The ICRP Principles of Radiological Protection

Dr Jack Valentin
Scientific Secretary emeritus, ICRP

- **The International Commission on Radiological Protection**
  How it emerged, what it is, what it does, and why
- **The System: Justification…**
  Of actions increasing OR DECREASING exposures
- **…optimisation…**
  A multi-dimensional exercise with constraints
- **…application of dose limits**
  Remember the purpose

What is ICRP?

ICRP: An Independent Registered Charity

Established to advance for the public benefit the science of radiological protection

in particular by providing recommendations and guidance

on all aspects of protection against ionising radiation

Primary Aim of ICRP Recommendations

To *contribute to* an *appropriate* level of protection for people

and the environment

without *unduly* limiting the *desirable human activities* that may be associated with radiation exposure

Objectives of ICRP Recommendations

Prevent deterministic harm

through dose limits and dose constraints, i.e., keeping doses below threshold levels

'Minimise' stochastic harm

through optimisation of protection, i.e., keeping doses *As Low As Reasonably Achievable*

The Early Days of Radiation and Protection

Radiation: Useful But Dangerous

- 1895 – Röntgen discovers x rays
- 1896 – E Grubbé describes x-ray dermatitis
  W Fuchs publishes advice for hands

'Keep exposure as short as possible
Keep at least 12 inches (30 cm) from the tube
Coat exposed skin with vaseline'

= after 1 year, the 'GOLDEN RULES':
TIME
DISTANCE
SHIELDING

The First ICRP Recommendations: Technical Protective Measures

The 1928 ICRP Recommendations: Basis

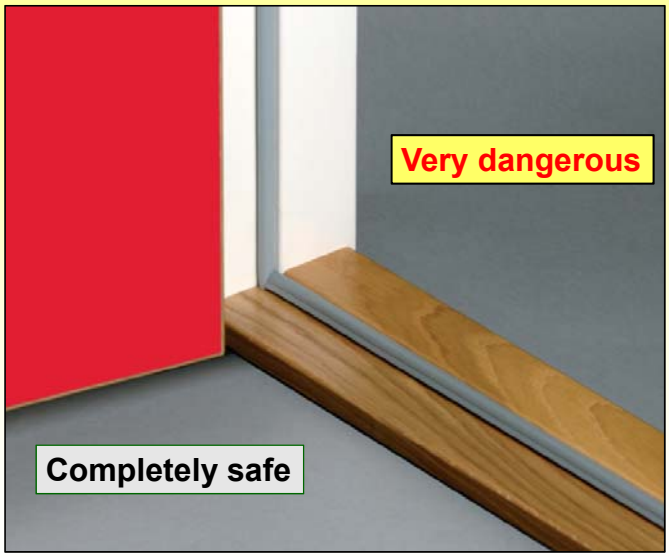
1. The dangers of over-exposure to X-rays and radium can be avoided by the provision of adequate protection and suitable working conditions.

The known effects to be guarded against are:
(a) Injuries to the superficial tissues;
(b) Derangements of internal organs and changes in the blood.

Recommended measures

- *Limitation of working hours*
- *General safety measures*
- *X ray safety measures* (distance, shielding…)
- *Electrical precautions* (!)
- *Radium safety measures*

Philosophy: A Dose Threshold



The First Dose Limit
- The Tolerance Dose

The 1934 Recommendations

- **Very similar to the 1928 Recommendations**

  …but…

The evidence at present available appears to suggest that under satisfactory working conditions a person in normal health can tolerate exposure to X rays to an extent of about 0·2 international röntgens (r) per day.

This corresponds to ~500 mSv y^{-1}

- **…and…**

No similar tolerance dose is at present available in the case of radium gamma rays.

