ICRP 2005

DRAFT FOR CONSULTATION

2005 RECOMMENDATIONS OF THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

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SUMMARY OF THE RECOMMENDATIONS

(S1) This Summary indicates the Commission's aims and the way in which the recommendations may be applied. The necessary concepts are defined and explained in the main text following this Summary.

The Aim of the Recommendations

(S2) The fundamental aim of the Commission was set out as follows in the 1990 Recommendations.

> 'The primary aim of radiological protection is to provide an appropriate standard of protection for man without unduly limiting the beneficial actions giving rise to radiation exposure. This aim cannot be achieved on the basis of scientific concepts alone. All those concerned with radiological protection have to make value judgements about the relative importance of different kinds of risk and about the balancing of risks and benefits. In this, they are no different from those working in other fields concerned with the control of hazards.'

This statement still represents the Commission's position.

(S3) The Commission has concluded that its recommendations should be based on a simple, but widely applicable, general system of protection that will clarify its objectives and will provide a basis for the more formal systems needed by operating managements and regulators. It also recognises the need for stability in regulatory systems at a time when there is no major problem identified with the practical use of the present system of protection in normal situations. The use of the optimisation principle, together with the use of constraints and the current dose limits, has led to a general overall reduction in both occupational and public doses over the past decade. The Commission now strengthens its recommendations by quantifying constraints for all controllable sources in all situations.

The Principles of Protection

(S4) The system of protection now recommended by the Commission is to be seen as a natural evolution of, and as a further clarification of, the 1990 Recommendations. The 2005 Recommendations establish quantified restrictions on individual dose from specified sources in all situations within their scope. These restrictions should be applied to the exposure of actual or representative individuals. They provide a level of protection for individuals that should be considered as obligatory, and not maintaining these levels of protection should be regarded as a failure. The quantified restrictions are complemented by the requirement to optimise the level of protection achieved.

(S5) The most fundamental level of protection is the source-related restriction on individual dose called a *dose constraint*. It is used to provide a level of protection for the most exposed *individuals* within a class of exposure, in all situations within the scope of the recommendations, *from a single source*. Except for the exposure of patients, these constraints should be regarded as the basic levels of protection to be attained in all situations that are addressed by the Commission; normal situations, accidents and emergencies, and the case of controllable existing exposure. These constraints represent the level of dose where action to avert exposures and reduce doses is virtually certain to be justified.

The development of effective dose

(S13) The weighting factors in calculating effective dose are intended to take account of many types of radiation, many types of stochastic effects, and many tissues in the body. They are therefore only loosely based on a wide range of experimental data. It is unrealistic to expect them to apply accurately to any particular case. In recent recommendations, the Commission has deliberately selected broadly based values of these weighting factors.

(S14) The weighting factor for radiation quality is applied directly to the absorbed dose in a tissue or organ. This weighted tissue dose has been called both dose equivalent and equivalent dose at various times. There has been substantial confusion between these terms, particularly in translation from English into other languages. The Commission now avoids both of those terms and uses ***radiation weighted dose*** in a tissue or organ. The unit of radiation weighted dose is the joule per kilogram with the special name sievert (Sv). The Commission is considering a new special name for radiation weighted dose so as to avoid the use of the name 'sievert' for both radiation weighted dose and effective dose.

(S15) When, as is usual, more than one tissue is exposed, it is necessary to use the tissue weighting factor. The application of both the radiation and the tissue weighting factors to the tissue absorbed doses leads to the effective dose. The effective dose, as currently defined, will continue to be used by the Commission for protection purposes,

$$E = \sum_T w_T \sum_R w_R \cdot D_{T,R}$$

where E is the effective dose, w_R and w_T are the radiation and tissue weighting factors, and $D_{T,R}$ is the mean absorbed dose in tissue or organ T due to incident radiation R. The unit of effective dose is the joule per kilogram and called the sievert (Sv). Since the effective dose is derived from mean absorbed doses in tissues and organs of the human body, a dosimetric model must be specified or implied in any statement of the magnitude of the effective dose.

