Implications of a reduced dose limit for the lens of the eye

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Overview

• Changes to the dose limit for the lens of the eye
  – Current limits
  – New limits
  – Why the limits have changed
• Who could be affected by the changes?
• Optimisation of protection
• Measuring dose to the lens of the eye
Current dose limits

Schedule A - Dose limits

The dose limits for ionizing radiation shall be as follows:

<table>
<thead>
<tr>
<th>Application</th>
<th>Occupational</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective dose</td>
<td>20 mSv per year, averaged over a period of 5 consecutive calendar years(^2,3)</td>
<td>1 mSv in a year(^4)</td>
</tr>
<tr>
<td><strong>Annual equivalent dose in</strong></td>
<td><strong>150 mSv</strong></td>
<td>15 mSv</td>
</tr>
<tr>
<td>the lens of the eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the skin(^5)</td>
<td>500 mSv</td>
<td>50 mSv</td>
</tr>
<tr>
<td>the hands and feet</td>
<td>500 mSv</td>
<td>-</td>
</tr>
</tbody>
</table>

New proposed dose limits

20 mSv per year averaged over 5 years
No single year exceeding 50 mSv

(3) For occupational exposure in planned exposure situations, the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv/year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.

ICRP 118: ICRP Statement of Tissue Reactions and Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context

(b) An equivalent dose to the lens of the eye of 20 mSv per year averaged over 5 consecutive years (100 mSv in 5 years) and of 50 mSv in any single year;

IAEA Safety Standards GSR Part 3 (Interim) – Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
Why have the limits changed?

Before

Dose thresholds for tissue effects

<table>
<thead>
<tr>
<th>Tissue effect</th>
<th>Acute or brief exposure</th>
<th>Fractionated or prolonged exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detectible opacity</td>
<td>0.5-2 Gy</td>
<td>5 Gy</td>
</tr>
<tr>
<td>Cataract</td>
<td>5 Gy</td>
<td>&gt;8 Gy</td>
</tr>
</tbody>
</table>

ICRP 60: 1990 Recommendations of the International Commission on Radiological Protection

Now

Dose thresholds for tissue effects

<table>
<thead>
<tr>
<th>Tissue effect</th>
<th>Acute or fractionated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cataract</td>
<td>0.5 Gy</td>
</tr>
</tbody>
</table>

- Acute doses up to ~0.1 Gy produce no functional impairment of tissues
Relevant documents

- ICRP 103 (2007)
- ICRP 118 – Statement on Tissue Effects (2011/2012)
- IAEA GSR Part 3 (interim) – International Basic Safety Standards (2011)
- IAEA TECDOC (Draft) – Implications for occupational radiation protection of the new dose limit for the lens of the eye (2013?)
Who is affected?

3 categories of workers exposed to:

• Uniform whole body radiation field
• Non-uniform radiation field, where the lens may be preferentially exposed
• Weakly penetrating radiation ($\beta$ or $\gamma < 15$ keV), contributing to dose to lens, but not to effective dose
Who is affected?

Workers in the second category include:

- Those whose trunks may be shielded but not the head
- Those whose heads are close to a source of penetrating radiation
- Those who are exposed to $\beta$ radiation
Who is affected?

**Medical workers**

- Interventional radiology and interventional cardiology
- Fluoroscopy guided interventional procedures
- Preparation of sources/radiopharmaceuticals and PET/CT
- Manual brachytherapy
- CT guided interventional procedures
- Cyclotrons
## Typical doses received per procedure