But The Spirit Of The Times Was Reckless

The 1959 Recommendations: ICRP 'Publication 1'

- **Policy: For leukaemia, 'LNT' cannot be excluded**
- **Occupational limit on accumulated dose:**
  5 (N – 18) rem = 5 rem y^{-1} (50 mSv y^{-1})
- **Public dose limit:**
  0.5 rem y^{-1} = 5 mSv y^{-1};
  Genetic dose < 5 rem (50 mSv) per generation

ICRP Publication 9, 1966: Basis

the Commission sees no practical alternative, for the purposes of radiological protection, to assuming a linear relationship between dose and effect

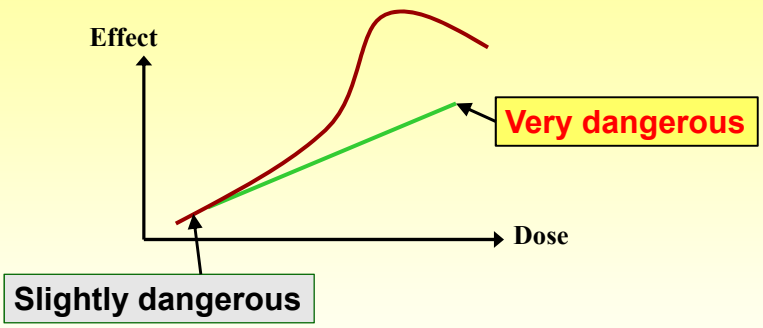
…and therefore:

(52) As any exposure may involve some degree of risk, the Commission recommends that any unnecessary exposure be avoided, and that all doses be kept as low as is readily achievable,

Dose limits: Occupational 50 mSv y^{-1}, public 5 mSv y^{-1}

(in old units: 5 rem, 0.5 rem)

Philosophy: Main Hazard = Cancer; Each Dose Increases The Risk



- **Thus, dose limits do NOT distinguish 'dangerous' from 'safe'**

ICRP Publication 26, 1977: The System Of Radiological Protection

(a) no practice shall be adopted unless its introduction produces a positive net benefit;
(b) all exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account; and
(c) the dose equivalent to individuals shall not exceed the limits recommended

- Genetic dose limit abandoned (superfluous)

Tolerable Detriment

ICRP Publication 60, 1990: Basis

- **The risk per mSv is 5 times higher than assumed in 1977**
- **Dose limits reduced**
  Occupational 20 mSv y^{-1} (100 mSv / 5 y, max 50 mSv in a year)
  Public 1 mSv y^{-1}
- **Limits separate 'unacceptable' from** (sometimes) **'tolerable'**
  Take account of mortality (5 dimensions) and morbidity (weighted)

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

Publication 60: Recommended Measures

- **Dose and risk constraints**
  Prospective limitations of the individual dose / risk from a particular source
- **Purpose 1: Restricting** (constraining) **the options during optimisation**
  A reduction of the collective dose should not be achieved by permitting a few high individual doses
  Primarily in occupational protection
- **Purpose 2: Taking account of exposures from several sources**
  Primarily in public protection

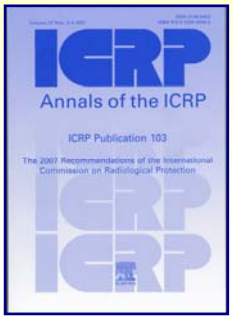
ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

All Exposure Situations
All Exposed Persons
The Environment

The 2007 ICRP Recommendations

- **Now: All exposures**
  - ***Avoid deterministic harm and minimise stochastic harm to man***
  - ***Maintain biodiversity and ecosystems*** *(virtue ethics)*
  - ***Same dose limits as 1990***
  - ***Dose constraints below limits = more focus on individuals' rights*** *(less utilitarian, more duty ethics)*

- **The three fundamental principles**
  - ***Justification***
  - ***Optimisation of protection***
  - ***Application of dose limits***



Justification

The Principle of Justification

- **Any decision that alters the radiation exposure situation should do more good than harm**

  By introducing a new radiation source,
  by reducing existing exposure, or
  by reducing the risk of potential exposure,

  one should achieve sufficient individual or societal benefit to offset the detriment it causes

Important Reminders

- **What is the expected change in radiation detriment**
  Include this explicitly in the decision-making

- **What other risks, costs, and benefits are there**
  Sometimes radiation detriment is a minor factor!

