The New ICRP Recommendations

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ABSTRACT

The present recommendations of the International Commission on Radiological Protection (ICRP) were published in 1991. Since then, the Commission has published additional recommendations, and the system of protection has become increasingly complex. The Commission has reviewed and revised its system and will in a near future present a new set of recommendations, which should be seen as a consolidation of earlier recommendations. When the Commission adopts these new recommendations in late 2006 or early 2007, 16 years would have passed since the 1990 recommendations were adopted.

INTRODUCTION

The advice of ICRP targets the regulators and implementers that have the responsibility for establishing radiological protection standards. The primary aim of the Commission is to contribute to an appropriate level of protection for people and the environment without unduly limiting the desirable human actions that may cause radiation exposures. This aim is achieved through the combined use of scientific concepts and value judgements about the balancing of risks and benefits, i.e. an approach similar to other fields concerned with the control of hazards.

ICRP's recommendations have evolved over time as our understanding of underlying mechanisms has increased, and they were revised substantially in 1990. The current system of protection, set out in Publication 60 [1], was developed over some 30 years. Since Publication 60 there have been many additional numerical restrictions on dose, based on different ideas and spanning several orders of magnitude [2-10]. A framework for environmental protection has also been published [11]. The system has thus become increasingly complex, and it has in some respects been difficult to explain or understand completely the variations between different applications.

New scientific data have been published since Publication 60, and the biological and physical assumptions and concepts need some updating. It has also become obvious that focusing on humans alone is not always sufficient. There have been societal developments in that more openness or transparency is expected in developing new recommendations that could be accepted globally. All this combined make the time ripe for a new set of recommendations. The Commission recognises the need for stability in international and national regulations, many of which have only relatively recently implemented the 1990 recommendations [1].

The Commission has prepared a series of scientific reports on which to base the new recommendations. Several of these reports have been put on ICRP's website for international consultation whereas others will soon be available for consultation. The documents cover subjects such as biological and epidemiological information on health risks attributable to ionising radiation; the basis for dosimetric quantities used in radiological protection; assessing doses to the representative individual; the optimisation of protection; and exclusion and exemption.

The international consultation on the 2005 draft recommendations was the culmination of several years of work and followed discussions with health physics professionals all around the world. The consultation resulted in nearly 200 responses with some 600 pages of written text. Many comments necessitate some clarification of policy points, but most of the comments deal with issues that will be explained in the above-mentioned reports

that were not available at the time of consultation. The comments will also be addressed in the next draft of the recommendations.

The new recommendations consolidate and add to previous recommendations issued in various ICRP publications. The existing numerical recommendations in the policy guidance given since 1991 remain valid unless otherwise stated. Thus, the new recommendations do not imply any changes to radiological protection regulations that are appropriately based on its previous Recommendations in ICRP 60 and subsequent policy guidance. The current recommendations emphasize the importance of optimisation in radiological protection and extend the successful experience for practices to other situations. The Commission will follow up these recommendations with subsequent reports applying the process of optimization in different situations.

The major features of the new recommendations are:

- Maintaining the Commission's three fundamental principles of radiological protection, and clarifying how they apply to radiation sources and to the individual, as well as that the source-related principles apply to all controllable situations;
- Maintaining the Commission's limits for effective dose and equivalent dose from all regulated sources that represent the most that will be accepted in planned situations by regulatory authorities;
- Using the same conceptual approach of constraints in the source-related protection to all situations, regardless of the type of source. The dose constraints quantify the most fundamental levels of protection for workers and the public from single sources in all situations;
- Complementing the limits and constraints with the requirement to optimise protection from a source.
- Updating the radiation and tissue weighting factors in the dosimetric quantity effective dose.
- Including a policy for radiological protection of non-human species.

QUANTITIES AND RADIATION WEIGHTING FACTORS

The fundamental dosimetric quantity in radiological protection is the *absorbed dose*, which is the energy absorbed per unit mass. The Commission uses absorbed dose to mean the average dose over a tissue or organ. The *equivalent dose* is the absorbed dose multiplied by the appropriate weighting factor for radiation quality. It is used to give a closer correlation with the risk of harm in the exposed organ or tissue. *Effective dose* remains the principal quantity for radiological protection, and is defined as the sum of the equivalent doses in the principal tissues and organs in the body, each weighted by a tissue weighting factor. Doses in organs within the body cannot be measured directly, so practical quantities that are measurable outside the body are needed. For radiation fields outside the body, the ICRU recommends *operational quantities*, which provide a set of field quantities that, in most practical situations, adequately reflect the protection quantities used by ICRP.

Since the publication of the 1990 Recommendations [1], there have been developments in biological and dosimetric knowledge that justify a re-appraisal of the radiation-weighting factors (w_R) and Publication 92 [12] deals with these issues. For practical purposes, the Commission recommends the use of the same w_R values for all organs and tissues. For photons and beta particles, a w_R of unity is retained for all low-LET radiations, and a w_R of 20 is retained for alpha particles. The Commission believes that a w_R of 5 to all protons of energy > 2 MeV is a significant overestimate of the biological effectiveness of these protons. The Commission now recommends a w_R of 2 for incident protons of practical importance (> 10 MeV). For neutrons, the Commission recommends the continued use of w_R values that depend upon energy of incident neutrons, and the use of a continuous function, rather than the step function given in Publication 60 [1]. The w_R for neutrons should thus be decreased for energies below 1 MeV to take account of the absorbed dose contribution by low-LET gamma rays that are induced in the body by neutrons.

RADIATION EFFECTS AND TISSUE WEIGHTING FACTORS

Two documents on radiation effects will give input to the new recommendations. The report *'Low-dose extrapolation of radiation-related cancer risk'* considers the evidence relating to cancer risk associated with exposure to low doses of low-LET radiation, and particularly doses below current dose limits for workers and the public [13]. The report addresses findings of epidemiological and experimental studies. The focus is on evidence regarding linearity of dose response for all cancers considered as a group at low doses and the possibility of a universal threshold dose. Current understanding of mechanisms and quantitative data on dose and time-dose relationships support a linear dose response at low doses for cancer and hereditary disease. While existence of a low-dose threshold does not seem unlikely for radiation-related cancers of certain tissues, the evidence as a whole does not favour the existence of a universal threshold, and there seems to be no particular reason to factor the possibility of a threshold into risk calculations for purposes of radiation protection. The dose and dose-rate effectiveness factor (DDREF) of 2 recommended in Publication 60 is retained. A better understanding of the mechanisms for radiation-related adaptive response, genomic instability, and bystander effects is needed before they can be evaluated as factors to be included in the estimation of risk after exposure to low levels of radiation.

An increasing number of studies on early tissue reactions have shown the ability to modify these using various factors. This ability to modify the response of tissues and organs has prompted the Commission to recommend a change of the term deterministic effects to *tissue reactions*, because the effects are not necessarily pre-determined in quantitative terms. The dose responses for radiation-induced tissue reactions in adults are, in general, judged to have true dose thresholds, which result in the absence of risk at low doses. The dose responses for *in-utero* tissue reactions, malformations and neurological effects are also judged to show dose thresholds above a few tens of mSv. Uncertainty remains on the induction of IQ deficits but at low doses the risk is thought to be insignificant. Risks of non-cancer disease at low doses remain uncertain and no specific judgement is possible.

New radiation detriment values and tissue weighting factors (w_T) have been proposed; the most significant changes from ICRP 60 relate to breast, gonads and treatment of remainder tissues (Table 1).

Detriment-adjusted nominal probability coefficients for cancer are 5.5 10^{-2} Sv^{-1} for the whole population and 4.1 10^{-2} Sv^{-1} for adult workers, as compared to the values in ICRP 60 of 6.0-10^{-2} Sv^{-1} and 4.8 10^{-2} Sv^{-1}, respectively (Table 2). The detriment-adjusted probability coefficients for hereditary disease up to the second generation are 0.2 10^{-2} Sv^{-1} for the whole population and 0.1 10^{-2} Sv^{-1} for adult workers; the respective ICRP60 values are 1.3 10^{-2} Sv^{-1} and 0.8 10^{-2} Sv^{-1} but these relate to risks at equilibrium.

Table 1. ICRP's new tissue weighting factors.

