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The 2007 Recommendations of the International Commission on Radiological Protection

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The 2007 Recommendations of the International Commission on Radiological Protection

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Aims and Scope

The International Commission on Radiological Protection (ICRP) is the primary body in protection against ionising radiation. ICRP is a registered charity and is thus an independent non-governmental organisation created by the 1928 International Congress of Radiology to advance for the public benefit the science of radiological protection. The ICRP provides recommendations and guidance on protection against the risks associated with ionishing radiation, from artificial sources widely used in medicine, general industry and nuclear enterprises, and from naturally occurring sources. These reports and recommendations are published four times each year on behalf of the ICRP as the journal *Annals of the ICRP*. Each issue provides in-depth coverage of a specific subject area.

Subscribers to the journal receive each new report as soon as it appears so that they are kept up to date on the latest developments in this important field. While many subscribers prefer to acquire a complete set of ICRP reports and recommendations, single issues of the journal are also available separately for those individuals and organizations needing a single report covering their own field of interest. Please order through your bookseller, subscription agent, or direct from the publisher.

ICRP is composed of a Main Commission and five standing Committees on: radiation effects, doses from radiation exposure, protection in medicine, the application of ICRP recommendations, and protection of the environment, all served by a small Scientific Secretariat. The Main Commission consists of twelve members and a Chairman. Committees typically comprise 15–20 members. Biologists and medical doctors dominate the current membership; physicists are also well represented.

ICRP uses Working Parties to develop ideas and Task Groups to prepare its reports. A Task Group is usually chaired by an ICRP Committee member and usually contains a majority of specialists from outside ICRP. Thus, ICRP is an independent international network of specialists in various fields of radiological protection. At any one time, about one hundred eminent scientists are actively involved in the work of ICRP. The Task Groups are assigned the responsibility for drafting documents on various subjects, which are reviewed and finally approved by the Main Commission. These documents are then published as the *Annals of the ICRP*.

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Annals of the ICRP

The 2007 Recommendations of the International Commission on Radiological Protection

ICRP Publication 103

Approved by the Commission in March 2007

Abstract–These revised Recommendations for a System of Radiological Protection formally replace the Commission's previous, 1990, Recommendations; and update, consolidate, and develop the additional guidance on the control of exposure from radiation sources issued since 1990.

Thus, the present Recommendations update the radiation and tissue weighting factors in the quantities equivalent and effective dose and update the radiation detriment, based on the latest available scientific information of the biology and physics of radiation exposure. They maintain the Commission's three fundamental principles of radiological protection, namely justification, optimisation, and the application of dose limits, clarifying how they apply to radiation sources delivering exposure and to individuals receiving exposure.

The Recommendations evolve from the previous process-based protection approach using practices and interventions by moving to an approach based on the exposure situation. They recognise planned, emergency, and existing exposure situations, and apply the fundamental principles of justification and optimisation of protection to all of these situations. They maintain the Commission's current individual dose limits for effective dose and equivalent dose from all regulated sources in planned exposure situations. They re-inforce the principle of optimisation of protection, which should be applicable in a similar way to all exposure situations, subject to the following restrictions on individual doses and risks; dose and risk constraints for planned exposure situations, and reference levels for emergency and existing exposure situations. The Recommendations also include an approach for developing a framework to demonstrate radiological protection of the environment.

Keywords: Justification; Optimisation; Dose limits; Constraints; Reference Levels

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Editorial

WE COULD NOT HAVE DONE IT WITHOUT YOUR HELP

The new recommendations of the International Commission on Radiological Protection were adopted on 21 March 2007, Essen, Germany, after eight years of discussions, involving scientists, regulators, and users all around the world.

The Commission is an advisory body that offers its recommendations to regulatory and advisory agencies, mainly by providing guidance on the fundamental principles on which appropriate radiological protection can be based. Since its inception in 1928, the Commission has regularly issued recommendations regarding protection against the hazards of ionising radiation. The first report in the current series, *Publication 1,* contained the recommendations adopted in 1958 (ICRP, 1959). The more recent recommendations have appeared as *Publication 26* (ICRP, 1977), and *Publication 60* (ICRP, 1991b), and contain the recommendations adopted in 1977 and 1990, respectively.

International organisations and national authorities responsible for radiological protection, as well as the users, have taken the recommendations and principles issued by the Commission as a key basis for their protective actions. As such, virtually all international standards and national regulations addressing radiological protection are based on the Commission's recommendations.

Currently, most national regulations are based on the 1990 Recommendations in *Publication 60*. International standards, such as the International Basic Safety Standards, various international labour conventions, and European directives on radiological protection are also based on these recommendations.

In *Publication 26*, the Commission quantified the risks of stochastic effects of radiation and proposed a system of dose limitation with its three principles of justification, optimisation of protection, and individual dose limitation. In *Publication 60*, the Commission revised its recommendations and extended its philosophy to a system of radiological protection while keeping the fundamental principles of protection.

New scientific data have been published since *Publication 60*, and while the biological and physical assumptions and concepts remain robust, some updating is required. The overall estimate of deterministic effects remain fundamentally the same. The estimates of cancer risk attributable to radiation exposure have not changed greatly in the past 17 years, whereas the estimated risk of heritable effects is currently lower than before. The new data provide a firmer basis on which to model risks and assess detriment.

The 2007 Recommendations evolve from the previous process-based approach of practices and interventions to an approach based on the characteristics of radiation exposure situations. The system of radiological protection applies in principle to any situation of radiation exposure. Similar procedures are used for deciding on the extent and level of protective actions, regardless of exposure situation. Specifically, the principles of justification and optimisation apply universally. ICRP is of the opinion that by focusing more on optimisation, the implementation of protection for what has until now been categorised as interventions could be enhanced.

In view of the importance afforded to the Commission's recommendations and to ensure that the new recommendations adequately and appropriately address national issues and concerns, the Commission has initiated a much more open process than that used for the development of the previous recommendations. It should also be noted that the Commission mentions, for the first time, the need to account for the views and concerns of stakeholders when optimising protection.

The Commission has therefore solicited input from a broad spectrum of radiological protection stakeholders, ranging from government institutions and international organisations to scientists and non-governmental organisations. The draft recommendations have been discussed at a large number of international and national conferences and by the many international and national organisations with an interest in radiological protection.

