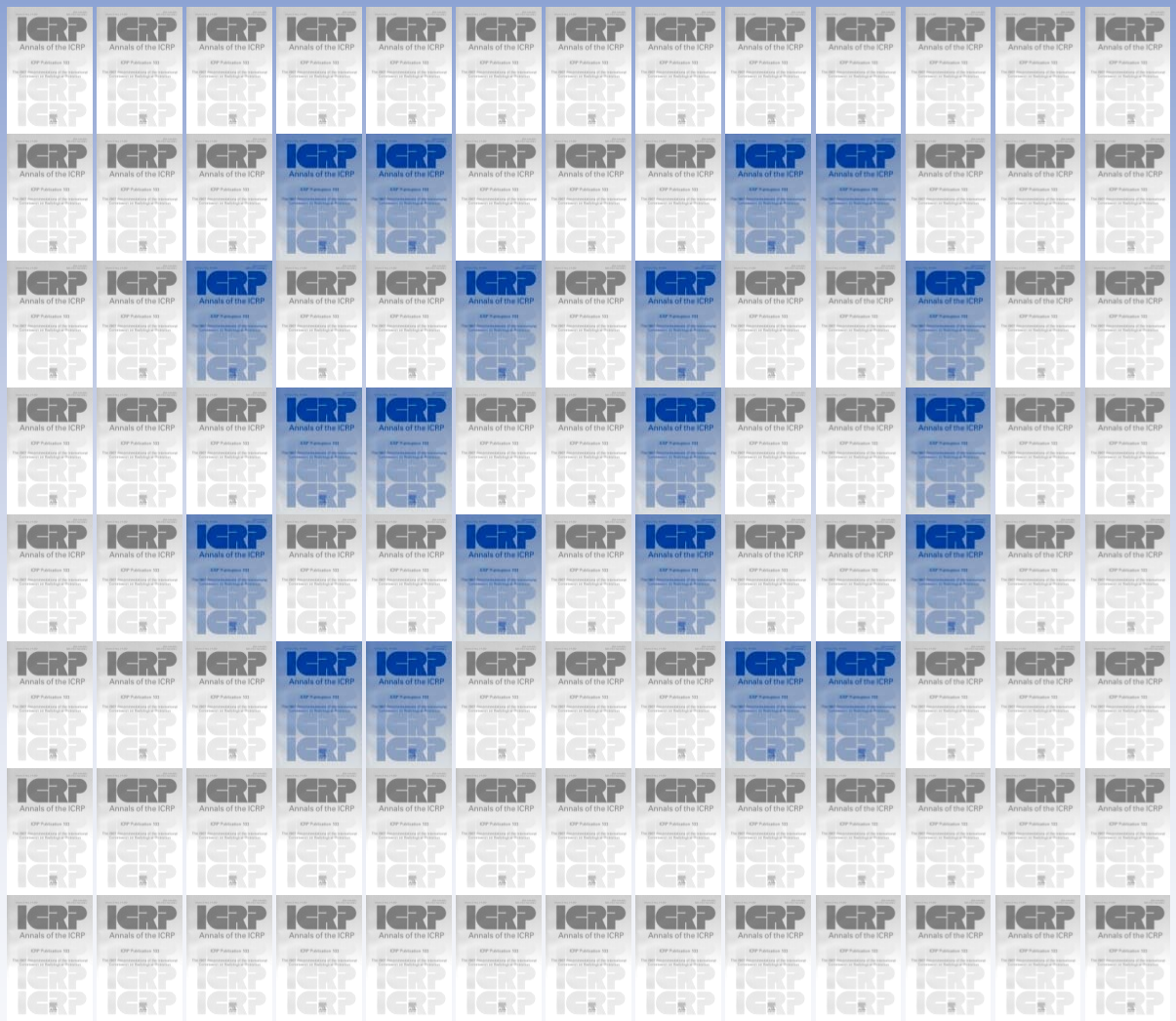
ICRP

International Commission on Radiological Protection

Report 2006-2008



80 Years of Radiological Protection

ICRP Report 2006-2008 *revision 1*
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CHAIRMAN'S FOREWORD

The ICRP Main Commission and all Committees achieved an important milestone in late 2007 with the approval of the *2007 Recommendations of the International Commission on Radiological Protection* (ICRP Publication 103). This marked the end of a major effort spanning nearly a decade, and the most extensive public consultation undertaken to date by ICRP. There were two rounds of formal world-wide consultation, aided by several international agencies including the Nuclear Energy Agency of the Organisation of Economic Cooperation and Development who organised seven international workshops and performed four in-depth reviews of draft ICRP texts. The European Commission organised a similar workshop to debate the scientific issues in the Recommendations. Overall more than two thousand pages of comments were received, in addition to direct feedback received through the many workshops that I and other ICRP members attended.

We are extremely grateful to the many organisations, experts, and individual members of the public who have devoted so much of their time and experience to this effort. As acknowledged in the editorial of ICRP Publication 103, "We could not have done it without your help".

There is no doubt that this extensive consultation, although costly both financially and in terms of the time spent, has resulted in more robust and useful Recommendations. Moreover, the consultation process, which engaged hundreds of radiological protection professionals world-wide, sparked in-depth discussions on the system of radiological protection resulting in a broadening and deepening our collective understanding of the paradigm that will serve us all well.

We look forward to continuing open consultation, crucial for the future success of our reports.

The end of 2008 draws us close to the end of the current four-year term of ICRP membership. At the end of this term, on June 30, 2009, I will retire from ICRP to focus on other challenges. Being part of this highly renowned scientific organisation has

been one of the most interesting and challenging tasks during my entire career. Over the years, I have learnt so much from my participation in Committee 1 and from my twelve years on the Main Commission.

I am particularly proud and grateful for having had the privilege of leading the Commission during the last period of work with the 2007 Recommendations. It was sometimes a difficult task but always rewarding and stimulating.

The new Main Commission is well suited for the new challenges of ICRP. I am delighted that Claire Cousins will lead the Commission over the next four years. Her experience and leadership, together with the collective experience and skills of all members of the Main Commission and Committees, will ensure that ICRP continues to be the leading international organisation for radiological protection.

Many exciting challenges lie ahead for ICRP. There is much work to do describing the revised system of radiological protection, introduced in ICRP Publication 103, in more detail. More work is required to develop the computational phantoms described in Publication 103; many of the essential tools, such as dose conversion factors, need to be updated; further work is required to describe the system as it applies in planned, existing, and emergency exposure situations; application of the system of protection to the environment needs to be fully developed and described; and the list goes on.

In addition, ICRP must continue to respond to emerging needs of the radiological protection community. For example, the last several years have seen a significant increase in patient doses related primarily to a rapid rise in the number of CT scans performed worldwide, as well as increased doses from individual CT scans using new technologies. Radiological protection in medicine has been a major focus for ICRP since its inception, and has continued to be a focus in recent years. ICRP must retain this focus in the new term in response to the current trend in CT doses.

Not least of all, ICRP must continue to be aware of changes in both the science and social values that are the foundations of the system of radiological protection, to ensure that the system continues to remain relevant and practical, and continues to provide an appropriate level of protection.

Lars-Erik Holm
ICRP Chairman 2005-2009

THE INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION (ICRP)

The International Commission on Radiological Protection (ICRP) is the primary international body in protection against ionising radiation. ICRP is a registered charity and is thus an independent non-governmental organisation. It was formed in 1928, by the International Congress of Radiology, as the 'International X-ray and Radium Committee', to advance for the public benefit the science of radiological protection.

ICRP adopted its present name in 1950 to reflect its growing involvement in areas outside that of occupational exposure in medicine, where it originated.

The ICRP provides recommendations and guidance on protection against the risks associated with ionising 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.

ICRP is an independent Registered Charity established to advance for the public benefit the science of radiological protection, in particular by providing recommendations and guidance on all aspects of protection against ionising radiation

BROAD STRUCTURE

ICRP consists of the Main Commission, Committee 1 (Radiation Effects), Committee 2 (Doses from Radiation Exposure), Committee 3 (Protection in Medicine), Committee 4 (Application of ICRP Recommendations), since 1 July 2005, Committee 5 (Protection of the Environment), ad hoc Task Groups and Working Parties, and the Scientific Secretariat.

MEMBERSHIP

The Main Commission consists of twelve members and a Chair, while the Committees contain some 15 members each (except Committee 5 which is somewhat smaller).

The Commission and its Committees run for four-year periods, from July 1st. On each occasion of a new period, at least three, and not more than five, members of the Commission must be changed. A similar rate of renewal is sought for the Committees. The current period runs from 2005 July 1st to 2009 June 30th.

MEETINGS

The Commission normally meets once or twice a year. Each Committee meets once a year. At least twice in each four-year period the annual meeting of the Committees is conducted jointly and together with the Commission.

FINANCING

The activities of ICRP are financed mainly by voluntary contributions from national and international bodies with an interest in radiologi-

cal protection. (A list of the bodies providing such contributions is included later in this report). Some additional funds accrue from royalties on ICRP Publications. Members' institutions also provide support to ICRP by making the members' time available without charge and, in many cases, contributing by covering their costs of attending ICRP meetings.

Mode of Operation

The Commission uses Task Groups and Working Parties to deal with specific areas. Task Groups are formally appointed by the Commission to perform a defined task, usually the preparation of a draft report. A Task Group usually contains a majority of specialists from outside the Commission's structure. It is funded as necessary from monies available to ICRP.