Tissue	w_T	$\sum w_T$
Breast, bone-marrow, colon, lung, stomach	0.12	0.60
Gonads[1], remainder tissues (nominal w_T applied to the average dose to 15 tissues)	0.08	0.16
Bladder, oesophagus, liver, thyroid	0.05	0.20
Bone surface, brain, salivary glands, skin	0.01	0.04

[1] w_T for gonads is applied to the mass-weighted mean of the doses to testes and ovaries (i.e. the average dose in gonadal tissue).

Table 2. Nominal probability coefficients for cancer and hereditary effects (10^{-2} Sv^{-1}).

Exposed population	Cancer Risk		Hereditary Effects		Total Detriment	
	2006	Publ. 60	2006	Publ. 60	2006	Publ. 60
Whole population	5.5	6.0	0.2	1.3	**5.7**	7.3
Workers	4.1	4.8	0.1	1.8	**4.2**	5.6

CONSTRAINTS

At the heart of the new Recommendations is the development of the concept of the *con*straint, which is defined as the fundamental level of protection for the most exposed individuals from a single source within a class of exposure. Constraints apply in all situations being used prospectively as the starting point in the optimisation process. The term was introduced by the Commission in 1990 as part of the principle of optimisation of protection [1].

> "*This procedure should be constrained by restrictions on the doses to individuals (dose constraints), or the risks to individuals in the case of potential exposures (risk constraints), so as to limit the inequity likely to result from the inherent economic and social judgements"*

In Publication 60, the only quantified values were the individual dose limits, and the concept of the constraint has not been clearly explained by the Commission in its subsequent publications. It has not always been well understood and, although it has been the subject of debate by international bodies, it has not been sufficiently utilised nor has it been implemented widely. The Commission now clarifies the meaning and use of the constraint.

The Commission now uses the same conceptual approach in the source-related protection, regardless of the type of source. This means that optimisation of protection is always constrained by a level of dose where action is almost always warranted. This level of dose, or constraint, is aimed at not selecting in the process of optimisation any protection options that would involve individual doses above the constraint. The constraint applies to all situations and is used prospectively as the starting point of the optimisation process. Compliance with the constraint is not in itself considered sufficient within the system of protection. The principle of optimisation of protection applies in all circumstances, including those where the relevant constraint is already satisfied. The manner in which the principle is applied will depend upon the specifics of the exposure situation under consideration. The important message from the Commission is that a similar approach is used in optimisation, regardless of the type of source or the exposure situation. It should be noted however that the dose constraint is not a form of retrospective limit - this function is provided by dose limits.

The numerical criteria recommended by the Commission in Publication 60 and subsequent publications can be regarded as constraints. The values fall into three defined bands: 0.1-1 mSv, 1-20 mSv and 20-100 mSv, each band having specific requirements. The Commission considers that it is useful to present these values in this manner as it enables selection of an appropriate value for a new constraint for a specific situation that has not been addressed explicitly by the Commission.

DISCUSSION

The probabilistic nature of stochastic effects makes it impossible to make a clear distinction between 'safe' and 'dangerous', and the major policy implication of the non-threshold relationship is that some finite risk must be accepted at any level of protection. This has led to the Commission's System of Protection with its principles of

justification, constrained optimisation and dose limits. These principles will continue to be the cornerstones of the Commission's Recommendations.

The philosophy of radiological protection is based on the linear non-threshold (LNT) hypothesis. This hypothesis is not proposed to be the biological truth, but rather, because we do not know the level of risk associated with very low radiation doses, the Commission considers it to be the best approach to avoid unnecessary risk from radiation exposure. The LNT hypothesis also has characteristics that make it a useful tool and facilitates radiological protection: it allows consideration of each source and exposure separately from other sources and exposures; it enables averaging dose within an organ or tissue over that organ or tissue; doses received at different times can be added; and doses received from one source can be considered independently of the doses received from other sources.

The next draft of the recommendations will be completed after the finalization of the scientific reports underpinning the new recommendations, and will be discussed by the Main Commission in March 2006. A second round of international consultation on the recommendations will be necessary, although only for a 3-month period, after which the Commission will need to complete them. The most likely consequence of this will be that the publication of the new recommendations will be adopted late 2006 or early 2007.

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