Many of these also arranged particular activities around the Recommendations project. Thus for instance, the International Radiation Protection Association arranged reviews through its member organisations world-wide for their 2000 and 2004 Congresses and in connection with our 2006 public consultation, the Nuclear Energy Agency of the OECD organised seven international workshops and performed four detailed assessments of draft ICRP texts (in 2003, 2004, 2006, and 2007), and the European Commission organised a seminar in 2006 to debate the scientific issues in the Recommendations. The United Nations agencies, with the International Atomic Energy Agency as the lead agency, are using the 2007 ICRP Recommendations as a major input to their project of revising the International Basic Safety Standards, and likewise the European Commission uses the 2007 Recommendations as a major input to their revision of the European Basic Safety Standards.

The Recommendations have been prepared after two phases of international public consultation. By following this policy of transparency and involvement of stakeholders, ICRP is expecting a clearer understanding and wide acceptance of its Recommendations. Although the revised Recommendations do not contain any fundamental changes to the radiological protection policy, they will help to clarify application of the system of protection in the plethora of exposure situations encountered, thereby improving the already high standards of protection.

The Commission is pleased at having arrived at the end of a long but useful gestation phase including numerous consultations and is proud to present these 2007 Recommendations. The extensive consultations resulted in a much improved document and the Commission is grateful to the many organisations, experts, and individual members of the public who have devoted so much of their time and

experience to helping us to improve the Recommendations. Their contributions have been crucial for the future success of the 2007 Recommendations.

LARS-ERIK HOLM
CHAIRMAN, ICRP

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PREFACE

Since issuing its 1990 Recommendations as ICRP *Publication 60* (ICRP 1991b), the Commission has reviewed these Recommendations regularly and, from time to time, has issued supplementary reports in the *Annals of the ICRP*. The extent of these supplementary reports has indicated the need for the consolidation and rationalisation presented here. New scientific data have also been published since *Publication 60*, and while the biological and physical assumptions and concepts remain robust, some updating is required. The overall estimates of deterministic effects and stochastic risk remain fundamentally the same. The overall estimates of cancer risk attributable to radiation exposure have not changed appreciably in the past 16 years. Conversely, the estimated risk of heritable effects is currently lower than before. Overall, the new data provide a firmer basis on which to model risks and assess detriment. Finally, it has also become apparent that the radiological protection of the environment should receive more emphasis than in the past.

Therefore, while recognising the need for stability in international and national regulations, the Commission has decided to issue these revised Recommendations having two primary aims in mind:

- to take account of new biological and physical information and of trends in the setting of radiation safety standards; and
- to improve and streamline the presentation of the Recommendations.

In addition, the Commission has maintained as much stability in the Recommendations as is consistent with the new scientific information and societal expectations.

In its revised System of Protection, the Recommendations of the Commission now evolve from the previous process-based approach of practices and interventions to an approach based on the characteristics of radiation exposure situations. In taking this approach, the Commission wishes to affirm that its system of protection can be applied in principle to any situation of radiation exposure. Similar procedures are used for deciding on the extent and level of protective actions, regardless of exposure situation. Specifically, the principles of justification and optimisation apply universally. The Commission is of the opinion that the implementation of protection for what has until now been categorised as interventions could be enhanced by increasing the attention to these common features.

These Recommendations were produced by the Main Commission of ICRP, based on an earlier draft that was subjected to public and internal consultation in 2004 and again, in revised form, in 2006. By introducing more transparency and by involving the many organisations and individuals having an interest in radiological protection in the revision process, the Commission is expecting a better common understanding and acceptance of its Recommendations.

The membership of the Main Commission during the period of preparation of the present Recommendations was:

(2001–2005)

R.H. Clarke (Chairman)	A.J. González	Y. Sasaki
R.M. Alexakhin	L.-E. Holm (Vice-Chairman)	C. Streffer
J.D. Boice jr	F.A. Mettler jr	A. Sugier (2003–2005)
R. Cox	Z.Q. Pan	B.C. Winkler (✠ 2003)
G.J. Dicus (✠ 2006)	R.J. Pentreath (2003–2005)	

Scientific Secretary: J. Valentin

(2005–2009)

L.-E. Holm (Chairman)	J.-K. Lee	Y. Sasaki
J.D. Boice jr	H. Menzel (2007–2009)	N. Shandala
C. Cousins	Z.Q. Pan	C. Streffer (2005–2007)
R. Cox (Vice-Chairman)	R.J. Pentreath	A. Sugier
A.J. González	R.J. Preston	

Scientific Secretary: J. Valentin

The work of the Commission was greatly aided by significant contributions from P. Burns, J. Cooper, J.D. Harrison, and W. Weiss. It also benefited from discussions at many international meetings on the present Recommendations.

The Commission wishes to express its appreciation to all international and national organisations, governmental as well as non-governmental, and all individuals who contributed in the development of these Recommendations.

EXECUTIVE SUMMARY

(a) On 21 March 2007, the Main Commission of the International Commission on Radiological Protection (ICRP) approved these revised Recommendations for a System of Radiological Protection which formally replace the previous Recommendations issued in 1991 as *Publication 60* (ICRP, 1991b) and update the additional guidance on the control of exposure from radiation sources issued since *Publication 60*. These revised Recommendations consolidate and develop the previous Recommendations and guidance.

(b) The Commission has prepared these Recommendations after two phases of international public consultation, one in 2004 and one in 2006, on draft Recommendations. By following this policy of transparency and involvement of stakeholders, the Commission is anticipating a clearer understanding and wider acceptance of its Recommendations.

(c) The major features of the present Recommendations are:

- Updating the radiation and tissue weighting factors in the quantities equivalent and effective dose, and updating the radiation detriment based on the latest available scientific information of the biology and physics of radiation exposure;
- Maintaining the Commission's three fundamental principles of radiological protection, namely justification, optimisation, and the application of dose limits, and clarifying how they apply to radiation sources delivering exposure and to individuals receiving exposure;
- Evolving from the previous process-based protection approach using practices and interventions, by moving to a situation-based approach applying the fundamental principles of justification and optimisation of protection to all controllable exposure situations, which the present Recommendations characterise as planned, emergency, and existing exposure situations;
- Maintaining the Commission's individual dose limits for effective dose and equivalent dose from all regulated sources in planned exposure situations – these limits represent the maximum dose that would be accepted in any planned exposure situations by regulatory authorities;
- Re-enforcing the principle of optimisation of protection, which should be applicable in a similar way to all exposure situations, with restrictions on individual doses and risks, namely dose and risk constraints for planned exposure situations and reference levels for emergency and existing exposure situations; and
- Including an approach for developing a framework to demonstrate radiological protection of the environment.

(d) The Commission's system of radiological protection applies to all exposures to ionising radiation from any source, regardless of its size and origin. However, the Recommendations can apply in their entirety only to situations in which either the source of exposure or the pathways leading to the doses received by individuals can be controlled by some reasonable means. Some exposure situations are excluded from radiological protection legislation, usually on the basis that they are unamenable to control with regulatory instruments, and some exposure situations are

exempted from some or all radiological protection regulatory requirements where such controls are regarded as unwarranted.

