ICRP RECOMMENDATIONS AND IAEA SAFETY STANDARDS: THEN AND NOW

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How the new recommendations of ICRP emerged?

- A discussion paper was prepared by the ICRP Chairman.
- Desire to reduce the complexity that has evolved and to cover exposures in a holistic approach.
Phases in the Development of the New Recommendations

2000 - technical discussion in the ICRP 10th Congress in Hiroshima

2004 – technical discussion in the ICRP 12th Congress in Madrid

2004 & 2006 – public consultations

21 March 2007 – approval of ICRP 103 in Eissen, Germany after 8 years of discussion.
Objectives of the New Recommendations

- To take account of new biological and physical information and of trends in the setting of radiation safety standards; and

- To improve and streamline the presentation of the Recommendations.
The *New ICRP 103* is consistent with the new scientific information and societal expectations.

The Recommendations of the Commission now evolve from the previous process-based approach of practices and interventions to an approach based on the characteristics of radiation exposure situations.
Recommendations in ICRP 103

PRACTICE & INTERVENTION

The Commission has previously distinguished between practices that add doses, and interventions that reduce doses.

The Commission now uses a situation-based approach to characterize the possible situations where radiation exposure may occur as planned, emergency, and existing exposure situations.

It applies one set of fundamental principles of protection to all of these situations.
Recommendations in ICRP 103

3 Types of Exposure Situations

Planned Exposure
Situations involving the planned introduction and operation of sources. (This type of exposure situation includes situations that were previously categorized as practices.)
Emergency

Unexpected situations such as those that may occur during the operation of a planned situation, or from a malicious act, requiring urgent attention.

Incident in Japan
Existing
Situations that already exist when a decision on control has to be taken, such as those caused by natural background radiation.
System of Radiological Protection
There is no change in the system of radiological protection.

Justification – applied in all exposure situations

Benefits $>$ Risk
The **ALARA** principle is still the same.

In order to avoid severely inequitable outcomes of this optimization procedure, there should be restrictions on the doses or risks to individuals from a particular source (dose or risk constraints and reference levels).

The principle of optimization of protection applies to all three exposure situations: planned exposure situations, emergency exposure situations, and existing exposure situations.
# Recommendations in ICRP 103

## Dose limits in Planned Exposures

<table>
<thead>
<tr>
<th>Categories of exposure</th>
<th>1990 Recommendation</th>
<th>103 Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Exposure</td>
<td>20 mSv over defined periods of 5 years not to exceed 50 mSv in a single year</td>
<td>20 mSv over defined periods of 5 years not to exceed 50 mSv in a single year</td>
</tr>
<tr>
<td>Eye</td>
<td>150 mSv</td>
<td>Same as occupational exposure</td>
</tr>
<tr>
<td>Skin</td>
<td>500 mSv/year</td>
<td>500 mSv/year</td>
</tr>
<tr>
<td>Hand and feet</td>
<td>500 mSv/year</td>
<td>500 mSv/year</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>2 mSv to the surface of abdomen or 1 mSv from intake of radionuclide</td>
<td>1 mSv to the embryo/fetus</td>
</tr>
<tr>
<td>Public Exposure</td>
<td>1 mSv in a year</td>
<td>1 mSv in a year</td>
</tr>
</tbody>
</table>
On Pregnancy:

In induction of malformations, the new data strengthen the view that there are gestational age-dependent patterns of in-utero radiosensitivity with maximum sensitivity being expressed during the period of major organogenesis.

On the basis of animal data it is judged that there is a true dose threshold of around 100 mGy for the induction of malformations; therefore, for practical purposes, the Commission judges that risks of malformation after in-utero exposure to doses well below 100 mGy are not expected.

Risk to embryo or fetus:

dose under 100 mGy, no lethal effect (same)
100 mGy – threshold for malformation
300 mGy – threshold for mental retardation (8-15 weeks old)
# Dose Limits for the Lens of the Eyes

<table>
<thead>
<tr>
<th>Categories of exposure</th>
<th>1990 Recommendation</th>
<th>103 Recommendation ADDENDUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Exposure</td>
<td>150 mSv/year</td>
<td>20 mSv over defined periods of 5 years not to exceed 50 mSv in a single year</td>
</tr>
<tr>
<td>Public Exposure</td>
<td>15 mSv in a year</td>
<td>15 mSv in a year</td>
</tr>
</tbody>
</table>

**Threshold dose**

- **Detectable opacities**: 0.5-2 Gy total for single exposure; 5 Gy total for fractionated doses; 0.1 Gy/y annual dose fractionated

- **Visual impairment**: 5 Gy total for single exposure

- **Cataract**: 0.5 Gy for the lens of the eye; 8 Gy for total fractionated
Why change the dose limit for the eyes???

Early History about cataract formation

Documented within 1 year of Roentgen’s discovery of X rays

CATARACT HAS A DOSE THRESHOLD
THE SEVERITY INCREASED AND THE LATENCY DECREASED AS THE RADIATION DOSE INCREASED ABOVE THAT THRESHOLD
LATENT PERIOD WAS STRONGLY INVERSELY CORRELATED WITH DOSE AND THAT THERE WAS NO CATARACT INDUCTION BELOW 2 GY.
Since 1950’s


Why change the dose limit for the eyes???