(S16) As in the 1990 Recommendations, radiation weighting factors are determined by the characteristics of the type and energy of the radiation incident on the body or, in the case of sources within the body, emitted by the source. The radiation weighting factors are then applied to the mean tissue dose in any specified part of the human body. The radiation weighting factors in Table S3 are essentially those suggested in *Publication 92* and are now recommended for general use in radiological protection. For neutrons a continuous curve is recommended shown in Figure S1. In order to reduce computational difficulties in evaluating effective dose the function in Figure S1 is given in Equation S1.

$$w_R = \begin{cases} 2.5 + 18.2 \exp[-(\ln E_n)^2/6] & \text{for } E_n < 1 \text{ MeV} \\ 5.0 + 17.0 \exp[-(\ln (2E_n))^2/6] & \text{for } E_n \geq 1 \text{ MeV.} \end{cases} \quad \text{.....(S1)}$$

where E_n is in MeV. The radiation weighting factor for neutrons is applied to the mean absorbed doses in the relevant tissues and organs. The dose is that from both the neutron induced charged particles and the secondary photons induced in the body.

(S17) The Commission has reviewed the epidemiological data that can be used to assess nominal risk factors for cancer and hereditary diseases. From these it has developed a new estimate of detriment resulting from radiation exposure which has been used to specify its recommended w_T values. The new values that apply for the tissue weighting factors are listed below in Table S4. The weighting factor for Remainder tissues is to be applied to dose averaged over the 14 specified organs and tissues that constitute the Remainder.

Table S3. Radiation weighting factors, w_R

Type and energy range	w_R
Photons	1
Electrons and muons	1
Protons	2
Alpha particles, fission fragments, heavy nuclei	20
Incident neutrons	See Figure S1 and Equation S1

Figure S1. Radiation weighting factor, w_R, for incident neutrons versus neutron energy. (A) Step function and (B) continuous function given in *Publication 60*, (C) function proposed in this report.

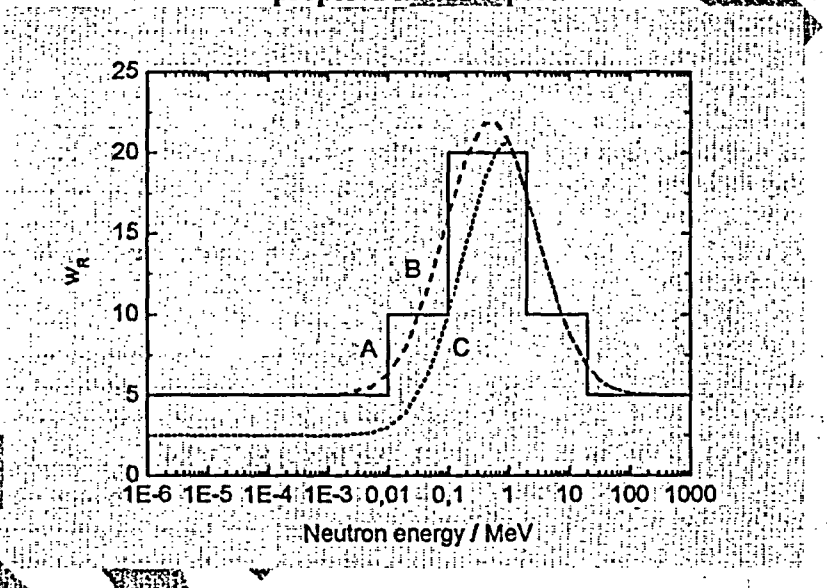

Table S4. Tissue weighting factors

Tissue	w_T	$\sum w_T$
Bone marrow, Breast, Colon, Lung, Stomach	0.12	0.60
Bladder, Oesophagus, Gonads, Liver, Thyroid	0.05	0.25
Bone surface, Brain, Kidneys, Salivary glands, Skin	0.01	0.05
Remainder Tissues*	0.10	0.10

***Remainder Tissues (14 in total)**

Adipose tissue, Adrenals, Connective tissue, Extrathoracic airways, Gall bladder, Heart wall, Lymphatic nodes, Muscle, Pancreas, Prostate, SI Wall, Spleen, Thymus, and Uterus/cervix.

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the body and also the estimation of dose distributions in tissues and organs are very complex and are strongly based on the models used. The estimated doses are, therefore, associated with large uncertainties. For this reason most epidemiological studies cannot be used as the sole basis for an assessment of the RBE for α emitters. From calculations using the $Q(L)$ function, the mean quality factor of a 6 MeV alpha particle slowing down in tissue is estimated to be about 20.

(77) The Commission continues to recommend a value for w_R of 20 for α particles. It also continues to recommend a value of 20 for w_R in the case of heavy nuclei and fission fragments. Doses from fission fragments are important in internal dosimetry and regarding radiation weighting factors the situation is similar to that for α particles. Due to their short ranges the distribution of the actinides in the organs and tissues has a strong influence on their biological effectiveness. A radiation weighting factor of 20 as for α particles may be a rough conservative estimate.