The first fundamental recommendations were produced in 1928, when ICRP was called the IXRPC (International X-ray and Radium Protection Committee)

Working Parties are set up by Committees to develop ideas, sometimes leading to the establishment of a Task Group. The membership of a Working Party is usually limited to Committee members. Working Parties receive no funding of their own, i.e. they operate primarily by correspondence and by meetings in direct conjunction with meetings of the Committee concerned.

These activities are co-ordinated with a minimum of bureaucracy by a Scientific Secretary, ensuring that ICRP recommendations are promulgated.

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 four-tier structure described provides a rigorous Quality Management system of peer review for the production of ICRP Publications.

Furthermore, before draft ICRP reports are approved for publication, they are regularly circulated to a number of bodies and individual experts, and posted for public consultation on the Internet.

Objective

In preparing its recommendations, the Commission considers the fundamental principles and quantitative bases on which appropriate radiation protection measures can be established, while leaving to the various national protection bodies the responsibility of formulating the specific advice, codes of practice, or regulations that are best suited to the needs of their individual countries.

The primary aim of the Commission's Recommendations is to contribute to an appropriate level of protection for people and the environment against the detrimental effects of radiation exposure without unduly limiting the desirable human actions that may be associated with such exposure.

This aim cannot be achieved solely on the basis of scientific knowledge on radiation exposure and its health effects. It requires a model for protecting humans and the environment against radiation. The Recommendations are based on scientific knowledge and on expert judgement. Scientific data, such as those concerning health risks attributable to radiation exposure, are a necessary prerequisite, but societal and economic aspects of protection have also to be considered. All of those con-

cerned 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, radiological protection is not different from other fields concerned with the control of hazards. The Commission believes that the basis for, and distinction between, scientific estimations and value judgements should be made clear whenever possible, so as to increase the transparency, and thus the understanding, of how decisions have been reached.

THE WORK PROGRAMME OF ICRP AND ITS COMMITTEES

THE MAIN COMMISSION AND THE SCIENTIFIC SECRETARIAT

Main Commission Members in Berlin, 2007

The Main Commission is responsible for management and oversight of all of the work of the Committees, and approval of all ICRP publications. The sections that follow, each focusing on one of the five ICRP Committees, describes this work in detail.

Main Commission members and the Scientific Secretary continued to play a key role in the dissemination of information beyond the Annals of the ICRP, through presentations and discussions at many seminars, meetings, conferences, workshops and other fora. During this period many, but not all, of these focused on the *2007 Recommendations of the Internationals Commission on Radiological Protection*.

Thus, contacts were held and continued with the International Atomic Energy Agency (IAEA), the International Commission on Radiation Units and Measurements (ICRU), the International Radiation Protection Association (IRPA), the International Society for Radiology, the OECD Nuclear Energy Agency (OECD-NEA), the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and many other organisations.

ICRP also continued its relationship with the International Electrotechnical Commission (IEC) and the International Standards Organization (ISO), primarily through exchange of draft reports and information. On a number of occasions when ICRP was unable to send a formal representative, we arranged to obtain observers' reports so as to keep abreast with developments.

During 2006-2008, the Scientific Secretariat continued to be situated in Stockholm, Sweden. The seat of ICRP remains in the United Kingdom where ICRP is a Registered Independent Charity.

Tasks of the Secretariat included preparations for and organisation of meetings, final editing of reports for publication in the Annals of the

ICRP, maintenance of contacts with all collaborating organisations, and administrative issues. The Secretariat also devoted an increasing part of its efforts to running the ICRP Internet web site. Apart from providing general information about ICRP, the web site has proved particularly useful when ICRP wants to consult on its own draft documents

As usual, there was also a brisk demand for informal enlightenment and information via telephone, e-mail, and regular mail to the Secretariat.

The current four-year ICRP term of membership ends on June 30, 2009. Thus, new members of the Main Commission and Committees were elected at the November 2008 meeting of the Main Commission in Buenos Aires (coinciding with the 12th International Congress of the International Radiation Protection Society).

In the term beginning July 1, 2009 Dr. Claire Cousins, consultant vascular radiologist at Addenbrooke's Hospital, UK, will serve as the 12th ICRP Chair since 1928, taking over from Dr. Lars-Erik Holm who served for the last two terms and is now retiring from ICRP service. Dr. Cousins is a member of the British Institute of Radiology Radiation Protection Committee and a guest member of the European Society of Radiology Radiation Protection Committee.

Dr. Abel González will serve as Vice-Chair. He succeeds Dr. Roger Cox who will continue to serve ICRP as a member of Committee 2. At the same time four new Main Commission members were elected: Professor Eliseo Vañó (Complutense University, Spain) as Committee 3 Chair, Dr. Jacques Lochard (CEPN France) as Committee 4 Chair, Dr. John Cooper (UK HPA), and Dr. Ohtsura Niwa (NIRS, Japan). Many new Committee and Task Group members were also elected.

As well, Dr. Jack Valentin announced his retirement after a long and distinguished career, the last decade of which has been as ICRP Scientific Secretary. Christopher Clement was formally introduced to the Main Commission at their November 2008 meeting as the new Scientific Secretary of ICRP, the 5th since the position became full-time in 1962. Mr. Clement began employment with ICRP on December 1, 2008, to officially take on the role of Scientific Secretary as of January 1, 2009. Dr. Valentin continued working part-time to aid in the transition.

ICRP Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection

The primary focus of the Main Commission, Secretariat, and all Committees during this period was the completion of the *2007 Recommendations of the International Commission on Radiological Protection* (ICRP Publication 103), approved at the Main Commission in October 2007. The final rounds of the extensive public consultation required considerable effort and resulted in approximately 1200 pages of comments. All of these comments were reviewed in detail, resulting in substantive improvements to the text.

The Main Commission, Secretariat, and all Committees played significant roles in the development of ICRP Publication 103.

Annex A of Publication 103 summarises all Committee 1 judgements since 1990 relating to the health effects of radiation, in order to underpin the New Recommendations. In many of the areas considered, Committee 1 had already provided specific judgements, e.g. on risk of multifactorial diseases (Publication 83) and on Relative Biological Effectiveness of different radiations (Publication 92). However, the revision of judgements on the induction of

tissue reactions, on the nominal risk coefficients for cancer and heritable disease, the transport of cancer risk between different populations, and on the choice of tissue weighting factors, required much additional work.

An additional feature is the extent to which the accumulation of epidemiological and biological knowledge since 1990 has served to strengthen some of the judgements made in Publication 60 or, in some cases, led to a revision in procedures for risk estimation. In spite of the detailed nature of these gains in knowledge the principal objective of this report is the provision of broad judgements for practical purposes of radiological protection. The primary risk of radiation-induced cancer is now based upon incidence data rather than the information on fatal cancer risks, as was used in Publication 60, because of improved data from the extended follow-up of the atomic-bomb survivors in Japan. Overall, however, when assessing total radiation detriment there is little difference from that given in Publication 60, reflecting little change in the assessment of the overall risk of radiation-induced cancer.

There is, however, an increase in the risk of breast cancer that is based upon incidence in the A bomb survivors and some medically exposed groups. The risk estimate for hereditary disease is decreased because multifactorial diseases are now judged to contribute less than previously assumed, and because the overall estimate is now based upon estimates of effects in the first two generations rather than in all future generations. The dose response for both cancer and hereditary effects, at low doses, continues to be based upon the assumption of a simple proportional relationship between dose and risk (i.e. the linear non-threshold, LNT, model). Also, a dose and dose rate effectiveness factor (DDREF) of 2 continues to be used for assessing risks at low doses from risks obtained in populations exposed at high doses. The radiation weighting factor w_R for protons was reduced from 5 to 2, and the value for neutrons was revised to be a continuous function of neutron energy. New information on the risk of cancer in different tissues and of the treatment of hereditary disease given in Publication 60 resulted in some changes to tissue weighting factors w_T for individual organs and tissues, with the main changes being an increase for the breast and a decrease for the gonads (based on the lower heritable risk).

For the 2007 Recommendations, Committee 2 was responsible for the preparation of Chapter 4 and Annex B, both entitled: Quantities used in Radiological Protection. Explanation is given of the calculation and intended application of the protection quantities, equivalent and effective dose.

Annex B provides a detailed discussion of the ICRP protection quantities and their application in radiological protection in the assessment and limitation of doses resulting from external and internal exposures. It explains the basis for and use of radiation weighting factors in the calculation of equivalent dose to organs and tissues and discusses the use of age- and gender- averaged tissue weighting factors, derived by Committee 1, in the calculation of effective dose. The document also discusses the relationship between these quantities and operational quantities used in dose monitoring and assessment. Doses calculated using ICRP methodology are single-valued, based on calculations for reference individuals, although in practice there is variation between individuals and uncertainties in the assumptions made in calculating dose. The document discusses sources of uncertainty and limitations on the use of ICRP protection quantities.