The 2007 ICRP report stated “
‘However, new data on the radiosensitivity of the eye with regard to visual impairment are expected’, and concluded ‘Because of the uncertainty concerning this risk, there should be particular emphasis on optimization in situations of exposure of the eyes’

In 2008, the research study on Retrospective Evaluation of Lens Injuries and Dose (RELID) was launched by IAEA for cardiologists and interventionists and studies showed a direct dose and effect relationship (Rehani et al)

ICP recommend further study on this issue.
Conclusions from IAEA studies

Threshold value, if any, is much lower than current guidelines indicate. Dose-response relationship between occupational exposure and the prevalence of radiation-associated posterior lens changes.

There is a need to find better means for eye lens dosimetry.

First ever published report among this group.
Recommendations in ICRP 103

Dose constraints and Reference level

Dose constraints
  – to be used in planned situations only for optimization of protection.

Reference level
  – used reference levels in emergency and existing exposure situations for optimization of protection.
<table>
<thead>
<tr>
<th>DOSE LIMITS</th>
<th>DOSE CONSTRAINTS &amp; REF. LEVELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protect individual workers from occupational exposure</td>
<td></td>
</tr>
<tr>
<td>and the representative person from public exposure</td>
<td></td>
</tr>
<tr>
<td>From all regulated sources</td>
<td>From a source in all exposure</td>
</tr>
<tr>
<td>In planned exposure situations</td>
<td>situation.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Recommendations in ICRP 103

The Radiation Weighting Factors $-W_R$

*vary with type and energy of radiation*

<table>
<thead>
<tr>
<th>Type &amp; energy</th>
<th>$W_R$</th>
<th>Type &amp; energy</th>
<th>$W_R$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photons, all energies</td>
<td>1</td>
<td>Photons</td>
<td>1</td>
</tr>
<tr>
<td>Electrons &amp; Muons, all energies</td>
<td>1</td>
<td>Electrons &amp; Muons</td>
<td>1</td>
</tr>
<tr>
<td>Neutrons, $&lt;10$ kev</td>
<td>5</td>
<td>Protons and charged pions</td>
<td>2</td>
</tr>
<tr>
<td>10 – 100 kev</td>
<td>10</td>
<td>Alpha, fission frag., heavy nucleon</td>
<td>20</td>
</tr>
<tr>
<td>&gt; 100 to 2 Mev</td>
<td>20</td>
<td>Neutrons</td>
<td></td>
</tr>
<tr>
<td>&gt; 2 TO 20 Mev</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 20 Mev</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protons (not recoil), $&gt;2$ Mev</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha, fission frag., heavy nucleon</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ICRP 60

ICRP 103
## Tissue Weighting Factors - $W_T$

<table>
<thead>
<tr>
<th>ORGAN</th>
<th>$W_t$ (ICRP60)</th>
<th>$W_t$(ICRP103)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonads</td>
<td>0.20</td>
<td>0.08</td>
</tr>
<tr>
<td>RBM</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Colon</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Lung</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Stomach</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Bladder</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Breast</td>
<td>0.05</td>
<td>0.12</td>
</tr>
<tr>
<td>Liver</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Skin</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Bone surface</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Salivary glands</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Brain</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Remainder</td>
<td>0.05</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1.0</strong></td>
<td><strong>1.0</strong></td>
</tr>
</tbody>
</table>
Biological Effects

Deterministic effects

Term deterministic effects changed to tissue reactions

Stochastic effects:

It is possible to assume that incidence of cancer or hereditary disorders will increase in direct proportion to increase in equivalent dose below about 100 mSv

Risk of Cancer

Commission judges that the weight of evidence on fundamental cellular processes coupled with dose-response data supports the view that, in the low dose range, below about 100 mSv, it is scientifically plausible to assume that the incidence of cancer or heritable effects will rise in direct proportion to an increase in the equivalent dose in the relevant organs and tissues
Detriment-adjusted nominal risk coefficients (10^{-2}\text{Sv}^{-1}) for stochastic effects after exposure to radiation at low dose rate.

<table>
<thead>
<tr>
<th>Exposed population</th>
<th>Cancer</th>
<th></th>
<th>Heritable effects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Publ. 60</td>
<td>Present</td>
<td>Publ. 60</td>
</tr>
<tr>
<td>Whole</td>
<td>5.5</td>
<td>6.0</td>
<td>0.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Adult</td>
<td>4.1</td>
<td>4.8</td>
<td>0.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

This risk reduction factor of 2 is used by the Commission to derive the nominal risk coefficients for all cancers given in Table, but the Commission recognizes that, in reality, different dose and dose rate effects may well apply to different organs/tissues.

The most significant change from Publication 6o is the 6–8 fold reduction in the nominal risk coefficient for heritable effects.
HERITABLE RISKS

The Commission has now adopted a new framework for the estimation of heritable risks that employs data from human and mouse studies (UNSCEAR, 2001, NAS/NRC, 2006)

Commission now expresses genetic risks up to the second generation only.