(78) In external exposure, heavy ions and other types of radiation, e.g. pions, are mainly occurring in radiation fields near high energy accelerators, at aviation altitudes, and in space. For heavy ions, the data obtained by in vitro experiments clearly show an LET dependence of RBE. The RBE decreases with increasing LET for LET values above about 200 keV/μm. For heavy charged particles incident on a human body and stopped in the body, the radiation quality of the particle changes strongly along the track. As an average value, a constant weighting factor of 20 for all types and energies of heavy charged particles is chosen to be sufficient for the general application in radiological protection.

Summary of radiation weighting factors

(79) The new radiation weighting factors are summarised in Table 2.

Table 2. Radiation weighting factors

Type and energy range	Radiation weighting factor, w_R
Photons	1
Electrons	1
Protons	2
Alpha particles, fission fragments, heavy nuclei	20
Neutrons	A continuous curve is recommended. See Figure 1 and equations (8)

3.4.2. The selection of tissue weighting factors

(80) The Commission has previously made a policy decision that there should be only one single set of w_T values that are averaged over both genders and all ages. The Commission continues to maintain that policy in these Recommendations.

(81) The tissue weighting factors, as defined in *Publication 60*, are based on complex reasoning, much of which is often overlooked. For example, they were not based solely on the cancer fatality risk. It was intended to reflect the relative detriment from the exposure of single organs or tissues. The Commission now begins with cancer incidence data and takes account of the lethality rate, the years of life lost and of a weighted contribution from the non-fatal cancers and from hereditary disorders. The values of w_T are normalised to give a total of one. The grouping of tissues is complex and substantial rounding takes place. The Commission's new approach to the calculation of detriment is outlined in Annex A and has been used to derive a new set of tissue weights. The new values that apply for the tissue weighting factors are listed below in Table 3.

Table 3. Tissue weighting factors

Tissue	w_T	$\sum w_T$
Bone marrow, Breast, Colon, Lung, Stomach	**0.12**	0.60
Bladder, Oesophagus, Gonads, Liver, Thyroid	**0.05**	0.25
Bone surface, Brain, Kidneys, Salivary glands, Skin	**0.01**	0.05
Remainder Tissues* (Nominal w_T applied to the average dose to 14 tissues)	**0.10**	0.10

***Remainder Tissues (14 in total)**

Adipose tissue, Adrenals, Connective tissue, Extrathoracic airways, Gall bladder, Heart wall, Lymphatic nodes, Muscle, Pancreas, Prostate, SI Wall, Spleen, Thymus, and Uterus/cervix.

3.5. Practical application in radiological protection

(82) Radiological protection is concerned with controlling exposures to low radiation doses that give rise to stochastic effects and preventing exposures that could give rise to high radiation doses resulting in tissue damage (deterministic effects). These two types of effect are considered separately below.

3.5.1. Control of stochastic effects

(83) Both ICRP and ICRU define dosimetric quantities for use in radiological protection. ICRU has introduced quantities, collectively referred to as *Operational Quantities,* for area and individual monitoring of radiation from sources external to the body. For area monitoring, these quantities are *ambient dose equivalent* and *directional dose equivalent.* They are based on simple geometric models for the radiation field and the dose at a specific point in the ICRU sphere phantom (ICRU, 1980).

(84) The definitions of the operational quantities take account of the common situation in which the individual dose assessment is performed with dosemeters worn on the body. The *personal dose equivalent* is, therefore, defined by the dose at a specific depth in the body below the point where the dosemeter is worn. The protection quantity adopted by ICRP for the control of stochastic effects is the effective dose. This quantity is by its definition related to doses in the human body and generally is not measurable. A variety of conversion coefficients link the effective dose to measurable physical quantities, e.g. radiation fluences or air kerma characterising the external radiation fields in the workplace.

(85) In *Publication 74* (1996b), the two Commissions jointly concluded that, for external sources, the two approaches are well correlated and in most practical situations the values of the operational dose quantities provide an assessment of effective dose that is sufficiently accurate for radiological protection applications. This will also be the situation after the recommended changes of w_R for neutrons and protons. ICRP also provides dose coefficients for the activity intake of radionuclides by inhalation and ingestion, and the airborne activity concentration of noble gas radionuclides.

(86) The calculation of absorbed dose within the tissues and organs of the body at risk of stochastic effects, which underlies the determination of effective dose, is derived by ICRP specified age- and gender-specific models of the body, and models describing the fate of radionuclides within the body – including dependence on the physico-chemical form of the radionuclides. The absorbed doses are modified by radiation weighting factors and age- and