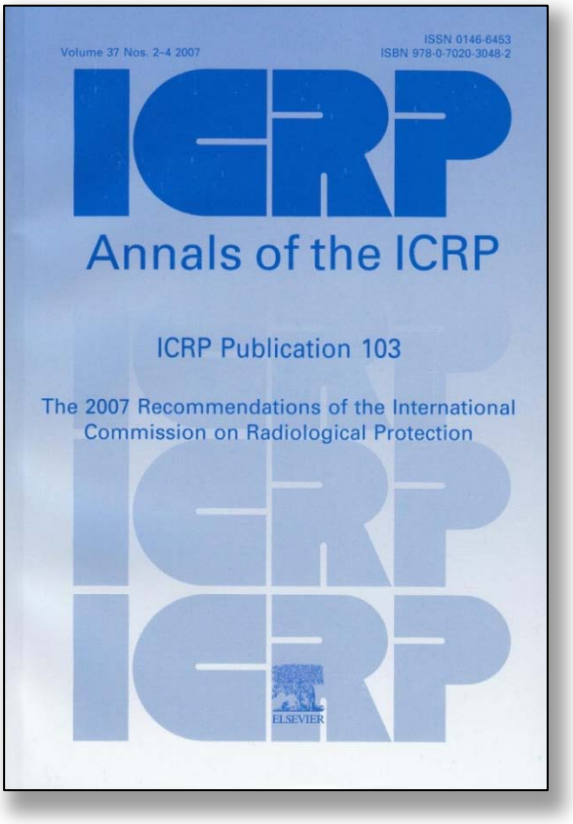
There are some changes to the recommended radiation weighting factors, w_R, used in the calculation of equivalent dose. In particular a continuous energy function is to be given for neutrons (with some change in the function

above 1 MeV from that given in Publication 92) and the w_R for protons is to be reduced from 5 to 2. For low-LET x-rays and gamma rays as well as tritium, the w_R will continue to be one and the value for alpha particles remains at 20.

Committee 3 used many of its recent publications on medical aspects of radiological protection to compile the Foundation Document for the 2007 Recommendations resulting in the separate Publication 105, "Radiological Protection in Medicine". This Task Group was chaired by Marvin Rosenstein.

Committee 4 supported the work of the Main Commission on the new Recommendations leading to their publication in 2007 (Publication 103). The dialogue with the observer organisations was of particular importance since agencies have been working towards revision of the international (under the auspices of IAEA) and regional (EURATOM) Basic Safety Standards in line with the new ICRP recommendations.

As a result of Committee 5's early deliberations the ICRP, in its 2007 Recommendations, considered it appropriate to broaden its overall scope in order to address directly the subject of protection of the environment, and thus to include in its general aims those of preventing or reducing the frequency of deleterious radiation effects in the environment to a level where they would have a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities, and ecosystems. The Commission also stated that it believed that its approach to environmental protection should be both commensurate with the overall level of risk, and thus optimised, and that it should be compatible with other approaches being made to protect the environment. A brief separate chapter on environmental protection was included for the first time.



COMMITTEE 1 (RADIATION EFFECTS)

Committee 1 has the responsibility for maintaining under review the biological effects of ionising radiation and developing documents that relate such effects to the needs of radiological protection. The members offer experience in epidemiology, statistics, medical sciences, animal sciences, cell and molecular biology, biophysics and genetics. The committee covers issues of tissue reactions, risks of cancer and heritable diseases including dose responses, effects of dose-rate and radiation quality, effects in the embryo/foetus and genetic factors in radiation response, as well as uncertainties in providing judgements on radiation-induced health effects. The committee advises the Main Commission on the biological basis of radiation-induced health effects and how epidemiological, experimental and theoretical data can be combined to make quantitative judgements on health risks to humans, particularly at low doses.

Committee 1 Members in Berlin, 2007

The major work of the committee in 2006-8 was to complete Annex A of the New ICRP Recommendations (as described previously), initiate three Task Groups on areas of concern identified in the draft Recommendations, review on an annual basis the activities of other organisations involved in radiation risks (e.g. UNSCEAR, NCRP, DOE, RERF) as well as the various topics of epidemiology, exposure and dosimetry, DDREF, radiobiology, germ cells and heritable effects, epigenetic effects, DNA repair and non-targeted effects.

Task Group 63 on Tissue Reactions and Non-cancer Effects

Chair: Dr. Fiona Stewart

This Task Group is reviewing tissue and health effects of ionising radiation at high doses, with particular reference to their implications for dose limits in radiation protection and for assessing health risks after accidental or therapeutic exposure. This entails a major update of ICRP publication 41 (1984), with special reference to those tissues and organs that are considered to be most important, based on an analysis of the relevant clinical and laboratory data. Apart from a general chapter on the principles of tissue response, dose-rate, fractionation and LET effects, there are specific chapters on the haematopoietic, digestive, reproductive, cardiovascular, musculoskeletal, endocrine and nervous systems, the eye, the skin and the urinary tract. In particular, there is inclusion of new data on the risk of radiation-induced cataracts and cardiovascular effects, which are suggesting lower threshold doses than previously considered. The influence of potential modifiers of the inherent radiation

sensitivity of normal tissues is also being considered, with respect to compounds that either exacerbate or ameliorate radiation injury. The increasing evidence for such modification has led to a change in terminology from 'deterministic effects' to 'tissue reactions'. The report is hoped to be completed for publication in 2010.

Task Group 64 on Alpha Emitters

Chair: Dr. Margot Tirmarche

This Task Group is considering exposure to radon in homes and in the mining environment, occupational exposures of Mayak and other workers to the clinical use of Thorotrast and the occupational and clinical use of radium. For radon, a review is nearing completion on lung cancer risk in relation to domestic exposure as well as recently published data coming from uranium miners focusing on relatively low annual exposure rates. In both situations results are available through large international joint analyses. Pooled epidemiological studies of residential radon exposures in Europe, North America and China have provided good evidence of increase in lung cancer risk in relation to accumulated domestic radon exposure, both for smokers and non smoker populations. A significant increase was observed at levels down to below 200 Bq m^{-3} in the European pooling. These data provide the basis for the control of radon exposures in homes on the basis of direct evidence of lung cancer risks. The report will be prepared in collaboration with members of Committee 2.

Task Group 75 on Stem Cell Biology in relation to Carcinogenic Radiation Risk

Chair: Dr. Ohtsura Niwa

The purpose of the Task Group is to review stem cell biology and radiobiology with reference to mechanisms of radiation carcinogenesis. There are chapters on the general feature of stem cells, stem cells in relation to the risk of prenatal irradiation, haematopoietic tissue, mammary gland, thyroid, digestive tract, lung, skin, and bone. Each chapter discusses carcinogenesis, radiation qualities, general features of tissues and target cells, tissue turnover rate, radiosensitivity and mutagenesis. The report is intended to compare the response of stem and associated cells in different tissues with the respective risks of cancer, and to elucidate the likely stem cell role. Finally, to use knowledge of stem cell responses and carcinogenic risks from homogeneous acute irradiations, to project stochastic risks for short-range radiations and chronic irradiation scenarios.

Publications 2006-2008

- Publication 99: Low dose extrapolation of radiation-related cancer risk
- Publication 100: Human Alimentary Tract Model for Radiological Protection (with Committee 2)
- Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection, Annex A: Biological and Epidemiological Information on Health Risks Attributable to Ionising Radiation: A Summary of Judgements for the Purposes of Radiological Protection of Humans

Planned Publications

- Tissue Reactions and Non-cancer Effects of Ionising Radiation Exposure
- The Risks of Alpha Emitters
- Stem Cell Biology in relation to Carcinogenic Radiation Risk

COMMITTEE 2 (DOSES FROM RADIATION EXPOSURES)

Committee 2 is concerned with the development of dose coefficients for the assessment of internal and external radiation exposure of workers and members of the public, considering different situations of exposure. This work involves the development of reference biokinetic and dosimetric models, reference anatomical models of the human body, and reference anatomical and physiological data.

Committee 2 in St. Petersburg, 2008

Like the other Committees, a major focus has been on contributions to ICRP Publication 103 as already described.

Effective dose has been widely used in radiological protection and is a valuable quantity for demonstrating compliance with dose limits in relation to exposure to external radiation and intakes of radionuclides. It is not appropriate in all circumstances and guidance is given on where its use is not appropriate, for example in retrospective assessments of organ/tissue dose for epidemiological studies, in individual risk estimates after exposures above dose limits and especially after exposures to high radiation doses. The need for further guidance is recognised and a Task Group will be set up to consider the use of effective dose for different applications.

The new recommendations have necessitated the recalculation of dose coefficients for exposure to external and internal sources of radiation. In addition to changes in radiation and tissue weighting factors, these calculations will, for the first time, be performed using reference anatomical models. Other improvements will also be made to dosimetric models and to the biokinetic models used to represent the behaviour of radionuclides in the body following intakes by inhalation or ingestion.

Task Group 4 on Dose Calculations (DOCAL)

Chair: Prof. Wesley Bolch (previously Dr. Keith Eckerman)

DOCAL is responsible for developing methods for the calculation of doses from both external and internal sources of radiation. A report has now been finalised as Publication 107: Nuclear Decay Data for Dosimetric Calculations, providing a replacement for Publication 38. It consists of an explanatory text, with an accompanying CD that provides data on the radiation emissions of 1252 radioisotopes of 97 elements. A report is also nearing completion on reference anatomical models for the adult male and female. These voxel-based computational phantoms, based on segmented tomographic images, will replace the stylised phantoms used previously in organ and tissue

dose calculations for external and internal radiations. Publication 110 will include a CD which will provide data to enable dose calculations to be performed with the reference models; annexes will give example dose calculations. Work is also in progress to improve the calculation of doses to regions within the skeleton that represent targets for the induction of bone cancer and leukaemia. Reference models for children will also be developed. The new models will be used in the calculation of revised dose coefficients for exposures to external radiation and intake of radionuclides. Work is in progress on a replacement for Publication 74, giving revised conversion coefficients for protons, pions, muons, and helium ions as well as neutrons, photons and electrons / positrons.