The Commission’s present estimate of genetic risks up to the second generation of about 0.2% per Gy is essentially the same as that cited by UNSCEAR (2001)
Recommendations in ICRP 103

Quantities

Effective dose

- Provides a measure of the radiation detriment for protection purposes.
- Not individual specific dose
- Should not be used for epidemiological evaluations

Collective dose

- Use of optimization of radiation protection
- Should not be used in epidemiological studies
- Should not be used in assessing hypothetical number of cases of cancer or hereditary effects.
Recommendations in ICRP 103

- Protection of the environment
- To develop a framework to assess the relationships between exposure and dose and the effects on non-human species.

- Establish relevant data for small sets of reference animals and plants typical of the major environment.

- There is *no limit* yet for environmental protection.
Protection of the Environment

Two ICRP Publications were issued after 103 regarding the protection of the environment.

ICRP 108- “Environmental Protection: The Concept and use of Reference Animals and Plants”.

ICRP 114- “Environmental Protection Transfer Parameters for Reference Animals and Plants”.
The link with ICRP

- In 1960: …the Agency’s basic safety standards will be based, to the extent possible, on the recommendations of ICRP
- The subsequent revisions of the BSS followed the development of new ICRP recommendations

Source: Division of Radiation, Waste and Transport, IAEA
Radiation Protection Paradigm to be maintained

UNSCAR
Scientific basis

IAEA, WHO, ILO, FAO etc.
- Safety standards
- Protection programmes
implemented by Member States

IAEA

effects
risks

recommendations

levels

ILO convention 115: occupational radiation protection

FAO/WHO
Codex Alimentarius Commission (food contamination guides)

UN transport regulations for radioactive material

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards
Geneva, 2009

General Safety Requirements, Part 3
No. ICRP 53 (2000)
International Standards for Radiation, Transport & Waste Safety

Committees & the Commission on Safety Standards + BSS Secretariat*

*participants include: FAO, IAEA, ILO, OECD/NEA, PAHO, WHO EC, UNEP, ICRP, IRPA

IAEA
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2010</td>
<td>Approval of the Radiation Safety and Waste Safety Standards</td>
</tr>
<tr>
<td>May 2011</td>
<td>Endorsement by the Commission on Safety Standards (CSS)</td>
</tr>
<tr>
<td>21 April 2011</td>
<td>ICRP issued the changes on dose limits of lens of eye</td>
</tr>
<tr>
<td>May 2011</td>
<td>Incorporated the revised dose limit</td>
</tr>
<tr>
<td>12 July 2011</td>
<td>Approval of the revised dose limit for lens of eye</td>
</tr>
<tr>
<td>Nov 2011</td>
<td>Issuance of the Interim Edition of the revised IAEA BSS (unedited)</td>
</tr>
<tr>
<td>July 2014</td>
<td>Issuance of the Final Edition of the IAEA BSS</td>
</tr>
</tbody>
</table>
Why revise the BSS?

• BSS (SS115) is 10 years old and due for review
• Conclusions of review conducted by RASSC:
  • No single urgent need for change, but…
    Some improvements could be made
• Need to bring BSS into current Safety Standards Series
• Need to take note of new Safety Fundamentals and anticipated new ICRP Recommendations
• which, overall, establish a case for revision
Principles of Radiation Protection
The same as ICRP 103)

**Planned exposure situations**
- justification
- optimization
- dose limitation (+dose constraints & risk constraints)

**Emergency exposure situations**
- optimization
- dose limitation (reference levels)

**Existing exposure situations**
- optimization
- dose limitation (reference levels)
Revision of International BSS – draft 4.0

- **Specific requirements** on responsibilities of regulatory bodies have been **included** (eg Req. 19, 20)
- The requirements on licensees, registrants, workers, are **essentially unchanged**
  - Some rearrangement, consolidation and editing of text
  - Some detailed requirements on monitoring have been removed – more appropriate in a Safety Guide
  - Requirements for “special circumstances” (relaxation of dose limit) have been removed – complicated, and no longer needed
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Medical exposure
Changes

- Responsibilities assigned for Government and Reg. Body as well as referrers, medical radiological practitioners, medical physicists, radiographers
- Requirements for key personnel on training, education and competence
- Emphasis is placed on key players (in RP) having the appropriate competence to fulfill their role
- Justification is expanded to follow ICRP 73, 103
- Introduction of the radiological review (audit)
- The patient is introduced into the picture
As a collaborative agency with ICRP on radiation protection, the recommendations in the ICRP 103 have been kept the same.

Additional recommendations are:

Occupational exposure of apprentices (16 to 18 years of age) dose limits:
(a) An effective dose of 6 mSv in a year;
(b) An equivalent dose to the lens of the eye of 20 mSv in a year;
(c) An equivalent dose to the extremities (hands and feet) or the skin of 150 mSv in a year.
For occupational exposure, the personal dose equivalent $Hp(10)$ may be used as an approximation of the effective dose from external exposure to penetrating radiation.
Thank you !!!!