(e) An understanding of the health effects of ionising radiation is central to the Commission's Recommendations. Following a review of the biological and epidemiological information on the health risks attributable to ionising radiation, the Commission has reached the following conclusions. The distribution of risks to different organs/tissues is judged to have changed somewhat since *Publication 60*, particularly in respect of the risks of breast cancer and heritable disease. However, assuming a linear response at low doses, the combined detriment due to excess cancer and heritable effects remains unchanged at around 5% per Sv. Embodied in this current estimate is the use of a dose and dose-rate effectiveness factor for solid cancers which is unchanged at a value of 2. The Commission also judges that, following prenatal exposure, a) cancer risk will be similar to that following irradiation in early childhood and b) threshold dose exists for the induction of malformations and for the expression of severe mental retardation. The Commission has retained the effective dose limits and the equivalent dose limits for the skin, hands/feet, and eye given in *Publication 60* but recognises that further information is needed and revised judgements may be required particularly in respect of the eye. The available data on possible excess in non-cancer diseases (e.g., cardiovascular disorders) are judged to be insufficient to inform on risks at low doses.

(f) The Commission's extensive review of the health effects of ionising radiation has, however, not indicated that any fundamental changes are needed to the system of radiological protection. Importantly, existing numerical recommendations in the policy guidance issued since 1991 remain valid unless otherwise stated. Therefore, these revised Recommendations should not imply any substantial changes to radiological protection regulations that are based on its previous Recommendations and subsequent policy guidance.

(g) The central assumption of a linear dose–response relationship for the induction of cancer and heritable effects, according to which an increment in dose induces a proportional increment in risk even at low doses, continues to provide the basis for the summation of doses from external sources of radiation and from intakes of radionuclides.

(h) The use of equivalent and effective dose remains unchanged, but a number of revisions have been made to the methods used in their calculation. Reviews of the range of available data on the relative biological effectiveness of different radiations, together with biophysical considerations, have led to changes to the values of radiation weighting factors used for neutrons and protons, with values for neutrons given as a continuous function of neutron energy, and the inclusion of a value for charged pions. Radiation weighting factors for photons, electrons, muons, and alpha particles are unchanged.

(i) An important change is that doses from external and internal sources will be calculated using reference computational phantoms of the human body based on medical tomographic images, replacing the use of various mathematical models. For adults, equivalent doses will be calculated by sex-averaging of values obtained using male and female phantoms. Effective dose will then be calculated using revised

age- and sex-averaged tissue weighting factors, based on updated risk data and intended to apply as rounded values to a population of both sexes and all ages. Effective dose is calculated for a Reference Person and not for an individual.

(j) Effective dose is intended for use as a protection quantity. The main uses of effective dose are the prospective dose assessment for planning and optimisation in radiological protection, and demonstration of compliance with dose limits for regulatory purposes. Effective dose is not recommended for epidemiological evaluations, nor should it be used for detailed specific retrospective investigations of individual exposure and risk.

(k) The collective effective dose quantity is an instrument for optimisation, for comparing radiological technologies and protection procedures, predominantly in the context of occupational exposure. Collective effective dose is not intended as a tool for epidemiological risk assessment, and it is inappropriate to use it in risk projections. The aggregation of very low individual doses over extended time periods is inappropriate, and in particular, the calculation of the number of cancer deaths based on collective effective doses from trivial individual doses should be avoided.

(l) In order to assess radiation doses, models are necessary to simulate the geometry of the external exposure, the biokinetics of incorporated radionuclides, and the human body. The reference models and necessary reference parameter values are established and selected from a range of experimental investigations and human studies through judgements. For regulatory purposes, these models and parameter values are fixed by convention and are not subject to uncertainty. The Commission is aware of uncertainties and lack of precision of the models and parameter values. Efforts are undertaken to critically evaluate and to reduce the uncertainties. For individual retrospective dose and risk assessments, individual parameters and uncertainties have to be taken into account.

(m) The Commission's process of consolidation of previous guidance and recommendations has indicated that some changes to the structure and terminology of the system of protection were desirable in order to improve clarity and utility. In particular the distinction between practices and interventions may not have been clearly understood in the wider radiological protection community. Additionally, there were exposure situations which were difficult to categorise in this manner.

(n) The Commission now recognises three types of exposure situations which replace the previous categorisation into practices and interventions. These three exposure situations are intended to cover the entire range of exposure situations. The three situations are:

- *Planned exposure* situations, which are situations involving the planned introduction and operation of sources. (This type of exposure situation includes situations that were previously categorised as practices.)
- *Emergency exposure* situations, which are unexpected situations such as those that may occur during the operation of a planned situation, or from a malicious act, requiring urgent attention.

- *Existing exposure* situations, which are exposure situations that already exist when a decision on control has to be taken, such as those caused by natural background radiation.

(o) The three key principles of radiological protection are retained in the revised Recommendations. The principles of *justification* and *optimisation* apply in all three exposure situations whereas the principle of *application of dose limits* applies only for doses expected to be incurred with certainty as a result of planned exposure situations. These principles are defined as follows:

- *The Principle of Justification*: Any decision that alters the radiation exposure situation should do more good than harm.
- *The Principle of Optimisation of Protection*: The likelihood of incurring exposure, 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 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 specified by the Commission.

The Commission continues to distinguish amongst three categories of exposure: occupational exposures, public exposures, and medical exposures of patients (and comforters, carers, and volunteers in research). If a female worker has declared that she is pregnant, additional controls have to be considered in order to attain a level of protection for the embryo/fetus broadly similar to that provided for members of the public.

(p) The revised Recommendations emphasise the key role of the principle of optimisation. This principle should be applied in the same manner in all exposure situations. Restrictions are applied to doses to a nominal individual (the Reference Person), namely dose constraints for planned exposure situations and reference levels for emergency and existing exposure situations. Options resulting in doses greater in magnitude than such restrictions should be rejected at the planning stage. Importantly, these restrictions on doses are applied prospectively, as with optimisation as a whole. If, following the implementation of an optimised protection strategy, it is subsequently shown that the value of the constraint or reference level is exceeded, the reasons should be investigated but this fact alone should not necessarily prompt regulatory action. The Commission expects that this emphasis on a common approach to radiological protection in all exposure situations will aid application of the Commission's Recommendations in the various circumstances of radiation exposure.