Task Group 21 on Internal Dosimetry (INDOS)

Chair: Dr. John Harrison (previously Dr. John Stather)

INDOS is responsible for developing biokinetic models for radionuclides entering the body by inhalation or ingestion and, working with DOCAL, prepares reports on doses from radionuclide intake by workers and members of the public. Work is in progress to replace Publications 30 and 68 that give biokinetic data and dose coefficients for occupational intakes of radionuclides by inhalation and ingestion, and Publications 54 and 78 that give information for bioassay interpretation, with a single series of publications. The new ICRP model of the human alimentary tract, Publication 100, will be used and revisions will be made to the Human Respiratory Tract Model. Consideration is being given to a separate report on intakes of radionuclides through wounds, following publication of a wound model by the US National Council on Radiation Protection and Measurements (NCRP). Doses will be calculated using revised nuclear decay data and new anatomical models (see Task Group on Dose Calculations, DOCAL).

Task Group 67 on Radiation Exposures of Astronauts in Space

Chair: Prof. Günther Dietze

This Task Group was set up in 2005 to assess exposures from the complex radiation fields encountered in space, which include high energy particles with unique high LET components, very different from radiation fields on earth. The report will focus on giving data on doses from exposure to the different radiation types encountered in space. With support from the DOCAL Task Group, the new ICRP reference anatomical models will be used to calculate absorbed dose coefficients for organs and tissues of the human body. These data, together with information on radiation field parameters outside and inside the vehicle, will be used to assess the correlation between dosimeter readings and values of the protection quantities.

Committee 2 also provides members for Task Groups of other committees: Committee 1 Task Group on epidemiology relating to exposures to alpha-emitting radionuclides; Committee 1 Task Group on stem cell radiobiology; Committee 3 Task Group on doses from radiopharmaceuticals; and the Committee 5 Task Group on radiation effectiveness factors for non-human biota.

Publications 2006-2008

- Publication 100: Human Alimentary Tract Model for radiological protection
- Publication 107: Nuclear Decay Data for Dosimetric Calculations

Planned Publications

- Publication 110: Computational reference phantoms for the adult male and female
- Dose Conversion Coefficients for External Radiation Source (ICRP / ICRU)
- Radiation Exposures of Aircrew: DOCAL (ICRU / ICRP)
- Radiation Protection Dosimetry in Space
- Internal SAF Values for the Reference Adult Male and Female
- Computational Phantoms for the Infant and Children
- Computational Phantoms for the Pregnant Female, Embryo, and Foetus
- Internal SAF Values for Embryo, Foetus, Children and Pregnant Female
- Occupational Intakes of Radionuclides Part 1
- Public Exposures to Radionuclides
- Radionuclides in Wounds
- Occupational Intakes of Radionuclides Parts 2 and 3
- Doses to the Embryo, Foetus, and Nursing Infant

COMMITTEE 3 (PROTECTION IN MEDICINE)

Committee 3 is concerned with protection of persons and unborn children when ionising radiation is used for medical diagnosis, therapy, or for biomedical research; also, assessment of the medical consequences of accidental exposures.

Committee 3 Members in Berlin, 2007

During 2006 – 2008, Committee 3 had meetings in San Francisco (2006), Berlin (2007) with the Main Commission and other Committees, and Mallorca (2008).

Committee 3 continued to highlight focussed aspects of radiological protection relevant to medicine with ongoing task groups and working parties as described below.

Task Group 70 on Avoiding Radiation Therapy Accidental Exposures when Using New Technologies

Chair: Dr. Pedro Ortiz Lopez

The rapidly evolving technology in this field requires new guidance on accidental exposures and hence an update of Publication 86 is appropriate. The title of this document has been changed to "Minimizing unintended exposures in radiation therapy from new technologies". This is an advanced document and only minor changes were proposed by the members of the Committee. The document was presented to the Main Commission in October 2008 and following consultation will be published in 2009.

Working Party on Evaluation and Management of Secondary Cancer Risk in Radiation Therapy (with special reference to modern techniques)

Chair: Prof. Jean-Marc Cosset

This is a project performed in collaboration with ICRU and a considerable amount of emerging data is being analysed for compilation of this report. It is hoped the work can be completed during 2009.

Task Group 62 on Radiation Protection for Cardiologists Performing Fluoroscopically Guided Procedures

Chair: Dr. Claire Cousins

This rapidly expanding field of medicine both in numbers and complexity requires guidance

for the practitioners. The title of the document was modified to "Radiological Protection in Cardiology" and the document will be extended to include cardiac CT and nuclear medicine imaging with completion in 2009.

Working Party on Protecting Children: Diagnostic Techniques Involving Ionizing Radiation

Chair: Dr. Hans Ringertz

It is important to emphasise that in the field of radiological protection, children cannot simply be treated as small adults and specific guidance is required. This working party continues to develop the document which it is anticipated can be completed during 2009.

Working Party on avoiding adverse radiation effects to doctors performing fluoroscopy guided procedures

Chair: Prof. Madhan Rehani

Many medical specialists now use ionising radiation as part of their practice and this is often performed with little or no knowledge of radiation effects. Areas to be addressed and which specialties to include were discussed by Committee 3 and the decision was made to proceed to a Task Group on this topic.

Working Party on Radiological protection training for medical professionals performing diagnostic and interventional procedures and for medical students

Chair: Prof. Eliseo Vañó

This is a complex and broad task to address with issues varying between countries and departments. Committee 3 decided to appoint a couple of new members to the working party and then take this forward as a Task group in 2009.

Committee 3 has also been working with Committees 2 and 4 as a working party on the use of effective dose (Committee 3 members M Rosenstein and P Ortiz). It is recognised that further guidance is necessary, including in medicine, and a Task group will be established to further this work.

Publications 2006-2008

Completed work during this time led to three ICRP Publications. The changing technology of computed tomography and rapid introduction of multi-detector scanners produced many challenges for the radiological protection of patients. An update of Publication 87 was required and Madan Rehani chaired the Task Group on "Managing Patient Dose in Multi-Detector Computed Tomography", which was published as Publication 102.

The continuing work of Committees 2 and 3 on "Radiation Dose to Patients from Radiopharmaceuticals", chaired by Sören Mattsson resulted in Publication 106. There is an appropriate annexe in this publication entitled "Radiation exposure of hands in radiopharmacies : monitoring of doses and optimisation of protection", led by Julian Liniecki, which highlights a common practical issue and includes original work by the authors.

- ICRP Publication 102: Managing Patient Dose in Multi-Detector Computed Tomography (MDCT)
- ICRP Publication 105: Radiological Protection in Medicine
- ICRP Publication 106: Radiation Dose to Patients from Radiopharmaceuticals: Addendum 3 to ICRP Publication 53

Proposed Areas of Work

- Follow up of persons accidentally exposed

- Radiological protection in radiation therapy with protons and heavy ions
- Widening the use of reference levels for interventional radiology, digital radiology and new technology
- Occupational protection in brachytherapy
- Dose reduction resulting from new imaging technology
- Screening with ionising radiation in asymptomatic individuals
- Protection in PET (PET/CT) and cyclotrons

Committee 3 continues to have close links with other organisations and many members of Committee 3 have been involved in both organising and lecturing at national and international meetings on radiological protection to increase awareness of the work of ICRP related to medicine.

COMMITTEE 4 (APPLICATION OF THE COMMISSION'S RECOMMENDATIONS)

ICRP Committee 4 has the responsibility to consider the practical application of the Commission's recommendations. The Committee also acts as a major point of contact between the ICRP structure and other international organisations and professional bodies concerned with protection against ionising radiation.

Committee 4 Members in Berlin, 2007

Committee 4 counts 16 members in the 2005-2008 membership, as well as 9 observers (EC, IAEA, IEC, ILO, IRPA, ISO, NEA, UNSCEAR, WHO) under the chairmanship of Annie Sugier and with Jean-François Lecomte as Secretary. Much of the program of work of Committee 4 during the years 2006 to 2008 was closely connected to the finalization of the new recommendations (Publication 103) and the relevant building blocks as well as their application in specific types of exposure situations.

Each member of Committee 4 is assigned specific responsibilities such as Vice-chair, Secretary, Chair of a TG, member of a WP, drafter of a discussion paper or critical reviewer of a draft report of the Committee.

Publication 101

Two building blocks completing Publication 103 were of the responsibility of Committee 4: on Optimisation and on the Representative Individual. The corresponding reports were completed and approved by the Main Commission in Bern in 2005. They were published in one document (Publication 101 – 2006). The first part of the issue is the report on assessing doses to representative persons. It concerns a classical problem: to ensure that members of the public are adequately protected. The second part is devoted to broadening the process of optimisation. It is a consolidation and an evolution of the Commission's recommendations concerning the optimisation principle which is at the very heart of successful radiological protection.

Publication 104

Committee 4 also discussed the document on the scope of radiological protection regulations issued in 2007 as Publication 104. It provides advice for determining the radiation exposure situations that should be covered by the relevant regulations based on justification of their regulatory control and, conversely, those that may be considered for exclusion from the regulations because the situation is deemed unamenable to regulatory control or the regulatory control is unjustified.

Two reports on the application of the new recommendations in specific situations have been developed during 2005 to 2008 for publication in 2009.

Task Group 65 on the application of the Commission's Recommendations for the protection of the populations during nuclear or radiological emergencies

Chair: Dr. Wolfgang Weiss

A report has been prepared by this Task Group to provide advice on the application of Publication 103 including the preparedness for, and response to, radiation emergency exposure situations. It deals with the recommendations related to such exposure situations in the Publication 103 which re-state the principles of justification and optimisation, the requirement to protect against severe deterministic injury. It recommends that appropriate reference levels should be set in the band of typically 20 to 100 mSv effective dose (acute or in a year), emphasising that protection against all exposures, above or below the reference level, should be optimised.