- **Justification goes far beyond radiological protection**
  Verify a net benefit, but
  don't seek the 'best' alternative -
  you are aiding, not making, decisions

Optimisation

The Principle of Optimisation of Protection

The likelihood of incurring exposures,
the number of people exposed, and
the magnitude of their individual doses
should all be kept as low as reasonably achievable,
taking into account economic and societal factors

The level of protection should be the best under the circumstances, maximising the margin of benefit over harm.

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

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

Cost-Benefit Analysis in Optimisation

ICRP Publication 26, 1977

- **This BASICALLY REDUCES COLLECTIVE DOSE**
  Reflects utilitarian ethics – what is best for society
  What does it cost, how many lives are saved?

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

The 2007 Recommendations of ICRP

- **Collective dose: a key parameter, but not sufficient**
  Average individual dose? Range? Number exposed? Etc
  Many small or few large doses? Now or in the future? Etc

- **Collective dose reduction, but avoiding unfair dose distribution**
  Individual dose constraints / reference levels add deontological (duty ethics) consideration

- **Radiation safety culture**
  Have I done all I reasonably can to reduce doses and risk of accidents?

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

Dose Constraints

- **Guide optimisation in *planned* exposure situations**
  Prospective restriction on the individual dose from a given source
  Do not apply to patients (use DRL=diagnostic reference levels)

- **Occupational: limit the range of options considered in optimisation**
  Individual dose monitoring possible
  Dose constraints increase equity, but also total detriment

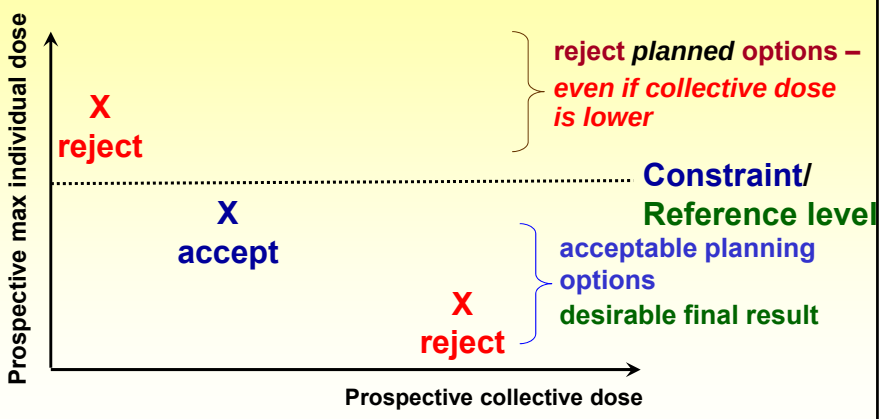
- **Public: an upper bound on doses from a planned operation**
  Individual doses can only be estimated
  Dose constraints take account of multiple sources

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

Reference Levels

- **Guide optimisation in *emergency* and *existing* exposure situations**
  - *Very similar to constraints, but it may not be possible to reduce doses to below constraint values*
  - *Conditions, not the chosen dose level, constrain optimisation*
  - *Hence the term 'reference level' instead of 'dose constraint'*
- **The principle of optimisation is the same as in planned situations, but the result may be different**

Exposure Situations: Planned / Emergency / Existing



Inappropriate to *plan to allow* higher exposures

Application of Dose Limits

The Principle of Application of Dose Limits

The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits recommended by ICRP

Regulatory dose limits are determined by the regulatory authority, taking account of international recommendations, and

apply to workers and to members of the public in planned exposure situations

In Summary…

Once More:

- **Optimisation, not limits, reduces doses**
- **Dose limits do not separate 'safe' from 'dangerous'**
- **Dose limits only serve to prevent deterministic harm and an unfair dose distribution among exposed persons**

Many Thanks For Your Attention!

ICRP INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION