Evoluzione della dosimetria protezionistica dalla Pubblicazione 60 alla Pubblicazione 103

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Annex B

(ICRP Committee 2 Foundation Document)

- Basis for Dosimetric Quantities Used in Radiological Protection

B.3.2 Absorbed dose

(B39) In radiation biology, clinical radiology and radiological protection the absorbed dose, *D*, is the basic physical dose quantity. It is used for all types of ionising radiation and any irradiation geometry.

Quantities used in Radiological Protection

- Protection Quantities: equivalent dose, effective dose.
- Operational quantities for external exposure: ambient dose equivalent, directional dose equivalent, personal dose equivalent.
- Operational quantities for internal exposure: air or body concentrations.

Effective Dose

$$E = \sum_T w_T \left[\frac{H_T^M + H_T^F}{2} \right]$$

The sum includes also the terms of the gonads (ovaries and testes), the male and the female breast and the male and female remainder.

Equivalent dose in an organ or tissue T

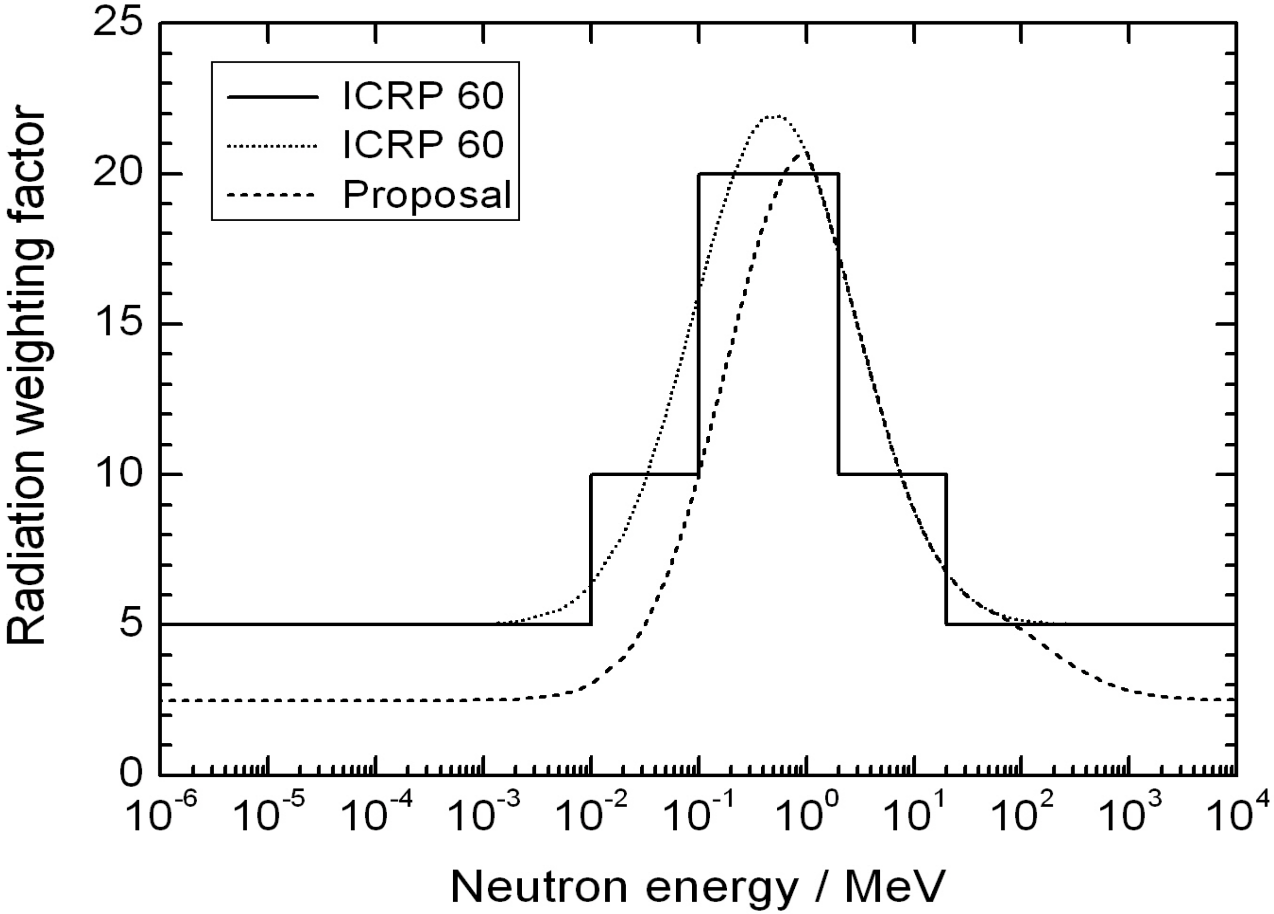
$$H_T = w_R D_{T,R}$$

- $D_{T,R}$ is the average absorbed dose from radiation R in the tissue or organ T
- w_R is the radiation weighting factor for the radiation R

Radiation Weighting Factors, w_R

Radiation Type	Publication 60	Publication 103
Photons	1	1
Electrons, muons	1	1
Protons	5	2
Charged Pions	-	2
Alpha, frag., heavy ions	20	20
Neutrons	stepwise function continuous function	continuous function

Weighting factor for neutrons



Radiation weighting factor for neutrons

$$w_R = 2.5 + 18.2 \exp[-(\ln E_n)^2/6]$$

$E_n < 1$ MeV

$$w_R = 5.0 + 17.0 \exp[-(\ln(2E_n))^2/6]$$

1 MeV ≤ E_n ≤ 50 MeV

$$w_R = 2.5 + 3.25 \exp[-(\ln(0.04E_n))^2/6]$$

$E_n > 50$ MeV

Weighting Factor for Heavy Ions, $w_R = 20$

(121) Heavy ions are encountered in external radiation fields in air flight at high altitudes and in space exploration. There are very limited RBE data for heavy ions and most of these are based on *in vitro* experiments. For heavy charged particles incident on and stopped in the human body the radiation quality of the particle changes markedly along its track. The selection of a single w_R value of 20 for all types and energies of heavy charged particles is a conservative estimate and is recommended as sufficient for general application in radiological protection.

For applications in space, where these particles contribute significantly to the total dose in the human body, a more realistic approach may have to be used.

Remainder Tissues

Adrenals, Extrathoracic region, Gall bladder, Heart wall, Kidneys, Lymphatic nodes, Muscle, Oral mucosa, Pancreas, Prostate, Small intestine, Spleen, Thymus, Uterus/cervix.

Remainder Dose

$$H_{rem}^{M} = \frac{1}{13}\sum_{T}^{13} H_{T}^{M}$$

$$H_{rem}^{F} = \frac{1}{13}\sum_{T}^{13} H_{T}^{F}$$

Each sum includes the doses of 12 organs and tissues present in both gender and of the prostate or uterus/cervix, respectively.

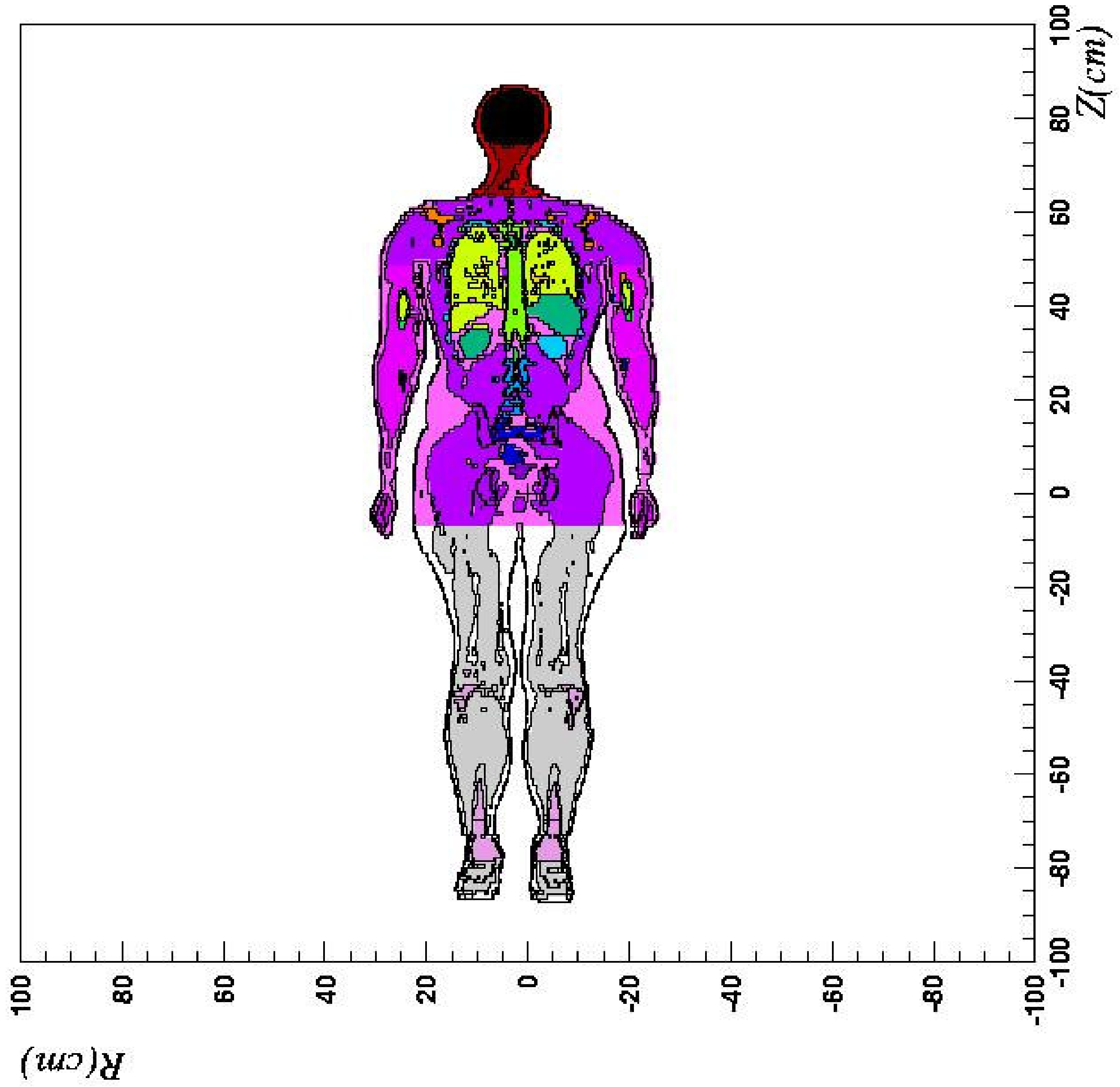
Tissue Weighting Factors

Bone-marrow, Colon, Lung, Breast, Stomach, Remainder Tissues	0.12
Gonads	0.08
Bladder, Oesophagus, Liver, Thyroid	0.04
Bone surface, Brain, Salivary glands, Skin	0.01

COMPUTATIONAL PHANTOMS

For radiation protection calculations, the Commission has adopted computational phantoms that are based on medical tomographic images. The phantoms are made up of 3-dimensional volume pixels (voxels). The voxels that make up defined organs are adjusted to approximate the organ masses assigned to the reference adult male and female in Publication 89.

- 141 organs/tissues
- 53 media of different density
- The male phantom is constituted by a matrix of 1946375 voxels 2.137x2.137x8.0 mm^3
- The female phantom is constituted by a matrix of 3886020 voxels 1.775x1.775x4.84 mm^3



Z(cm)
R(cm)
100
80
60
40
20
0
-20
-40
-60
-80
-100

Operat. quantity	Phantom	d(mm)	Radiation field
$H^*(d)$	ICRU sphere	10	Aligned and exp.
$H'(d,\Omega)$	ICRU sphere	0.07 10	Expanded
$H_p(d)$	Human body	0.07 10	Real

Task	Operational	quantities
	Area monitoring	Individual monitoring
Control of effective dose	Ambient dose eq. $H^*(10)$	Personal dose eq. $H_p(10)$
Control of dose to the skin, lens, extremities	Directional dose eq. $H'(0.07,\Omega)$	Personal dose eq. H_p (0.07)

Internal exposure

Activity quantities in combination with models and computations.

Committed Effective Dose Coefficients for Internal Exposure

Committed effective dose coefficients, $e(\tau)$, are conversion coefficients for a reference person which provide numerical links between $E(\tau)$ and measurable quantities, usually the activity introduced by either inhalation (e_{inh}) or ingestion (e_{ing}).

Assessment of occupational exposure

$$E \cong H_{\mathrm{p}}(10) + E(50)$$

$$E(50) = \sum_{\mathrm{j}} e_{\mathrm{j,inh}}(50) I_{\mathrm{j,inh}} + \sum_{\mathrm{j}} e_{\mathrm{j,ing}}(50) I_{\mathrm{j,ing}}$$

(143) .... In certain situations, such as exposure of air crew or where individual monitoring is not performed, an assessment of effective dose may be performed by area monitoring applying the quantity ambient dose equivalent, $H^*(10)$, and calculating effective dose using appropriate conversion coefficients.

Collective Dose

- Only the collective effective dose is retained.
- Collective dose is not intended as a tool for epidemiological risk assessment and it is therefore inappropriate to use it in risk projections based on epidemiological studies.
- The computation of cancer deaths based on collective dose involving trivial exposures to large populations is not reasonable and must be avoided.
- The dose range and the time period should be stated.