The report recommends that more complete protection be achieved by simultaneously considering all exposure pathways and all relevant protection options when deciding on the optimum course of action in the context of an overall protection strategy. Such an overall protection strategy must be justified, resulting in more good than harm. In order to optimise an overall strategy, it is necessary to identify the dominant exposure pathways, the timescales over which components of the dose will be received, and the potential effectiveness of individual protective options.

The report also recommends that, in both planning and in the event of an emergency, decisions to terminate protective measures should have due regard to the appropriate reference level. The change from an emergency exposure situation to an existing exposure situation is based on a decision by the authority responsible for the overall response.

The report explains that this transition may happen at any time during an emergency exposure situation and that it may take place at different geographical locations at different times. The report also recommends that this transition should be undertaken in a coordinated and fully transparent manner and understood by all involved parties. The report was approved by the Main Commission in October 2008 for publication.

Task Group 66 on the application of the Commission's Recommendations for the protection of populations living in contaminated territories after a nuclear accident or a radiological event

Chair: Dr. Jacques Lochard

A report has been prepared by this Task Group to provide guidance for the protection of individuals living in long-term contaminated areas resulting from either a nuclear accident or a radiological event. The report considers the effects of a nuclear accident or radiological event on the affected population. This includes the pathways of human exposure, the types of exposed populations and the characteristics of exposures. Although the focus is put on radiation protection, the report also recognises the complexity of the post-accident situations, which cannot be managed without addressing all the affected domains of daily life i.e. environmental, health, economic, social, psychological, cultural, ethical, political, etc.

The report explains how the new Commission's Recommendations apply to this type of existing exposure situation including consideration on the justification and the optimisation of protection strategies and the introduction and application of a reference level to drive the optimisation process. The report also consid-

ers practical aspects of the implementation of protection strategies, both by authorities and the affected population. It emphasises the effectiveness of involving directly the affected population and the local professionals in the management of the situation and the responsibility of authorities at both national and local levels to create the conditions and provide the means favouring the involvement and empowerment of the population. The role of radiation monitoring, health surveillance and the management of contaminated foodstuffs and other commodities are described in this context.

An appendix summarizes past experience with long-term contaminated areas resulting from radiological events and nuclear accidents including radiological criteria followed in carrying out remediation measures. The report was approved by the Main Commission in October 2008 for publication.

Task Group 76 on the application of the Commission's Recommendations to NORM (Naturally Occurring Radioactive Materials)

Chair: Dr. Peter Burns (previously Dr. Mary Clark)

This Task Group was approved by the Main Commission in Berlin in 2007. It's objective is to develop a conceptual framework that provides a link between the system of radiation protection (as described in Publications 103 and 104) and the detailed guidance required by international agencies and national authorities for the development of standards and guides related to management of risks due to NORM in an effective and optimised manner. The issue is complex as NORM activities may be managed either as planned or as existing exposure situations. A report containing recommendations on the processes that should be adopted in the management of NORM industry is scheduled to be presented to the Main Commission for approval in 2010.

Task Group 71 on protection principles for deliberate exposure for security and legal requirements

In 2007 the Main Commission approved the terms of reference of this Task Group to include situations involving deliberate exposure of individuals for security and legal requirements where the benefit is generally for other persons than the exposed individuals. After a dialogue with Committee 3 in 2006 and 2007, it was decided that the issue is mainly within the scope of Committee 4. In 2008, Committee 4 discussed what ICRP could do in addition to paragraph 210 of Publication 103 ("certain exposures should be deemed to be unjustified … unless there are exceptional circumstances") and concluded that complementary guidance may more usefully be provided by regulatory agencies. It was decided that Committee 4 should keep aware of developments related to this issue and raise it again if deviations were identified. Donald Cool was designated as Committee 4 observer.

Working Party on the application of the Commission's Recommendations to occupational exposure

Chair: Dr. Ann McGarry (previously Dr. Gustavo Massera)

This Working Party was created in 2007 to review the current status of occupational exposure in order to identify particular occupational exposure situations which would benefit from further guidance from ICRP. In 2008, Committee 4 considered a report prepared by CEPN (France) as an input for the WP, reviewing occupational exposures in the various sectors (nuclear industry, medical sector, NORM industry) and comparing the risk associated with ionising radiation exposures with other occupational risks. It was concluded that the WP would prepare a discussion paper providing more complete and consolidated data with, if relevant, proposals for further guid-

ance, and to discuss the paper with relevant stakeholders. Upgrading the WP to a TG is under consideration.

Working Party on ICRP International Outreach

Chair: Dr. Khammar Mrabit

The purpose of this WP, created in 2007, is to facilitate the application of ICRP Recommendations and further promote the dialogue between ICRP and relevant professionals. Due consideration is given to the improvement of the C4 web site, the development of a network of ICRP Focal Points among professionals particularly in developing countries, the development of a roster of "Experts on ICRP recommendations" (per theme and language) and the development of a "database" of standard presentations as well as lectures on ICRP recommendations and positions in different languages.

C4/C5 Working Party on the application of the Commission's recommendations to Releases of Radioactive Material in the Environment

Chair: Dr. Don Cool

The objectives of this Working party, created in 2007, are to investigate, in collaboration with Committee 5, the tools developed for protection of the environment in the context of the ICRP system of protection for man by looking at exposure scenarios where man is protected, and seeing what the predicted impact was on flora and fauna, and then comparing with the bands of protection suggested by Committee 5. The work is in progress.

C1/C2/C4 Working Party on the use of the quantity Effective Dose and of Dose Coefficients

Chair: Dr. John Cooper

Gathering members of Committees 2, 3 and 4, this WP was approved by the Main Commission in 2007. Considering the importance of the concept of effective dose in the radiological protection system, the objective of the WP is: 1) to provide guidance on when the quantity 'effective dose' should be used and when it should not, if possible with alternatives for situations where the quantity should not be used; 2) to provide guidance on the use of dose coefficients in estimating effective dose and on how to use foetal dose coefficients in comparisons with dose limits, constraints and reference levels, and; 3) to provide guidance on calculating the contribution of non-uniform skin exposure to effective dose.

The WP aims to provide a discussion paper in 2010. Meanwhile, the Main Commission has decided to upgrade the WP to a TG of the Main Commission chaired by John Cooper who will become member of the Main Commission for the next ICRP mandate.

Standing Working Party on Interface with other Committees

Chair: Dr. John Cooper

Committee 4 also set provisions for the interface with other Committees. A standing Working Party was formed to include Committee 4 members who follow the work of the other Committees: Michiaki Kai (C1), Peter Burns (C2), Wolfgang Weiss (C3), Kirsti-Liisa Sjöblom (C5).

COMMITTEE 5 (PROTECTION OF THE ENVIRONMENT)

Committee 5 is concerned with radiological protection of the environment. It will aim to ensure that the development and application of approaches to environmental protection are compatible with those for radiological protection of man, and with those for protection of the environment from other potential hazards.

Committee 5 Members in Berlin, 2007

Committee 5 first met in 2005 and immediately set to work on developing a basis for providing advice with regard to protection of the environment, following on from ICRP 91, which had concluded that a broader framework needed to be developed, and that it should be sufficiently flexible to be applied within the context of the many existing and varied global approaches to environmental management generally, and to environmental protection in particular. It had also concluded that such an approach should relate as closely as possible to the current system for human radiological protection, based on a clear understanding of the relationships between exposure and dose, and dose and effect, and that this objective could best be met by the development of a limited number of Reference Animals and Plants. The Committee also used, as its base material, the work of a second Task Group which had already been put out for public consultation, plus the responses that had been received. This work included a first consideration of the types of Reference Animals and Plants that could be used by the ICRP; the types of dose models relevant to them; the range of existing information on radiation effects for such types of organisms; how such an approach could be used for assessing and managing different levels of radiation exposure in non-human species; and how it could be harmonised with the Commission's existing approach to the protection of human beings.

One aspect that could clearly be advanced relatively quickly was that of bringing more rigour to the basic approach of modelling dosimetry. Committee 5 therefore established its own Task Group on Reference Animal and Plant dosimetric modelling, chaired by G. Pröhl, with the objectives of summarizing current modelling approaches and then, after selecting and justifying a preferred approach, using it to calculate a set of dose conversion factors with respect to external and internal exposure pathways. The results were incorpo-

rated into a more comprehensive report on the concept and use of Reference Animals and Plants. An initial draft of this report was discussed by the Main Commission in 2007 and then posted on the ICRP's web site for consultation in January 2008. Many valuable comments were received and these have been taken fully into account in the production of the final document which will be published (as ICRP 108) in 2009.

The report introduces the concept of Reference Animals and Plants, defines a small set of them, and discusses their pathways of exposure. It collates and discusses the adequacy of the best available data relating to their dosimetry, at different stages of their life cycle, and further develops and uses this information to derive sets of tabulated data (Dose Conversion Factors, in terms of μGy day^{-1} per Bq kg^{-1}) that allow the dose to be calculated for 75 radionuclides that may be within, or external to, each organism. It then reviews what is known about the effects of radiation upon such biotic types (or of organisms similar to them, where more precise data are lacking) and thus derives a set of Derived Consideration Reference Levels (DCRLs) for each biotic type in order to help optimise the level of effort that might be expended on the environmental protection of them, or to similar types of organisms. The various factors that should be taken into account when considering what to do if such DCRLs are attained or exceeded is also briefly discussed.

A Working Party was also set up, chaired by F Brechignac, to explore and examine the interface with, and relevance to, other approaches to environmental protection, in order to ensure that the Committee's approach is compatible with them, or justifiably different, and to advise with regard to the application of the ICRP approach to different exposure situations and different environmental management objectives.

Other issues currently being examined by Committee 5 are the derivation of a complementary set of environmental transfer factors relevant to modelling the exposure of Reference Animals and Plants under different exposure situations, the relevance or otherwise of the concept of radiation weighting factors and RBE to Reference Animals and Plants, and the need for more advanced dosimetry for some of the larger animals and plants.

Sadly one of the members of Committee 5, Dr. M Doi, died suddenly in 2006; he was succeeded by K. Sakai. The Committee is deeply indebted to the contributions made by Dr. Doi to this subject, and wishes to record its thanks and admiration for his contributions.

ICRP PUBLICATIONS 2006-2008

Ten reports were published in the Annals of the ICRP in 2006 – 2008:

- Publication 99: Low-dose Extrapolation of Radiation-related Cancer Risk;
- Publication 100: Human Alimentary Tract Model for Radiological Protection;
- Publication 101: Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public *and* The Optimisation of Radiological Protection: Broadening the Process *(two reports in one issue);*
- Publication 102: Managing Patient Dose in Multi-Detector Computed Tomography (MDCT);
- Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection;
- Publication 104: Scope of Radiological Protection Control Measures;
- Publication 105: Radiological Protection in Medicine;
- Publication 106: Radiation Dose to Patients from Radiopharmaceuticals (Addendum 3 to ICRP Publication 53); and,
- Supporting Guidance 5: Analysis of the Criteria Used by the International Commission on Radiological Protection to Justify the Setting of Numerical Protection Level Values.
- Publication 107: Nuclear Decay Data for Dosimetric Calculations.
- Publication 108: Environmental Protection: the Concept and Use of Reference Animals and Plants.

The latter two reports complete the 2008 publication year of the Annals of ICRP, but will be released in 2009.

Publication 99: Low-dose Extrapolation of Radiation-related Cancer Risk

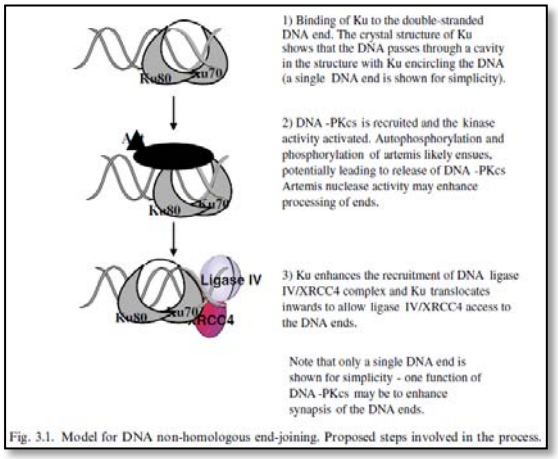


Fig. 3.1. Model for DNA non-homologous end-joining. Proposed steps involved in the process.

This report considers the evidence relating to cancer risk associated with exposure to low doses of low linear energy transfer radiation, and particularly doses below current recommended limits for protection of radiation workers and the general public. The focus is on evidence regarding linearity of the dose–response relationship for all cancers considered as a group, but not necessarily individually, at low doses [the so-called linear, non-threshold (LNT) hypothesis]. It looks at the possibility of establishing a universal threshold dose below which there is no risk of radiation-related cancer. The report is organised by scientific discipline, beginning with epidemiological studies of exposed human populations. Extrapolation of risk estimates based on observations at moderate to high doses continues to be the primary basis for estimation of radiation-related risk at low doses and dose rates. The fundamental role of radiation-induced DNA damage in the induction of mutations and chromosome aberrations provides a framework for the analysis of risks at low radiation doses and low-dose-rate exposures. Although cells have a vast array of damage

response mechanisms, these mechanisms are not foolproof, and it is clear that damaged or altered cells are capable of escaping these pathways and propagating. Cellular consequences of radiation-induced damage include chromosome aberrations and somatic cell mutations. Current understanding of mechanisms and quantitative data on dose and time–dose relationships support the LNT hypothesis. Emerging results with regard to radiation-related adaptive responses, genomic instability, and bystander effects suggest that the risk of low-level exposure to ionising radiation is uncertain, and a simple extrapolation from high-dose effects may not be wholly justified in all instances. However, although there are intrinsic uncertainties at low doses and low dose rates, direct epidemiological measures of radiation cancer risk necessarily reflect all mechanistic contributions including those from induced genomic instability, bystander effects, and, in some cases, adaptive responses, and therefore may provide insights about these contributions. Experimental approaches using animal models support the view that the response for early initiating events is likely to correspond to that for the induction of cytogenetic damage. On this basis, mechanistic arguments support a linear response in the low-dose region. Quantitative analyses of dose responses for tumourigenesis and for life shortening in laboratory animals also support this prediction. These studies also support a dose and dose rate effectiveness factor (DDREF) in the range of about 2 when data are extrapolated to low doses from effects induced by doses in the range of 2–3 Gy. A formal quantitative uncertainty analysis combines the different uncertain components of estimated radiation-related cancer risk with and without allowing for the uncertain possibility of a universal low-dose threshold. Unless the existence of a threshold is assumed to be virtually certain, the effect of introducing the uncertain possibility of a threshold is equivalent to that of an uncertain increase in the value of DDREF, i.e. merely a variation on the result obtained by ignoring the possibility of a threshold.

The report concludes that while existence of a low-dose threshold does not seem to be unlikely for radiation-related cancers of certain tissues, the evidence does not favour the existence of a universal threshold. The LNT hypothesis, combined with an uncertain DDREF for extrapolation from high doses, remains a prudent basis for radiation protection at low doses and low dose rates.

Publication 100: Human Alimentary Tract Model for Radiological Protection

In this report, the ICRP provides a new biokinetic and dosimetric model of the human alimentary tract to replace the Publication 30 model. The new human alimentary tract model (HATM) will be used together with the human respiratory tract model (HRTM) in future ICRP publications on doses from ingested and inhaled radionuclides.

The HATM is applicable to all situations of radionuclide intake by children and adults. It provides age-dependent parameter values for the dimensions of the alimentary tract regions, and associated transit times for the movement of materials through these regions. For adults, gender-dependent parameter values are given for dimensions and transit times. The default assumption is that radionuclide absorption takes place in the small intestine, but the model allows for absorption in other regions and for retention in or on tissues within the alimentary tract when information is available. Doses are calculated to target cells for cancer induction in the oral cavity, oesophagus, stomach, small intestine, and colon.

This report provides reviews of information on the transit of materials through the alimentary tract and on radionuclide retention and absorption. It considers data on health effects, principally in order to specify the target cells for cancer induction within the mucosal lining of the tract and to justify approaches taken to dose averaging within regions. Comparisons are made between doses calculated using the HATM and the Publication 30 model for examples of radionuclide ingestion for which absorption is assumed to occur in the small intestine alone. Examples are also given of the effect on doses of considering absorption from other regions and the effect of possible retention in the alimentary tract. This report also considers uncertainties in model assumptions and their effect on doses, including alimentary tract dimensions, transit times, radionuclide absorption values, and the location of targets for cancer induction.

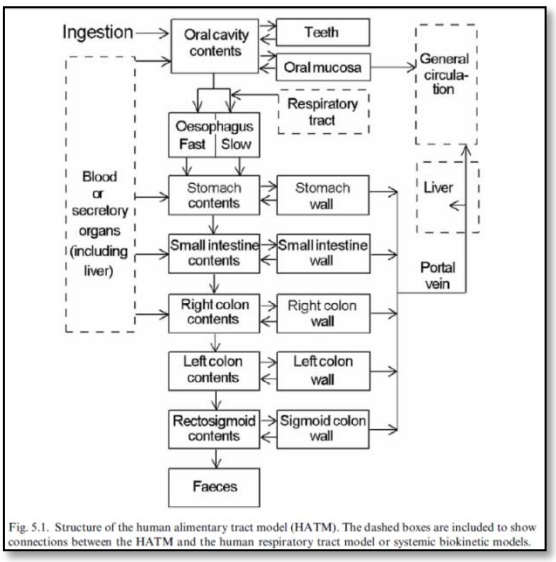


Fig. 5.1. Structure of the human alimentary tract model (HATM). The dashed boxes are included to show connections between the HATM and the human respiratory tract model or systemic biokinetic models.

Publication 101: Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public

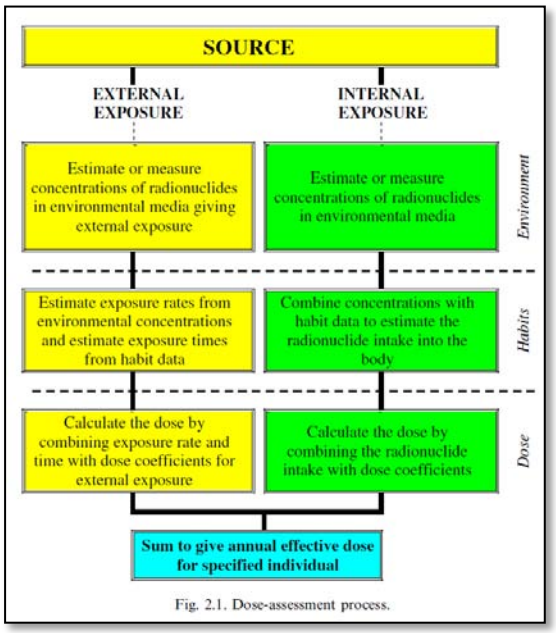


Fig. 2.1. Dose-assessment process.