(q) The relevant national authorities will often play a major role in selecting values for dose constraints and reference levels. Guidance on the selection process is provided in the revised Recommendations. This guidance takes account of numerical recommendations made previously by the Commission.

(r) Planned exposure situations encompass sources and situations that have been appropriately managed within the Commission's previous Recommendations for

practices. Protection during the medical uses of radiation is also included in this type of exposure situation. The process of planning protection in planned exposure situations should include consideration of deviations from normal operating procedures including accidents and malicious events. Exposures arising in such circumstances are referred to by the Commission as potential exposures. Potential exposures are not planned but they can be anticipated. The designer and the user of a source must therefore take actions to reduce the likelihood of a potential exposure happening, such as assessing the probability of an event and introducing engineering safeguards commensurate to this probability. Recommendations for planned exposure situations are substantially unchanged from these provided in *Publication 60* and subsequent publications. The dose limits for occupational and public exposures for practices are retained for application to regulated sources in planned exposure situations.

(s) Radiological protection in medicine includes the protection not only of patients but also of individuals exposed to radiation whilst caring for or comforting patients, and volunteers involved in biomedical research. The protection of all of these groups requires special consideration. The Commission's Recommendations for radiological protection and safety in medicine are given in *Publication 73* (ICRP 1996a) which has been further elaborated in a series of publications. The recommendations, guidance and advice in these publications remain valid and are summarised in the present Recommendations and in *Publication 105* (ICRP, 2007b) which was drafted by ICRP Committee 3 to support these Recommendations.

(t) Emphasis on optimisation using reference levels in emergency and existing exposure situations focuses attention on the residual level of dose remaining after implementation of protection strategies. This residual dose should be below the reference level, which represents the total residual dose as a result of an emergency, or in an existing situation, that the regulator would plan not to exceed. These exposure situations often involve multiple exposure pathways which means that protection strategies involving a number of different protective actions will have to be considered. The process of optimisation will however continue to use the dose averted by specific countermeasures as an important input into the development of optimised strategies.

(u) Emergency exposure situations include consideration of emergency preparedness and emergency response. Emergency preparedness should include planning for the implementation of optimised protection strategies which have the purpose of reducing exposures, should the emergency occur, to below the selected value of the reference level. During emergency response, the reference level would act as a benchmark for evaluating the effectiveness of protective actions and as one input into the need for establishing further actions.

(v) Existing exposure situations include naturally occurring exposures as well as exposures from past events and accidents, and practices conducted outside the Commission's Recommendations. In this type of situation, protection strategies will often be implemented in an interactive, progressive manner over a number of years. Indoor radon in dwellings and workplaces is an important existing exposure situation and is one where the Commission made specific recommendations in 1994 in

Publication 65 (ICRP 1993b). Since then several epidemiological studies have confirmed the health risk from radon exposure and have generally provided support for the Commission's Recommendations on protection against radon. Consistent with its approach to radiological protection in the revised Recommendations, the Commission now recommends that national authorities should set national reference levels as an aid to optimisation of protection against radon exposures. For the sake of continuity and practicability, the Commission retains the upper value of 10 mSv (effective dose, converted by convention from 600 Bq m^{-3} Rn-222 in dwellings) for the annual dose reference level, as given in *Publication 65*. The Commission reaffirms that radon exposure at work at levels above the national reference level should be considered part of occupational exposure whereas exposures at levels below should not. Nevertheless, optimisation is a requirement below the national reference level.

(w) The revised Recommendations acknowledge the importance of protecting the environment. The Commission has previously concerned itself with mankind's environment only with regard to the transfer of radionuclides through it, mainly in the context of planned exposure situations. In such situations, the Commission continues to believe that the standards of environmental control needed to protect the general public would ensure that other species are not placed at risk. To provide a sound framework for environmental protection in all exposure situations, the Commission proposes the use of Reference Animals and Plants. In order to establish a basis for acceptability, additional doses calculated to these reference organisms could be compared with doses known to have specific biological effects and with dose rates normally experienced in the natural environment. The Commission, however, does not propose to set any form of 'dose limits' for environmental protection.

(x) The Commission anticipates that although the revised Recommendations do not contain any fundamental changes to the radiological protection policy, these Recommendations will help to clarify application of the system of protection in the plethora of exposure situations encountered, thereby further improving the already high standards of protection.

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GLOSSARY

α/β ratio

A measure of the curvature of the cell survival curve and a measure of the sensitivity of a tissue or tumour to dose fractionation. The dose at which the linear and quadratic components of cell killing are equal.

Absorbed dose, D

The fundamental dose quantity given by

$$D = \frac{\mathrm{d}\bar{\varepsilon}}{\mathrm{d}m}$$

where $\mathrm{d}\bar{\varepsilon}$ is the mean energy imparted to matter of mass $\mathrm{d}m$ by ionising radiation. The SI unit for absorbed dose is joule per kilogram (J kg^{-1}) and its special name is gray (Gy).

Active (red) bone marrow

The organ system bone marrow contains the cell systems for the formation of blood cells starting from the pluripotent haematopietic stem cells to the mature blood cells.

Activity, A

The expectation value of the number of nuclear transformations occurring in a given quantity of material per unit time. The SI unit of activity is per second (s^{-1}) and its special name is becquerel (Bq).

Activity Median Aerodynamic Diameter (AMAD)

The value of aerodynamic diameter such that 50% of the airborne activity in a specified aerosol is associated with particles greater than the AMAD. Used when deposition depends principally on inertial impaction and sedimentation, typically when the AMAD is greater than about 0.5 μm.

Adaptive response

A post-irradiation cellular response which, typically, serves to increase the resistance of the cell to a subsequent radiation exposure.

Ambient dose equivalent, $H^*(10)$

The dose equivalent at a point in a radiation field that would be produced by the corresponding expanded and aligned field in the ICRU sphere at a depth of 10 mm on the radius vector opposing the direction of the aligned field. The unit of ambient dose equivalent is joule per kilogram (J kg^{-1}) and its special name is sievert (Sv).

Annual intake, *AI*

The amount of a specified radionuclide entering the human body by ingestion or inhalation within one year.

Apoptosis

An active biochemical process of programmed cell death following radiation or other insults.

Averted dose

The dose prevented or avoided by the application of a protective measure or set of protective measures, i.e., the difference between the projected dose if the protective measure(s) had not been applied and the expected residual dose.

Baseline rates

The annual disease incidence observed in a population in the absence of exposure to the agent under study.

Becquerel (Bq)

The special name for the SI unit of activity, 1 Bq = 1 s^{-1} ($\approx$2.7 10^{-11} Ci).

Bioassay

Any procedure used to determine the nature, activity, location, or retention of radionuclides in the body by in vivo measurement or by in vitro analysis of material excreted or otherwise removed from the body.

Biological half-life

The time required, in the absence of further input, for a biological system or compartment to eliminate, by biological processes, half the amount of a substance (e.g., radioactive material) that has entered it.

Brachytherapy

Radiation treatment of a patient using sealed or unsealed sources of radiation placed within the patient's body.

Bystander effect

A response in unirradiated cells that is triggered by signals received from irradiated neighbouring cells.

Categories of exposure

The Commission distinguishes between three categories of radiation exposure: occupational, public, and medical exposures of patients.

Collective dose

See 'Collective effective dose'.

Collective effective dose, S

The collective effective dose due to individual effective dose values between E_1 and E_2 from a specified source within a specified time period ΔT is defined as:

$$S(E_1, E_2, \Delta T) = \int_{E_1}^{E_2} E \left[\frac{\mathrm{d}N}{\mathrm{d}E}\right]_{\Delta T} \mathrm{d}E$$

It can be approximated as $S = \Sigma_i E_i N_i$ where E_i is the average effective dose for a subgroup i, and N_i is the number of individuals in this subgroup. The time period and number of individuals over which the effective doses are summed should always be specified. The unit of the collective effective dose is joule per kilogram (J kg^{-1}) and its special name is man sievert (man Sv). The number of individuals experiencing an effective dose in the range E_1 to E_2, $N(E_1, E_2, \Delta T)$ is

$$N(E_1, E_2, \Delta T) = \int_{E_1}^{E_2} \left[\frac{\mathrm{d}N}{\mathrm{d}E}\right]_{\Delta T} \mathrm{d}E$$

and the average value of effective dose $\overline{E}(E_1, E_2, \Delta T)$ in the interval of individual doses between E_1 and E_2 for the time period ΔT is:

$$\overline{E}(E_1, E_2, \Delta T) = \frac{1}{N(E_1, E_2, \Delta T)} \int_{E_1}^{E_2} E \left[\frac{\mathrm{d}N}{\mathrm{d}E}\right]_{\Delta T} \mathrm{d}E$$

Committed effective dose, $E(\tau)$

The sum of the products of the committed organ or tissue equivalent doses and the appropriate tissue weighting factors (w_T), where τ is the integration time in years following the intake. The commitment period is taken to be 50 years for adults, and to age 70 years for children.

Committed equivalent dose, $H_T(\tau)$

The time integral of the equivalent dose rate in a particular tissue or organ that will be received by an individual following intake of radioactive material into the body by a Reference Person, where τ is the integration time in years.

Confidence limits

An interval giving the lowest and highest estimate of a parameter that is statistically compatible with the data. For a 95% confidence interval, there is a 95% chance that the interval contains the parameter.

Controlled area

A defined area in which specific protection measures and safety provisions are, or could be, required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures. A controlled area is often within a supervised area, but need not be.

DD
: See 'Doubling dose'.

Derived air concentration (DAC)
: This equals the annual limit on intake, ALI, (of a radionuclide) divided by the volume of air inhaled by a Reference Person in a working year (i.e., $2.2\ 10^3\ m^3$). The unit of DAC is Bq m^{-3}.

Designated area
: An area that is either 'controlled' or 'supervised'.

Deterministic effect
: Injury in populations of cells, characterised by a threshold dose and an increase in the severity of the reaction as the dose is increased further. Also termed tissue reaction. In some cases, deterministic effects are modifiable by post-irradiation procedures including biological response modifiers.

Detriment
: The total harm to health experienced by an exposed group and its descendants as a result of the group's exposure to a radiation source. Detriment is a multi-dimensional concept. Its principal components are the stochastic quantities: probability of attributable fatal cancer, weighted probability of attributable non-fatal cancer, weighted probability of severe heritable effects, and length of life lost if the harm occurs.

Detriment-adjusted risk
: The probability of the occurrence of a stochastic effect, modified to allow for the different components of the detriment in order to express the severity of the consequence(s).

Diagnostic reference level
: Used in medical imaging with ioning radiation to indicate whether, in routine conditions, the patient dose or administered activity (amount of radioactive material) from a specified procedure is unusually high or low for that procedure.

Directional dose equivalent, $H'(d, \Omega)$
: The dose equivalent at a point in a radiation field that would be produced by the corresponding expanded field in the ICRU sphere at a depth, d, on a radius in a specified direction, Ω. The unit of directional dose equivalent is joule per kilogram (J kg^{-1}) and its special name is sievert (Sv).

DMF
: Dose modifying factor: the ratio of doses with and without modifying agents, causing the same level of biological effect.

DNA damage signalling
: Interacting biochemical processes which recognise and respond to DNA damage in cells, e.g., by causing the arrest of the reproductive cell cycle.

Differentiation
: The process whereby stem cells enter a pathway of proliferation during which daughter cells acquire specialised functions.

Dose and dose-rate effectiveness factor (DDREF)
: A judged factor that generalises the usually lower biological effectiveness (per unit of dose) of radiation exposures at low doses and low dose rates as compared with exposures at high doses and high dose rates.

Dose coefficient
: Used as a synonym for dose per unit intake of a radioactive substance, but sometimes also used to describe other coefficients linking quantities or concentrations of activity to doses or dose rates, such as the external dose rate at a specified distance above a surface with a deposit of a specified activity per unit area of a specified radionuclide.

Dose commitment, E_c
: A calculational tool, defined as the infinite time integral of the per caput dose rate $\dot{E}$ due to a specified event, such as a year of a planned activity causing discharges. In the case of indefinite discharges at a constant rate, the maximum annual per caput dose rate $\dot{E}$ in the future for the specified population will be equal to the dose commitment of one year of practice, irrespective of changes in the population size. If the activity causing discharges is continued only over a time period, τ, the maximum future annual per caput dose will be equal to the corresponding truncated dose commitment, defined as

$$E_c(\tau) = \int_0^{\tau} \dot{E}(t)dt$$

Dose constraint
: A prospective and source-related restriction on the individual dose from a source, which provides a basic level of protection for the most highly exposed individuals from a source, and serves as an upper bound on the dose in optimisation of protection for that source. For occupational exposures, the dose constraint is a value of individual dose used to limit the range of options considered in the process of optimisation. For public exposure, the dose constraint is an upper bound on the annual doses that members of the public should receive from the planned operation of any controlled source.

Dose equivalent, H

The product of D and Q at a point in tissue, where D is the absorbed dose and Q is the quality factor for the specific radiation at this point, thus:

$$H = DQ$$

The unit of dose equivalent is joule per kilogram (J kg^{-1}), and its special name is sievert (Sv).

