
Personal dose equivalent $H_p(d)$

- Definition (ICRU 47):
  - Equivalent dose $H$ in a person at an appropriate depth of $d$ (mm) below a specified point on the body
- Measurement:
  - With a suitable dosemeter on a person at the specified point
### Appropriate depth $d$

<table>
<thead>
<tr>
<th>$d$ (mm)</th>
<th>$H_p(d)$ is a good estimator for:</th>
<th>Annual limit A-worker (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Effective dose, $E$</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Equivalent eye lens dose, $H_{lens}$</td>
<td>150</td>
</tr>
<tr>
<td>0.07</td>
<td>Equivalent skin dose, $H_{skin}$</td>
<td>500</td>
</tr>
</tbody>
</table>
Suitable dosimeter

- Type tested
  - Energy and angular response
- Calibrated
  - Traceable to primary measurement standard

- Appropriate phantoms are needed, because
  - dosimeters are intended to be worn at a specified point on the body
  - dosimeter will be exposed to backscattered radiation
Guidance type testing and calibration

ISO 4037 “.. calibrating dosemeters … and determining their response”

- Definition phantoms

<table>
<thead>
<tr>
<th>Position of dosemeter on the body</th>
<th>ISO phantom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk</td>
<td>Water slab</td>
</tr>
<tr>
<td>Wrist, ankle</td>
<td>Pillar</td>
</tr>
<tr>
<td>Finger</td>
<td>Rod</td>
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</tbody>
</table>

- Traceability
  - No primary measurement standards for $H_p(d)$ available
  - Traceability to air kerma standard by use of conversion factors
Lack of specific guidance for $H_p(3)$

- ISO 4037
  - No specific phantom for dosemeters worn on the head
  - No conversion factors $H_p(3)/K_a$
- ISO 12794:2000
  - Individual thermoluminescence dosemeters for extremities and eyes
  - No specific phantom (use slab…)
  - Limited set of conversion factors $H_p(3)/K_a$ for slab
$H_p(d)/K_a$ conversion coefficients (Sv/Gy)

- ISO water slab phantom

![Graph showing $H_p(d)/K_a$ conversion coefficients for different photon energies and thicknesses.](image)
**$H_p(3)$ barely used in practice**

- “monitoring of $H_p(3)$ will be required only in unusual circumstances” (ICRU 39, 1985)

- “… $H_p(3)$ has rarely been used in practice and very few instruments exist for measuring this quantity. It is suggested that its use is discontinued…” (ICRP 103, 2007)

- Main arguments:
  - Eye lens will be protected sufficiently if $E$ and $H_{\text{skin}}$ are below limits
  - $H_p(0.07)$ can be used to estimate $H_{\text{lens}}$ with sufficient accuracy.
On the other hand…

- “… further information is needed and revised judgements may be required particularly in respect of the eye” (ICRP 103, 2007)

- “The Commission has now reviewed recent epidemiological evidence suggesting that there are some tissue reaction effects, particularly those with very late manifestation, where threshold doses are or might be lower than previously considered … the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv in a year” (ICRP, 2011)

- “With this new proposed limit, 45% of the operators have annual eye doses above 3/10th of the annual limit of which 24% exceed the new proposed annual limit” (Oramed, Eurados, 2012)
Test NRG whole body dosemeter

- Data used from previous type test (1991)
- NRG dosemeter tested for:
  - 16 photon energies, 10 keV to 1250 keV
  - 4 angles of incidence, 0° to 60°
- Dosemeter on 30 x 30 x 15 cm$^3$ PMMA slab
- Re-evaluation with $H_{p,\text{slab}}(3)$ conversion coefficients
$H_p(3)$ response of the NRG dosemeter

- Detector at position B passes criteria ISO 12794
EU initiative: Oramed

- Optimization of radiation Protection of Medical Staff (Eurados Report 2012-02)
- Filled in a number of gabs
  - Proposal for suitable head phantom
  - Conversion factors
  - Design dedicated dosemeter
Type test eye lens dosemeter at NRG
Neighbour countries: UK

Eye Dosemeter: Update

In Monitor No. 40, we reported on the work we are doing on a new dosimeter for measuring the dose to the lens of the eye, in the context of a probable reduction in the eye lens dose limit.

This will only be of direct interest to employees where individual eyes are exposed to significantly non-uniform fields - a prime example is in interventional radiology, where a surgeon's eye is well protected by a lead apron, but where the eye may be less so. Other examples are where beta radiations are encountered, e.g. in nuclear medicine or in some applications in the nuclear industry.

It may be that, in the long run, not many more workers will require routine monitoring. However, we have developed the new headband to help meet the need for those, say, the next five years, the scope and magnitude of the problem.

On the design, we have consulted with customers and colleagues and believe we have struck a balance between usability and affordability.

The type testing of the dosimeter - when we assess its generic radiation detection characteristics - is almost complete. We have conducted a new programme according to the recommendations of OIMAR/GRS (Optimisation of Interim Action for Risk Assessment and Risk Management) and have established here the response values with the energy of beta, gamma and X-rays. The results so far have been as expected, and we are completing the type tests by looking at the directional dependence of the response.

How Not to Do Things ...

You may remember that a few years ago we ran a number of articles in Monitor that were taken from the UK limiting Radiation Incident Database (RID). RID contained unprecedented details of incidents that had resulted in elevated levels of radiation exposure, or had been 'near misses'. The object was to learn lessons so that other people's mistakes could be avoided.

Together with a number of other organisations, the NRG has established an international online database, known as OPIRA, that fulfills a similar function. The latest incident entries include:

- Contamination of personal and equipment by a damaged lead gauge source in a food factory
- Incident involving radiation injury from gamma non-destructive testing source exchange
- Exposure of a package containing iodine-131
- Search for a lost laboratory source found elsewhere on same premises
- Historical thorium contamination in a research facility.

The reports make instructive reading - see www.orcha.net

Also in this issue:

- NRG Dosimetry Online: Update
- Emergency leading of Dosimetry
- Radiation Protection Training Courses
- News from April 2012
- Getting Connected
Neighbour countries: Germany

• In photon radiation fields, the personal dose equivalent quantity $Hp(0.07)$ adequately estimates the eye lens dose (…) there is therefore no need to introduce the additional personal dose equivalent quantity $Hp(3)$ (…) for the specific case of lens monitoring.

• For the dose equivalent quantity $Hp(0.07)$, the personal dosimeter used must, however, be calibrated on an ISO water slab phantom (slab phantom), like a whole-body dosimeter, not on an ISO rod phantom as in the case of a extremity dosimeter.

• Beta fields: maybe better to use $Hp(3)$?

SSK, Monitoring the Eye lens Dose, Statement of the German Commission on Radiological protection with Scientific Reasoning (2010)
Wrap-up

• Considerable amount of debate concerning $H_p(3)$ still going on

• A lot of work is needed for robust metrology of $H_p(3)$

• There may be work-arounds, avoiding the need for $H_p(3)$

• Meanwhile, a lot of information and guidance has become available

• So, why not make use of it?
or…