The Commission intended that its revised recommendations should be based on a simple, but widely applicable, system of protection that would clarify its objectives and provide a basis for the more formal systems needed by operating managers and regulators. The recommendations would establish quantified constraints, or limits, on individual dose from specified sources. These dose constraints apply to actual or representative people who encounter occupational, medical, and public exposures. This report updates the previous guidance for estimating dose to the public. Dose to the public cannot be measured directly and, in some cases, it cannot be measured at all. Therefore, for the purpose of protection of the public, it is necessary to characterise an individual, either hypothetical or specific, whose dose can be used for determining compliance with the relevant dose constraint. This individual is defined as the 'representative person'. The Commission's goal of protection of the public is achieved if the relevant dose constraint for this individual for a single source is met and radiological protection is optimised.

This report explains the process of estimating annual dose and recognises that a number of different methods are available for this purpose. These methods range from deterministic calculations to more complex probabilistic techniques. In addition, a mixture of these techniques may be applied. In selecting characteristics of the representative person, three

important concepts should be borne in mind: reasonableness, sustainability, and homogeneity. Each concept is explained and examples are provided to illustrate their roles. Doses to the public are prospective (may occur in the future) or retrospective (occurred in the past). Prospective doses are for hypothetical individuals who may or may not exist in the future, while retrospective doses are generally calculated for specific individuals.

The Commission recognises that the level of detail afforded by its provision of dose coefficients for six age categories is not necessary in making prospective assessments of dose, given the inherent uncertainties usually associated with estimating dose to the public and with identification of the representative person. It now recommends the use of three age categories for estimating annual dose to the representative person for prospective assessments. These categories are 0–5 years (infant), 6–15 years (child), and 16–70 years (adult). For practical implementation of this recommendation, dose coefficients and habit data for a 1-year-old infant, a 10-year-old child, and an adult should be used to represent the three age categories.

In a probabilistic assessment of dose, whether from a planned facility or an existing situation, the Commission recommends that the representative person should be defined such that the probability is less than about 5% that a person drawn at random from the population will receive a greater dose. If such an assessment indicates that a few tens of people or more could receive doses above the relevant constraint, the characteristics of these people need to be explored. If, following further analysis, it is shown that doses to a few tens of people are indeed likely to exceed the relevant dose constraint, actions to modify the exposure should be considered.

The Commission recognises the role that stakeholders can play in identifying characteristics of the representative person. Involvement of stakeholders can significantly improve the quality, understanding, and acceptability of the characteristics of the representative person and the resulting estimated dose.

Publication 101: The Optimisation of Radiological Protection: Broadening the Process

The principle of optimisation of radiation protection is defined by the Commission as the source-related process to keep the magnitude of individual doses, the number of people exposed, and the likelihood of potential exposure as low as reasonably achievable below the appropriate dose constraints, with economic and social factors being taken into account. According to the revised recommendations of ICRP, this process of optimisation below constraint should be applied whatever the exposure situation; i.e. planned, emergency, and existing.

The previous recommendations for the practical implementation of the optimisation process are still valid. It must be implemented through an ongoing, cyclical process that involves the evaluation of the exposure situation to identify the need for action, the identification of the possible protective options to keep the exposure as low as reasonably achievable, the selection of the best option under the prevailing circumstances, the implementation of the selected option through an effective optimisation programme, and regular review of the exposure situation to evaluate if the prevailing circumstances call for the implementation of corrective protective actions. However, the way in which the optimisation process should be implemented is now viewed more broadly to reflect the increasing role of individual equity, safety culture, and stakeholder involvement in our modern societies.

This report is a consolidation and an evolution of the Commission's recommendations concerning the optimisation principle. After some background information on the foundation and evolution of the principle, this report describes the main characteristics of the process, addresses the issue of exposure distribution in that process, and provides the basic requirements for its application in operation and regulation. A description of decision-aiding techniques commonly used for practical implementation of the optimisation process is provided in Annex A of Publication 101.

Publication 102: Managing Patient Dose in Multi-Detector Computed Tomography (MDCT)

Computed tomography (CT) technology has changed considerably in recent years with the introduction of increasing numbers of multiple detector arrays. There are several parameters specific to multi-detector computed tomography (MDCT) scanners that increase or decrease patient dose systematically compared to older single detector computed tomography (SDCT) scanners.

This document briefly reviews the MDCT technology, radiation dose in MDCT, including differences from SDCT and factors that affect dose, radiation risks, and the responsibilities for patient dose management. The document recommends that users need to understand the relationship between patient dose and image quality and be aware that image quality in CT is often higher than that necessary for diagnostic confidence.

Automatic exposure control (AEC) does not totally free the operator from selection of scan parameters, and awareness of individual systems is important. Scanning protocols cannot simply be transferred between scanners from different manufacturers and should be determined for each MDCT. If the image quality is appropriately specified by the user, and suited to the clinical task, there will be a reduction in patient dose for most patients. Understanding of some parameters is not intuitive and the selection of image quality parameter values in AEC systems is not straightforward.

Examples of some clinical situations have been included to demonstrate dose management, e.g. CT examinations of the chest, the heart for coronary calcium quantification and non-invasive coronary angiography, colonography, the urinary tract, children, pregnant patients, trauma cases, and CT guided interventions. CT is increasingly being used to replace conventional x-ray studies and it is important that patient dose is given careful consideration, particularly with repeated or multiple examinations.

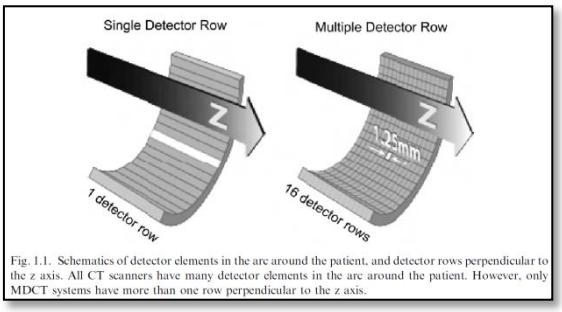


Fig. 1.1. Schematics of detector elements in the arc around the patient, and detector rows perpendicular to the z axis. All CT scanners have many detector elements in the arc around the patient. However, only MDCT systems have more than one row perpendicular to the z axis.

Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection

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 reinforce 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.

Publication 104: Scope of Radiological Protection Control Measures

In this report the Commission recommends approaches to national authorities for their definition of the scope of radiological protection control measures through regulations, by using its principles of justification and optimisation. The report provides advice for deciding the radiation exposure situations that should be covered by the relevant regulations because their regulatory control can be justified, and, conversely, those that may be considered for exclusion from the regulations because their regulatory control is deemed to be unamenable and unjustified.

It also provides advice on the situations resulting from regulated circumstances but which may be considered by regulators for exemption from complying with specific requirements because the application of these requirements is unwarranted and exemption is the optimum option. Thus, the report describes exclusion criteria for defining the scope of radiological protection regulations, exemption criteria for planned exposure situations, and the application of these concepts in emergency exposure situations and in existing exposure situations.

The report also addresses specific exposure situations such as exposure to low-energy or low-intensity adventitious radiation, cosmic radiation, naturally occurring radioactive materials, radon, commodities, and low-level radioactive waste. The quantitative criteria in the report are intended only as generic suggestions to regulators for defining the regulatory scope, in the understanding that the definitive boundaries for establishing the situations that can be or need to be regulated will depend on national approaches.

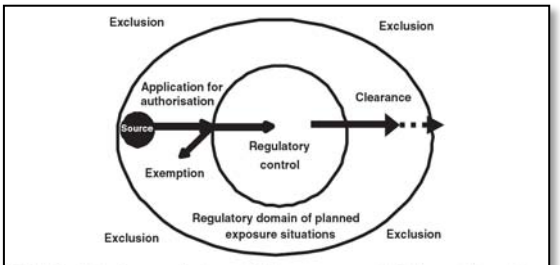


Fig. 4.2. Regulation of exposure situations: excluded exposures are regulated in the sense that regulations define the conditions for an exposure to be excluded (specifying which exposures are unamenable to be controlled). Exempted exposures are already within regulatory control, even if they are exempted from some of the regulatory control procedures.

Publication 105: Radiological Protection in Medicine

This report was prepared to underpin the Commission's 2007 Recommendations with regard to the medical exposure of patients, including their comforters and carers, and volunteers in biomedical research. It addresses the proper application of the fundamental principles (justification, optimisation of protection, and application of dose limits) of the Commission's 2007 Recommendations to these individuals.

With regard to medical exposure of patients, it is not appropriate to apply dose limits or dose constraints, because such limits would often do more harm than good. Often, there are concurrent chronic, severe, or even life-threatening medical conditions that are more critical than the radiation exposure. The emphasis is then on justification of the medical procedures and on the optimisation of radiological protection.

In diagnostic and interventional procedures, justification of procedures (for a defined purpose and for an individual patient), and management of the patient dose commensurate with the medical task, are the appropriate mechanisms to avoid unnecessary or unproductive radiation exposure. Equipment features that facilitate patient dose management, and diagnostic reference levels derived at the appropriate national, regional, or local level, are likely to be the most effective approaches. In radiation therapy, the avoidance of accidents is a predominant issue.

With regard to comforters and carers, and volunteers in biomedical research, dose constraints are appropriate. Over the last decade, the Commission has published a number of documents that provided detailed advice related to radiological protection and safety in the medical applications of ionising radiation. Each of the publications addressed a specific topic defined by the type of radiation source and the medical discipline in which the source is applied, and was written with the intent of communicating directly with the relevant medical practitioners and supporting medical staff. This report consolidates that advice.