Dose limit

The value of the effective dose or the equivalent dose to individuals from planned exposure situations that shall not be exceeded.

Dose of record, $H_p(10)$

The effective dose of a worker assessed by the sum of the measured personal dose equivalent $H_p(10)$ and the committed effective dose retrospectively determined for the Reference Person using results of individual monitoring of the worker and ICRP reference biokinetic and dosimetric computational models. Dose of record may be assessed with site-specific parameters of exposure, such as the type of materials and AMAD, but the parameters of the Reference Person shall be fixed as defined by the Commission. Dose of record is assigned to the worker for purposes of recording, reporting and retrospective demonstration of compliance with regulatory dose limits.

Dose-threshold hypothesis

A given dose above background, below which it is hypothesised that the risk of excess cancer and/or heritable disease is zero. (See also Threshold dose for tissue reactions).

Doubling dose (DD)

The dose of radiation (Gy) that is required to produce as many heritable mutations as those arising spontaneously in a generation.

DS02

Dosimetry System 2002, a system for estimating gamma and neutron exposure under a large variety of situations and which allows the calculation of absorbed dose to specific organs for members of the Life Span Study. DS02 improved on the DS86 dose system.

DS86

Dosimetry System 1986, a system for estimating gamma and neutron exposure under a large variety of situations and which then allowed the calculation of absorbed dose to specific organs for members of the Life Span Study.

Effective dose, E

The tissue-weighted sum of the equivalent doses in all specified tissues and organs of the body, given by the expression:

$$E = \sum_{T} w_T \sum_{R} w_R D_{T,R} \quad \text{or} \quad E = \sum_{T} w_T H_T$$

where H_T or w_R $D_{T,R}$ is the equivalent dose in a tissue or organ, T, and w_T is the tissue weighting factor. The unit for the effective dose is the same as for absorbed dose, J kg^{-1}, and its special name is sievert (Sv).

ELR

See 'Lifetime risk estimates'.

Emergency

A non-routine situation or event that necessitates prompt action primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment. This includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

Emergency exposure situation

An unexpected situation that occurs during the operation of a practice, requiring urgent action. Emergency exposure situations may arise from practices.

Employer

An organisation, corporation, partnership, firm, association, trust, estate, public or private institution, group, political or administrative entity, or other persons designated in accordance with national legislation, with recognised responsibility, commitment, and duties towards a worker in her or his employment by virtue of a mutually agreed relationship. A self-employed person is regarded as being both an employer and a worker.

Equivalent dose, H_T

The dose in a tissue or organ T given by:

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

where $D_{T,R}$ is the mean absorbed dose from radiation R in a tissue or organ T, and w_R is the radiation weighting factor. Since w_R is dimensionless, the unit for the equivalent dose is the same as for absorbed dose, J kg^{-1}, and its special name is sievert (Sv).

Excess absolute risk

The rate of disease incidence or mortality in an exposed population minus the corresponding disease rate in an unexposed population. The excess absolute risk is often expressed as the additive excess rate per Gy or per Sv.

Excess relative risk
: The rate of disease in an exposed population divided by the rate of disease in an unexposed population, minus 1.0. This is often expressed as the excess relative risk per Gy or per Sv.

Exclusion
: The deliberate exclusion of a particular category of exposure from the scope of an instrument of regulatory control.

Exemption
: The determination by a regulatory body that a source or practice activity involving radiation need not be subject to some or all aspects of regulatory control.

Existing exposure situation
: A situation that already exists when a decision on control has to be taken, including natural background radiation and residues from past practices that were operated outside the Commission's recommendations.

Exposed individuals
: The Commission distinguishes between three categories of exposed individuals: workers (informed individuals), the public (general individuals), and patients, including their comforters and carers.

Fluence (particle fluence), Φ
: The quotient of dN by da, where dN is the number of particles incident upon a small sphere of cross-sectional area da, thus:

$$\Phi = \frac{dN}{da}$$

FSU
: Functional subunits of tissues, e.g., nephrons in kidney, alveoli in lung.

Gray (Gy)
: The special name for the SI unit of absorbed dose: 1 Gy = 1 J kg^{-1}.

Growth factors
: Molecules that act to control cell reproduction and proliferation/differentiation of a population of cells.

Incidence (incidence rate)
: The rate of occurrence of a disease in a population within a specified period of time, often expressed as the number of cases of a disease arising per 100,000 individuals per year (or per 100,000 person-years).

Induced genomic instability

The induction of an altered cellular state characterised by a persistent increase over many generations in the spontaneous rate of mutation or other genome-related changes.

Intake, I

Activity that enters the body through the respiratory tract or the gastrointestinal tract or the skin.

– Acute intake

A single intake by inhalation or ingestion, taken to occur instantaneously.

– Chronic intake

An intake over a specified period of time.

Justification

The process of determining whether either (1) a planned activity involving radiation is, overall, beneficial, i.e. whether the benefits to individuals and to society from introducing or continuing the activity outweigh the harm (including radiation detriment) resulting from the activity; or (2) a proposed remedial action in an emergency or existing exposure situation is likely, overall, to be beneficial, i.e., whether the benefits to individuals and to society (including the reduction in radiation detriment) from introducing or continuing the remedial action outweigh its cost and any harm or damage it causes.

Kerma, K

The quotient of the sum of the kinetic energies, dE_{tr}, of all charged particles liberated by uncharged particles in a mass dm of material, and the mass dm of that material.

$$K = \frac{dE_{tr}}{dm}$$

Kerma is defined as a non-stochastic quantity and dE_{tr} is the expectation value of the sum of the kinetic energies. The unit for kerma is joule per kilogram (J kg^{-1}) and its special name is gray (Gy).

LAR

See 'Lifetime risk estimates'.

LD50

Dose that is lethal for half of the exposed individuals.

LET

See 'Linear energy transfer'.

Licensee

The holder of a current legal document issued by the regulatory body granting authorisation to perform specified activities related to an installation or activity.

Life Span Study (LSS)

The long-term cohort study of health effects in the Japanese atomic bomb survivors in Hiroshima and Nagasaki.

Lifetime risk estimates

Several types of lifetime risk estimates can be used to calculate the risk, over a lifetime, that an individual will develop, or die from, a specific disease caused by an exposure: 1) the excess lifetime risk (ELR) which is the difference between the proportion of people who develop or die from the disease in an exposed population and the corresponding proportion in a similar population without the exposure; 2) the risk of exposure-induced death (REID) which is defined as the difference in a cause-specific death rate for exposed and unexposed populations of a given sex and a given age at exposure, as an additional cause of death introduced into a population; 3) loss of life expectancy (LLE) which describes the decrease in life expectancy due to the exposure of interest; and 4) lifetime attributable risk (LAR) which is an approximation of the REID and describes excess deaths (or disease cases) over a follow-up period with population background rates determined by the experience of unexposed individuals. The LAR was used in this report to estimate lifetime risks.

Linear dose response

A statistical model that expresses the risk of an effect (e.g., disease or abnormality) as being proportional to dose.

Linear energy transfer (L or LET)

The average linear rate of energy loss of charged particle radiation in a medium, i.e., the radiation energy lost per unit length of path through a material. That is, the quotient of dE by dl where dE is the mean energy lost by a charged particle owing to collisions with electrons in traversing a distance dl in matter.

$$L = \frac{\mathrm{d}E}{\mathrm{d}l}$$

The unit of L is J m^{-1}, often given in keV μm^{-1}.

Linear-non-threshold (LNT) model

A dose-response model which is based on the assumption that, in the low dose range, radiation doses greater than zero will increase the risk of excess cancer and/or heritable disease in a simple proportionate manner.

Linear-quadratic dose response

A statistical model that expresses the risk of an effect (e.g., disease, death, or abnormality) as the sum of two components, one proportional to dose (linear term) and the other one proportional to the square of dose (quadratic term).

LLE
See 'Lifetime risk estimates'.

MC
See 'Mutation component'.

Mean absorbed dose in a tissue or organ (T), D_T
The absorbed dose D_T, averaged over the tissue or organ T, which is given by

$$D_T = \frac{\varepsilon_T}{m_T}$$

where ε_T is the mean total energy imparted in a tissue or organ T, and m_T is the mass of that tissue or organ.

Medical exposure
Exposure incurred by patients as part of their own medical or dental diagnosis or treatment; by persons, other than those occupationally exposed, knowingly, while voluntarily helping in the support and comfort of patients; and by volunteers in a programme of biomedical research involving their exposure.

Mendelian diseases
Heritable diseases attributable to single-gene mutations.

Multifactorial diseases
Diseases that are attributable to multiple genetic and environmental factors.

Multistage tumorigenesis
The stepwise acquisition of cellular properties that can lead to the development of tumour from a single (target) cell.

Mutation component (MC)
A quantity that provides a measure of the relative change in disease frequency per unit relative change in mutation rate, i.e., a measure of responsiveness; MC values differ for different classes of heritable disease.

Nominal risk coefficient
Sex-averaged and age-at-exposure-averaged lifetime risk estimates for a representative population.

Non-cancer diseases
Somatic diseases other than cancer, e.g., cardiovascular disease and cataracts.

NORM (naturally occurring radioactive material)
Radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides. Material in which the activity

concentrations of the naturally occurring radionuclides have been changed by some process are included in NORM.

Occupational exposure

This refers to all exposure incurred by workers in the course of their work, with the exception of

1) excluded exposures and exposures from exempt activities involving radiation or exempt sources; 2) any medical exposure; and 3) the normal local natural background radiation.

Operating management

The person or group of persons that directs, controls, and assesses an organisation at the highest level. Many different terms are used, including, e.g., chief executive officer (CEO), director general (DG), managing director (MD), and executive group.

Operational quantities

Quantities used in practical applications for monitoring and investigating situations involving external exposure. They are defined for measurements and assessment of doses in the body. In internal dosimetry, no operational dose quantities have been defined which directly provide an assessment of equivalent or effective dose. Different methods are applied to assess the equivalent or effective dose due to radionuclides in the human body. They are mostly based on various activity measurements and the application of biokinetic models (computational models).

Optimisation of protection (and safety)

The process of determining what level of protection and safety makes exposures, and the probability and magnitude of potential exposures, as low as reasonably achievable, economic and societal factors being taken into account.

Particle fluence, Φ

See 'Fluence'.

Personal dose equivalent, $H_p(d)$

An operational quantity: the dose equivalent in soft tissue (commonly interpreted as the 'ICRU sphere') at an appropriate depth, d, below a specified point on the human body. The unit of personal dose equivalent is joule per kilogram ($J\ kg^{-1}$) and its special name is sievert (Sv). The specified point is usually given by the position where the individual's dosimeter is worn.

Planned exposure situations

Everyday situations involving the planned operation of sources including decommissioning, disposal of radioactive waste and rehabilitation of the previously occupied land. Practices in operation are planned exposure situations.

Pooled analysis
: An analysis of epidemiological data from several studies based on original data from those studies that are analysed in parallel.

Potential exposure
: Exposure that is not expected to be delivered with certainty but that may result from an accident at a source or an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

PRCF (potential recoverability correction factor)
: A set of factors that take account of knowledge that different classes of germ line mutation will show different degrees of recoverability in live-born offspring, i.e., through differing capacities to allow completion of embryonic/fetal development.

Principles of protection
: A set of principles that apply equally to all controllable exposure situations: the principle of justification, the principle of optimisation of protection, and the principle of application of limits on maximum doses in planned situations.

Progenitor cell
: Undifferentiated cell capable of limited proliferation.

Projected dose
: The dose that would be expected to be incurred if no protective measure(s) – were to be taken.

Protection quantities
: Dose quantities that the Commission has developed for radiological protection that allow quantification of the extent of exposure of the human body to ionising radiation from both whole and partial body external irradiation and from intakes of radionuclides.

Public exposure
: Exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation.

Quality factor, $Q(L)$
: The factor characterising the biological effectiveness of a radiation, based on the ionisation density along the tracks of charged particles in tissue. Q is defined as a function of the unrestricted linear energy transfer, L_{∞} (often denoted as L or LET), of charged particles in water:

$$Q(L) = \begin{cases} 1 & L < 10 \text{ keV}/\mu\text{m} \\ 0.32L - 2.2 & 10 \leqslant L \leqslant 100 \text{ keV}/\mu\text{m} \\ 300/\sqrt{L} & L > 100 \text{ keV}/\mu\text{m} \end{cases}$$

Q has been superseded by the radiation weighting factor in the definition of equivalent dose, but it is still used in calculating the operational dose equivalent quantities used in monitoring.

Radiation detriment

A concept used to quantify the harmful health effects of radiation exposure in different parts of the body. It is defined by the Commission as a function of several factors, including incidence of radiation-related cancer or heritable effects, lethality of these conditions, quality of life, and years of life lost owing to these conditions.

Radiation weighting factor, w_R

A dimensionless factor by which the organ or tissue absorbed dose is multiplied to reflect the higher biological effectiveness of high-LET radiations compared with low-LET radiations. It is used to derive the equivalent dose from the absorbed dose averaged over a tissue or organ.

Radioactive material

Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity, often taking account of both activity and activity concentration.

Radiological attack

The use of radioactive or nuclear materials for malicious purposes, such as blackmail, murder, sabotage, or terrorism.

Random error

Errors that vary in a non-reproducible way. These errors can be treated statistically by use of the laws of probability.

RBE

See 'Relative biological effectiveness'.

Reference Animals and Plants

A Reference Animal or Plant is a hypothetical entity, with the assumed basic characteristics of a specific type of animal or plant, as described to the generality of the taxonomic level of Family, with defined anatomical, physiological, and life-history properties, that can be used for the purposes of relating exposure to dose, and dose to effects, for that type of living organism.

Reference Male and Reference Female (Reference Individual)
: An idealised male or female with characteristics defined by the Commission for the purpose of radiological protection, and with the anatomical and physiological characteristics defined in the report of the ICRP Task Group on Reference Man (*Publication 89*, ICRP 2002).

Reference Person
: An idealised person for whom the organ or tissue equivalent doses are calculated by averaging the corresponding doses of the Reference Male and Reference Female. The equivalent doses of the Reference Person are used for the calculation of the effective dose by multiplying these doses by the corresponding tissue weighting factors.

Reference phantom
: Voxel phantoms for the human body (male and female voxel phantoms based on medical imaging data) with the anatomical and physiological characteristics defined in the report of the ICRP Task Group on Reference Man (*Publication 89*, ICRP 2002).

Reference value
: The value of a parameter recommended by the Commission for use in a biokinetic model in the absence of more specific information, i.e., the exact value used to calculate the dose coefficients presented in the report. Reference values may be specified to a greater degree of precision than that which would be chosen to reflect the uncertainty with which an experimental value is known, in order to avoid the accumulation of rounding errors in a calculation.

Reference level
: In emergency or existing controllable exposure situations, this represents the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and below which optimisation of protection should be implemented. The chosen value for a reference level will depend upon the prevailing circumstances of the exposure under consideration.

Relative biological effectiveness (RBE)
: The ratio of a dose of a low-LET reference radiation to a dose of the radiation considered that gives an identical biological effect. RBE values vary with the dose, dose rate, and biological endpoint considered. In radiological protection, the RBE for stochastic effects at low doses (RBE_M) is of particular interest.

Relative life lost
: The ratio of the proportion of observed years of life lost among people dying of a disease in an exposed population and the corresponding proportion in a similar population without the exposure.

REID
See 'Lifetime risk estimates'.

Relative survival
The ratio of the proportion of cancer patients who survive for a specified number of years (e.g., 5 years) following diagnosis to the corresponding proportion in a comparable set of cancer-free individuals.

Representative Person
An individual receiving a dose that is representative of the more highly exposed individuals in the population (see *Publication 101*, ICRP 2006a). This term is the equivalent of, and replaces, 'average member of the critical group' described in previous ICRP Recommendations.

Residual dose
The dose expected to be incurred after protective measure(s) have beenfully implemented (or a decision has been taken not to implement any protective measures).

Risk constraint
A prospective and source-related restriction on the individual risk (in the sense of probability of detriment due to a potential exposure) from a source, which provides a basic level of protection for the individuals most at risk from a source and serves as an upper bound on the individual risk in optimisation of protection for that source. This risk is a function of the probability of an unintended event causing a dose, and the probability of detriment due to that dose. Risk constraints correspond to dose constraints but refer to potential exposures.

Safety
The achievement of proper operating conditions, prevention of accidents, or mitigation of accident consequences.

Security
The prevention and detection of, and response to, theft, sabotage, unauthorised access, illegal transfer, or other malicious acts involving nuclear material, other radioactive substances, or their associated installations.

Sensitivity analysis
This aims to quantify how the results from a model depend upon the different variables included in it.

Sievert (Sv)
The special name for the SI unit of equivalent dose, effective dose, and operational dose quantities. The unit is joule per kilogram (J kg^{-1}).

Source
: An entity for which radiological protection can be optimised as an integral whole, such as the x-ray equipment in a hospital, or the releases of radioactive materials from an installation. Sources of radiation, such as radiation generators and sealed radioactive materials, and, more generally, the cause of exposure to radiation or to radionuclides.

Source region, S_i
: An anatomical region within the reference phantom body which contains the radionuclide following its intake. The region may be an organ, a tissue, the contents of the gastrointestinal tract or urinary bladder, or the surfaces of tissues as in the skeleton, the alimentary tract, and the respiratory tract.

Specific absorbed fraction
: The fraction of energy of that emitted as a specified radiation type in a source region, S, that is absorbed in 1 kg of a target tissue, T.

Statistical power
: The probability that an epidemiological study will detect a given level of elevated risk with a specified degree of confidence.

Stem cell
: Non-differentiated, pluripotent cell, capable of unlimited cell division.

Stochastic effects of radiation
: Malignant disease and heritable effects for which the probability of an effect occurring, but not its severity, is regarded as a function of dose without threshold.

Supervised area
: A defined area not designated as a controlled area but for which occupational exposure conditions are kept under review, even though no specific protection measures or safety provisions are normally needed.

Systematic error
: Errors that are reproducible and tend to bias a result in one direction. Their causes can be assigned, at least in principle, and they can have constant and variable components. Generally these errors cannot be treated statistically.

Target region, T_i
: Anatomical region within the body (reference phantom) in which radiation is absorbed. The region may be an organ or a specified tissue as in the gastrointestinal tract, urinary bladder, skeleton, and respiratory tract.

Threshold dose for tissue reactions
: Dose estimated to result in only 1% incidence of tissue reactions.

Tissue reaction
: See 'Deterministic effect'.

Tissue weighting factor, w_T
: The factor by which the equivalent dose in a tissue or organ T is weighted to represent the relative contribution of that tissue or organ to the total health detriment resulting from uniform irradiation of the body (ICRP 1991b). It is weighted such that:

$$\sum_T w_T = 1$$

Track structure
: Spatial patterns of energy deposition in matter along the track from the passage of ionising radiation.

Transport of risk (also called transfer of risk)
: Taking a risk coefficient estimated for one population and applying it to another population with different characteristics.

Voxel phantom
: Computational anthropomorphic phantom based on medical tomographic images where the anatomy is described by small three-dimensional volume elements (voxels) specifying the density and the atomic composition of the various organs and tissues of the human body.

Worker
: Any person who is employed, whether full time, part time or temporarily, by an employer, and who has recognised rights and duties in relation to occupational radiological protection.

References for the Glossary

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