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Eye Dose (mSv)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatic chemoembolization</td>
<td>0.27-2.1 (range) 0.016-0.064 (range)</td>
<td>Unshielded Shielded</td>
</tr>
<tr>
<td>Iliac angioplasty</td>
<td>0.25-2.2 (range) 0.015-0.066 (range)</td>
<td>Unshielded Shielded</td>
</tr>
<tr>
<td>Neuroembolization (head, spine)</td>
<td>1.4-11 (range) 0.083-0.34 (range)</td>
<td>Unshielded Shielded</td>
</tr>
<tr>
<td>Pulmonary angiography</td>
<td>0.19-1.5 (range) 0.011-0.045 (range)</td>
<td>Unshielded Shielded</td>
</tr>
<tr>
<td>TIPS creation</td>
<td>0.41-3.7 (range) 0.025-0.11 (range)</td>
<td>Unshielded Shielded</td>
</tr>
<tr>
<td>Cerebral angiography (CA)</td>
<td>0.046 (mean) 0.025 (mean) 0.014 (mean) 0.013 (mean)</td>
<td>Unshielded Shielded Shielded Shielded Shielded</td>
</tr>
<tr>
<td>Endovascular aneurysm repair (EVAR)</td>
<td>0.01 (mean)</td>
<td>Unshielded</td>
</tr>
<tr>
<td>Urology</td>
<td>0.026 (mean)</td>
<td>Unshielded</td>
</tr>
<tr>
<td>Orthopedic</td>
<td>0.05</td>
<td>Unshielded</td>
</tr>
<tr>
<td>Hysterosalpingography (HSG)</td>
<td>0.14 (mean)</td>
<td>Unshielded</td>
</tr>
<tr>
<td>Endoscopic retrograde cholangiopancreatography (ECRP)</td>
<td>0.094 (mean) 0.55 (mean) 2.8 (maximum)</td>
<td>Under-couch X-ray tube Over-couch X-ray tube</td>
</tr>
</tbody>
</table>
Who is affected?

Other industries

• Industrial radiographers (homogenous radiation field)
• Staff in nuclear facilities using hot cells
• Decommissioning of nuclear facilities
Optimisation of Protection

Engineered controls

• Ceiling-suspended lead glass shielding
• Design of equipment used in interventional procedures

One Zone Devices

Kenex
Optimisation of Protection

Administrative Controls

• Designating controlled areas
• Operational procedures and restrictions
• Staff training
• Raise awareness with affected workers
Optimisation of Protection

Personal protective equipment (PPE)

• Perspex glasses (β-particles)
• Lead glasses (γ and X-rays)
Monitoring doses to the lens of the eye

- $H_p(10)$ – equivalent dose to tissues at depth 10 mm (organs)
- $H_p(0.07)$ – equivalent dose to tissues at depth 0.07 mm (skin/extremities)
- $H_p(3)$ – equivalent dose to tissues at depth 3 mm (radiation-sensitive tissue of the lens)

Monitoring doses to the lens of the eye

Public Health England headband dosimeter

ORAMED head phantom
Monitoring doses to the lens of the eye
Alternatives to $H_p(3)$ monitors

Possibility of using extremity ($H_p(0.07)$) monitor

- Worn near eyes
- Calibrated on suitable phantom (head)
- Consideration of:
  - Energy and angle of incident radiation
  - Geometry of radiation field (and changes)
  - Usage of PPE (PPE factors?)
Alternatives to $H_p(3)$ monitors

Using $H_p(0.07)$ TLD monitors

• Worn above lead aprons
• Only for homogenous radiation fields
• Consideration of PPE worn (lead glasses)
Where to from here?

- RHC – Statement on Changes to Occupational Dose Limit for Lens of the Eye (2011)
- ARPANSA Code of Practice for Radiation Protection in Planned Exposure Situations as Applied to Workers, the Public and the Environment (to be published)
- ARPANSA Fact Sheet – Improving Eye Safety in Image Guided Interventional Procedures (IGIP)
- National Uniformity – ARPANSA to encourage licence holders to implement best practice
- Measurement of doses to the lens of the eye
- Development of lens monitors in Australian context
Key messages

• Lifetime threshold of 0.5 Gy - lower by factor of ~10!

• New dose limit
  – 20 mSv averaged over 5 years
  – 50 mSv in any single year

• No data for doses in Australian context

• RSOs to consider doses to the lens of the eye in light of reduced dose limit
Thank-you

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