Radiation Monitoring and Dose Assessment

Key requirements for the implementation of the principles of limitation and optimization in occupational exposure

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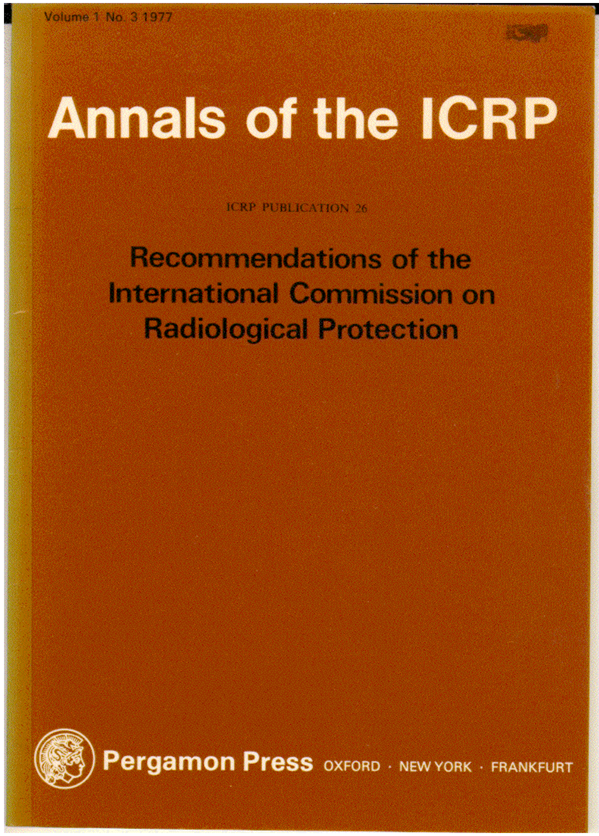
International Commission on Radiation Units & Measurements

ICRP Publication 26
"Birth" of modern radiation protection

– No practice shall be adopted unless it produces a net benefit (Justification)

– All exposures shall be As Low As Reasonably Achievable, economic and social factors taken into account (Optimization)

– Doses to individuals shall not exceed limits (Limitation)



Fundamental requirement

The definition of
appropriate quantities, and their associated units,
is a fundamental requirement for any scientific endeavour and
for any practical applications of scientific knowledge.

In radiation protection,
dosimetric quantities are required.
(preferably a single quantity for all types of radiations and conditions)

New Dose Concept by ICRP following Publication 26

Enough (epidemiological) knowledge available to calculate a weighted whole-body dose.

Publication *26* described the weighting procedure but does not present the new quantity.

In a statement from the 1978 Stockholm Meeting of the ICRP the

effective dose equivalent , H_E

was introduced following a proposal by

Wolfgang Jacobi

and E Pochin

EffectiveDose (ICRP 60)

(averaged) **Organ absorbed dose**

$$E = \sum_T w_T H_T = \sum_T w_T \sum_R w_R D_{T,R} [Sv]$$

effective dose

Organ equivalent dose

tissue weighting

radiation (quality)weighting

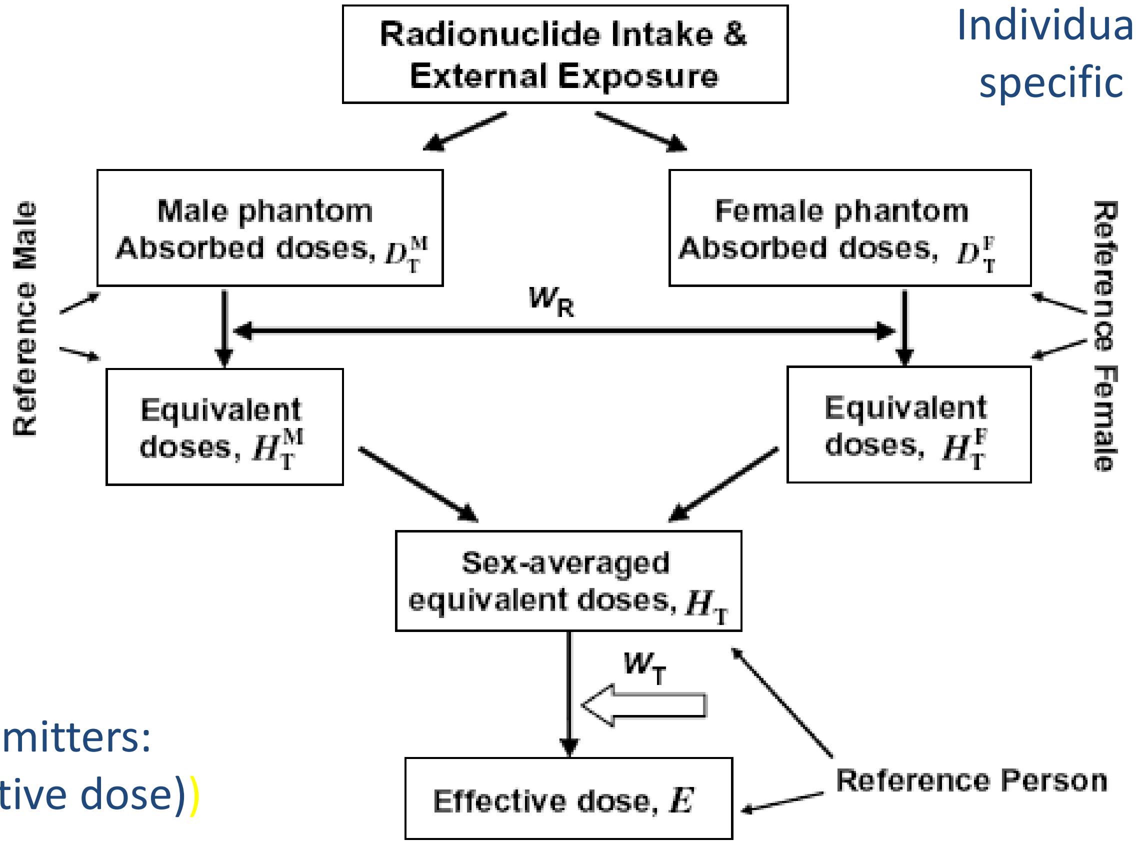
The quantity enables the summation of doses from internal emitters and external radiation fields to provide

a <u>single</u> numerical value for limitation and optimization

for stochastic effects.

Determination of Effective Dose: Reference Values

Transport Calculations and Biokinetic and Dosimetric Models



Individual specific

(For internal emitters: committed effective dose)

$$E \cong H_p(10) + E(50)$$

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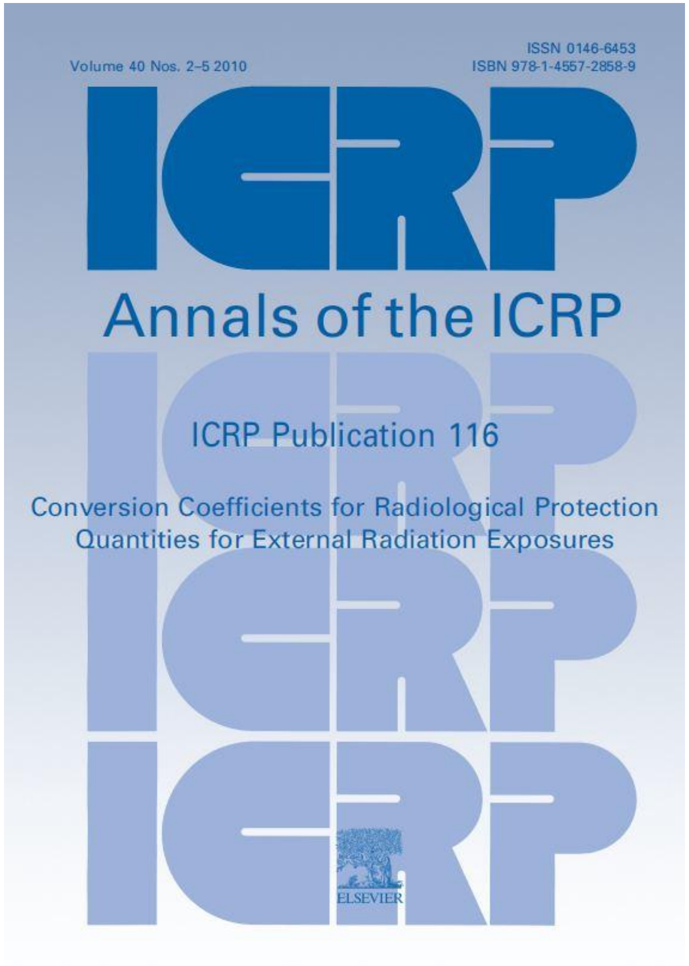
Effective Dose:

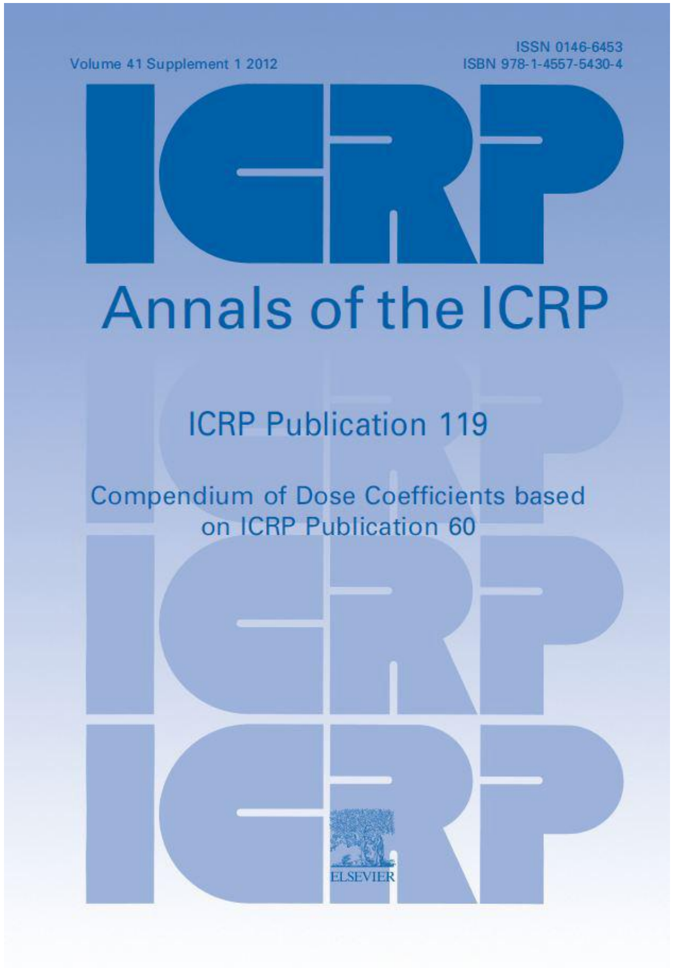
The application is restricted to the control of stochastic effects and is based on the assumptions that

- at low doses - the total radiation detriment to an exposed person is given by the (weighted) average of radiation detriments to single organs
- organ dose equivalent is linearly correlated with detriment.

The applicability of this quantity and its underlying concept **requires** the use of a linear dose –risk model without a threshold (LNT model).

Requirement: Reference values





However,

Effective Dose is not measurable !

Requirement:

Measurable quantities to assess effective dose

For external radiation
ICRU introduced Operational Quantities

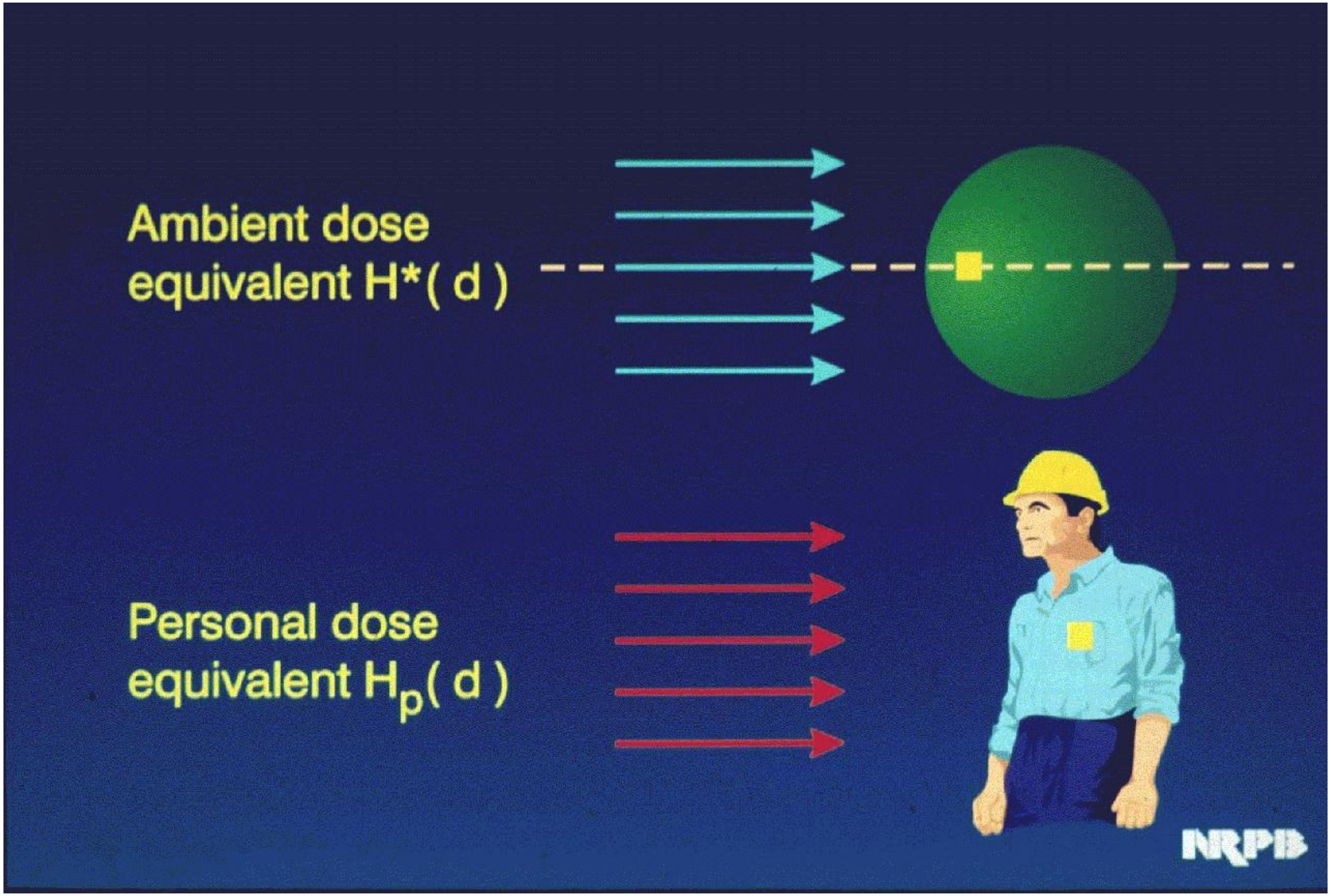
For internal exposure methods to assess intake are used and dose coefficients applied

Practical requirements

Why do we require operational dose quantities for external radiation exposure ?

- The protection quantities equivalent dose in an organ or tissue and effective dose are not measurable.
- Control of dose limits needs the assessment of values of the protection quantities by measurements.
- Measurements need the calibration of instruments in terms of measurable quantities.

Operational Quantities for external radiation



System of dosimetric quantities for <u>external radiation</u>

ICRP 74 and ICRU 57

Monitoring **Reference phantom!**

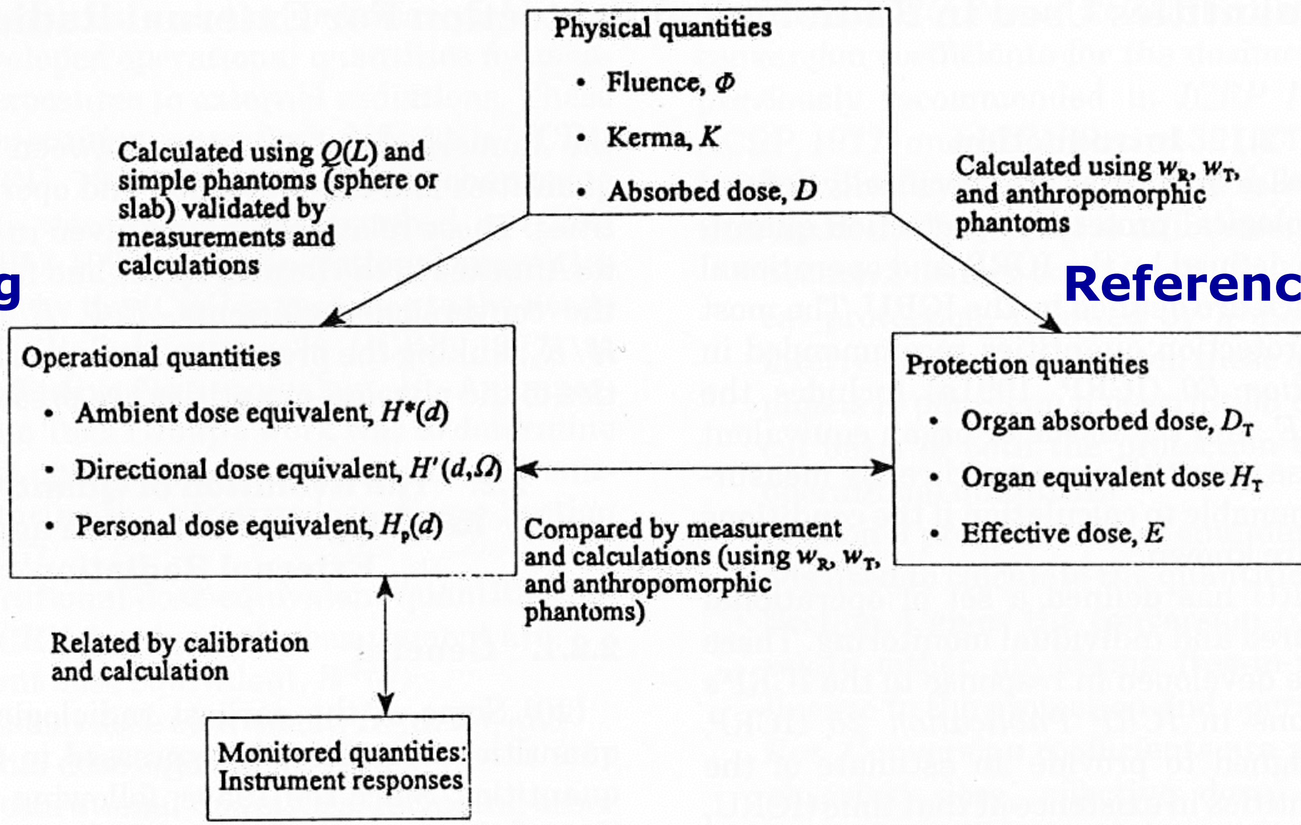


Fig. 1. Relationship of quantities for radiological protection monitoring purposes.

Operational Dose Quantities

Exposure limits (ICRP 103) are given in terms of

- effective dose, E
- equivalent dose to the skin, H_{skin}
- equivalent dose to the lens of the eye, $H_{eye\ lens}$
- equivalent dose to extremities

Task	Area monitoring	Individual monitoring
Monitoring of effective dose	Ambient dose equivalent, $H^*(10)$	Personal dose equivalent, $H_p(10)$
Monitoring of equivalent dose to the skin and the extremities	Directional dose equivalent, $H'(0.07,\Omega)$	Personal dose equivalent, $H_p(0.07)$
Monitoring of equivalent dose to the eye lens	Directional dose equivalent, $H'(3,\Omega)$	Personal dose equivalent, $H_p(3)$

Implementation of protection and operational quantities for monitoring and dose assessments:

- **Legal and regulatory requirement**:

  Basic Safety Standards and the related national legislation and regulations provide the legal basis for their use in practice.

- **Practical requirements**:

  The practical implementation of these requires the use of instruments and their standardization and technical guidance (ISO, IEC, ...)

Regulatory Requirements

IAEA BSS:

Requirement 20:

The regulatory body shall establish and enforce requirements for the monitoring and recording of occupational exposures in planned exposure situations

Regulatory Requirements

IAEA BSS:

Requirement 25: Assessment of occupational exposure and workers' health surveillance:

Employers, registrants and licensees shall be responsible for making arrangements for assessment and recording of occupational exposures and for workers' health surveillance.

Practical Requirements

BSS:

Appropriate monitoring equipment is provided and arrangements are made for its proper use, calibration, testing and maintenance.

► **Standardization of radiation monitoring :**

e.g. By Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies and radiological protection*

IEC, DIN, ……

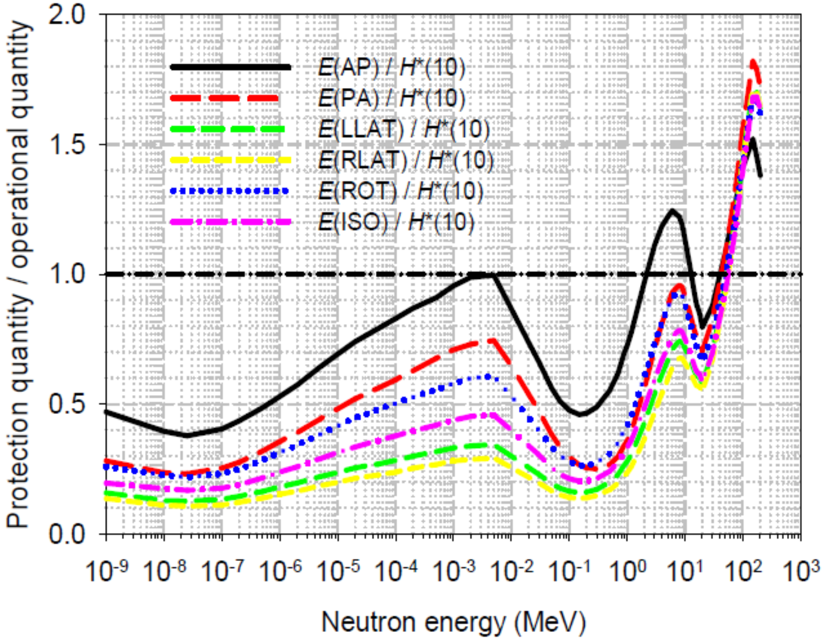
Challenges for external expsure

- Operational Quantities for external radiation have been introduced 30 years ago and are facing limitations and restrictions in their application:
  - at high radiation energies
  - due to conceptual difficulties (ICRU tissue of sphere, depth in sphere ,...
  - Currently an ICRU Committee is reviewing the definition of operational quantities

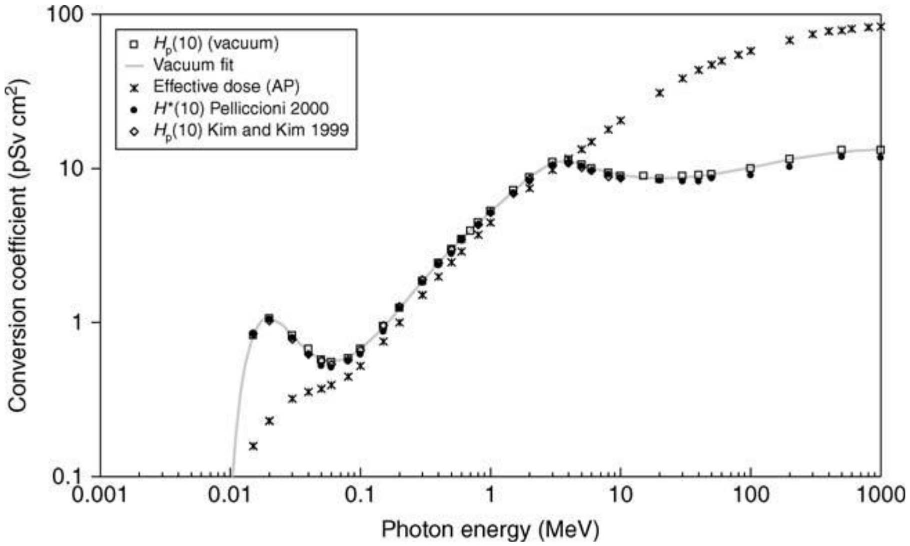
Challenges

Problems at high energies

ICRU sphere



Kerma approximatiom



Challenges

- Dose coefficients for occupational intake of radionuclides (OIR) following the ICRP 103 recommendations need to evaluated and published.

- Are equivalent organ doses suitable at high radiation doses?

- Radiation weighting factors are still based on few, not always pertinent scientific data (RBE values)

Concluding Remarks

- The ICRP radiation protection quantities and related measurement quantities have proved to play a fundamental role for the implementation of the limitation and optimization principle.
- The complimentary role of ICRP, ICRU, Basic Safety Standards (IAEA, EU) and international standards organization has led to an effective practical implementation of radiation monitoring and dose assessment in occupational exposure.
- Optimization using protection quantities has led to a substantial reduction of mean individual and collective doses.

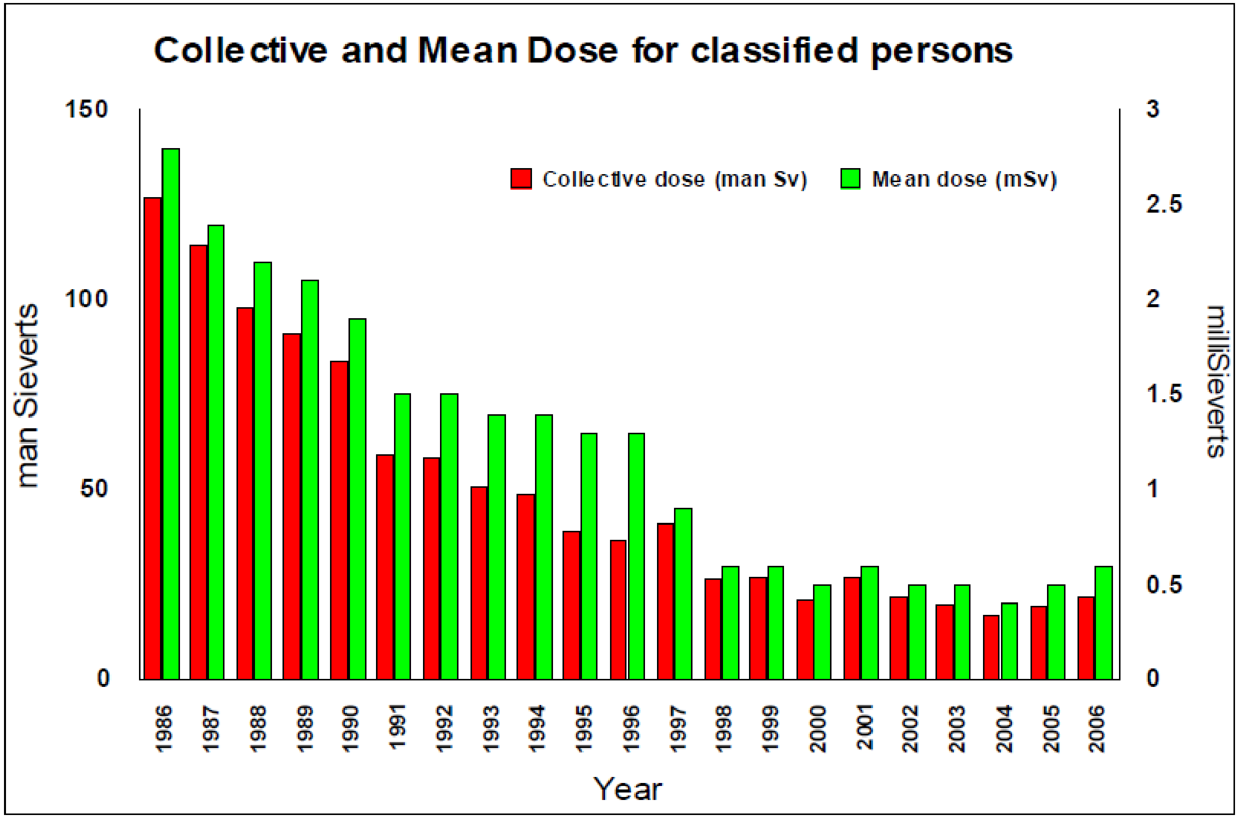


Figure 27, Collective an mean doses for classified persons on CIDI 1986-2006

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UK

Adopted from ESOREX 2010,Book of Country Reports

Thank you for your patience

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