Publication 106: Radiation Dose to Patients from Radiopharmaceuticals (Addendum 3 to ICRP Publication 53)

In this report, the Commission provides biokinetic and dosimetric models for 33 radiopharmaceuticals, as well as recommendations related to breast feeding for mothers who have undergone a nuclear medicine investigation. The report is based on Addenda 3–9 to Publication 53. Addenda 3–7 have been available on the ICRP website (www.icrp.org) as interim reports. The work has been carried out by a Joint Task Group of ICRP Committees 2 and 3.

This publication provides biokinetic models, absorbed doses, and effective doses for the following radiopharmaceuticals: ^{11}C-acetate; ^{11}C-amino acids; ^{11}C-brain receptor substances; ^{11}C-methionine; ^{18}F-amino acids; ^{18}F-FET; ^{18}F-FDG; ^{111}In-monoclonal antibodies/fragments; ^{123}I-fatty acids (BMIPP, IPPA); ^{123}I-monoclonal antibodies/fragments; ^{131}I-monoclonal antibodies/fragments; and ^{201}Tl-ion. The publication also provides realistic maximum models for ^{11}C- and ^{18}F-substances, for which no specific models are available.

Supporting Guidance 5: Analysis of the Criteria Used by the International Commission on Radiological Protection to Justify the Setting of Numerical Protection Level Values

This report compiles the various numerical protection level values published by the International Commission on Radiological Protection (ICRP) since its 1990 Recommendations (Publication 60). Several terms are used to denominate the protection levels: individual dose limit, 'maximum' individual dose, dose constraint, exemption level, exclusion level, action level, or intervention level. The reasons provided by the Commission for selecting the associated numerical values are quoted as far as available. In some cases the rationale is not totally explicit in the original ICRP report concerned; in such cases the Task Group that prepared the present report have proposed their own interpretation. Originally, this report was prepared by a Task Group at CEPN, a French research and development centre, on behalf of IRSN, a French public expert body engaged in radiological protection and nuclear safety. It is published here with kind permission by CEPN and IRSN.

ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations

In this report, the Commission provides an electronic database of the physical data needed in calculations of radionuclide-specific protection and operational quantities. This database supersedes the data of Publication 38 (ICRP, 1983), and will be used in future ICRP publications of dose coefficients for the intake of or exposure to radionuclides in the workplace and the environment.

The database contains information on the half-lives, decay chains, and yields and energies of radiations emitted in nuclear transformations of 1252 radionuclides of 97 elements. The CD accompanying the publication provides electronic access to complete tables of the emitted radiations, as well as the beta and neutron spectra. The database has been constructed such that user-developed software can extract the data needed for further calculations of a radionuclide of interest.

A Windows-based application is provided to display summary information on a user-specified radionuclide, as well as the general characterisation of the nuclides contained in the database. In addition, the application provides a means by which the user can export the emissions of a specified radionuclide for use in subsequent calculations.

ICRP Publication 108: Environmental Protection: the Concept and Use of Reference Animals and Plants

In its latest recommendations for a system of radiological protection, the Commission considered it necessary and appropriate to broaden its scope in order to address, directly, the subject of protection of the environment, although it acknowledged that there is no simple or single universal definition of 'environmental protection', and that the concept differs between countries and from one circumstance to another. It is a very large and complicated subject. Nevertheless, the Commission did consider it appropriate to set out some high-level ambitions with regard to environmental protection and the specific issue of potential radiation effects, and thus included within its general aims those of wishing to prevent or reduce the frequency of deleterious radiation effects in the environment to a level

where they would have a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities, and ecosystems. It also recognised the needs of some national authorities to demonstrate, directly and explicitly, that the environment is being protected within their own legislative frameworks.

The Commission also stated, however, that it believed that its approach to environmental protection should be commensurate with the overall level of risk (and thus optimised), and that it should be compatible with other approaches being made to protect the environment. Some form of numerical guidance is therefore necessary, and the Commission said that it considered that such guidance – built on a knowledge of the relationships between exposure and dose, between dose and effect, and between effect and possible consequences – needed to be based on a sound scientific system similar to that developed for human protection, and that this could best be achieved by the creation of a set of Reference Animals and Plants.

This publication therefore introduces the concept of reference animals and plants, and defines a small set. It discusses their pathways of exposure, and collates and discusses the adequacy of the best-available data relating to their dosimetry at different stages of their life cycles. In addition, this publication further develops and uses this information to derive sets of tabulated data (dose conversion factors, in terms of μGy/day/Bq/kg) that allow the dose to be calculated for 75 radionuclides that may be within, or external to, each organism.

This publication reviews what is known about the effects of radiation upon such biotic types (or of similar organisms, where more precise data are lacking) with regard to the effects of mortality, morbidity, reduced reproductive success, and chromosomal damage. Drawing on this information, the report derives a set of derived consideration reference levels for each biotic type in order to help optimise the level of effort that might be expended on its environmental protection, or that of similar types of organisms, and thus serve as points of reference in any wider consideration of what authorities may wish to do under different exposure situations. The various factors that should be taken into account when considering what to do if the derived consideration reference levels are likely to be attained are also discussed.

Some broader background information on the types of animals and plants used is also. Additional information is provided on advice with regard to extrapolating and interpolating the limited set of dosimetric models to other shapes and sizes of animals and plants.

The Commission acknowledges that, in many circumstances, exposure to radiation is but one factor to consider. It therefore intends to provide high-level guidance and advice upon which regulators and operators may draw in order to demonstrate compliance, where necessary, with the wide range of international and national environmental legislation that already exists, or is likely to emerge in the near future. It also intends to supplement this introductory report with additional relevant data sets, and with further guidance on issues such as radiation weighting factors.

Complete List of ICRP Publications in the First 80 Years (1928-2008)

(Fundamental recommendations are listed in bold, blue type)

ICRP Publication 108: Environmental Protection: the Concept and Use of Reference Animals and Plants, JAICRP 38(4-6), 2008.

ICRP Publication 107: Nuclear Decay Data for Dosimetric Calculations, JAICRP 38(3), 2008.

ICRP Publication 106: Radiation Dose to Patients from Radiopharmaceuticals: Addendum 3 to ICRP Publication 53, JAICRP 38(1-2), 2008.

ICRP Publication 105: Radiological Protection in Medicine, JAICRP 37(6), 2007.

ICRP Publication 104: Scope of Radiological Protection Control Measures, JAICRP 37(5), 2007.

ICRP Publication 103: The 2007 Recommendations of the International Commission on Radiological Protection, JAICRP 37(2-4), 2007.

ICRP Publication 102: Managing Patient Dose in Multi-Detector Computed Tomography (MDCT), JAICRP 37(1), 2007.

ICRP Publication SG5: Analysis of the Criteria Used by the International Commission on Radiological Protection to Justify the Setting of Numerical Protection Level Values, JAICRP 36(4), 2006.

ICRP Publication 101: The Optimisation of Radiological Protection: Broadening the Process, JAICRP 36(3), 2006.

ICRP Publication 101: Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public, JAICRP 36(3), 2006.

ICRP Publication 100: Human Alimentary Tract Model for Radiological Protection, JAICRP 36(1-2), 2006.

ICRP Publication 99: Low-dose Extrapolation of Radiation-related Cancer Risk, JAICRP 35(4), 2005.

ICRP Publication 98: Radiation safety aspects of brachytherapy for prostate cancer using permanently implanted sources, JAICRP 35(3), 2005.

ICRP Publication 97: Prevention of high-dose-rate brachytherapy accidents, JAICRP 35(2), 2005.

ICRP Publication 96: Protecting people against radiation exposure in the event of a radiological attack, JAICRP 35(1), 2005.

ICRP Publication SG4: Development of the Draft 2005 recommendations of the ICRP: a collection of papers, JAICRP 34(Supplement 1), 2004.

ICRP Publication 95: Doses to infants from radionuclides ingested in mothers' milk, JAICRP 34(3-4), 2004.

ICRP Publication 94: Release of Patients after Therapy with Unsealed Radionuclides, JAICRP 34(2), 2004.

ICRP Publication 93: Managing patient dose in digital radiology, JAICRP 34(1), 2004.

ICRP Publication 92: Relative Biological Effectiveness (RBE), Quality Factor (Q), and Radiation Weighting Factor (w_R), JAICRP 33(4), 2003.

ICRP Publication 91: A Framework for Assessing the Impact of Ionising Radiation on Non-human Species, JAICRP 33(3), 2003.

ICRP Publication 90: Biological Effects after Prenatal Irradiation (Embryo and Foetus), JAICRP 33(1-2), 2003.

ICRP Publication 89: Basic Anatomical and Physiological Data for Use in Radiological Protection: Reference Values, JAICRP 32(3-4), 2002.

ICRP Publication SG3: Guide for the Practical Application of the ICRP Human Respiratory Tract Model, JAICRP 32(1-2), 2002.

ICRP Publication SG2: Radiation and your patient: A guide for medical practitioners, JAICRP 31(4), 2001.

ICRP Publication 88: Doses to the Embryo and Foetus from Intakes of Radionuclides by the Mother, JAICRP 31(1-3), 2001.

ICRP Publication 87: Managing Patient Dose in Computed Tomography, JAICRP 30(4), 2000.

ICRP Publication 86: Prevention of accidental exposures to patients undergoing radiation therapy, JAICRP 30(3), 2000.

ICRP Publication 85: Avoidance of Radiation Injuries from Medical Interventional Procedures, JAICRP 30(2), 2000.

ICRP Publication 84: Pregnancy and Medical Radiation, JAICRP 30(1), 2000.

ICRP Publication 83: Risk Estimation for Multifactorial Diseases, JAICRP 29(3-4), 1999.

ICRP Publication 82: Protection of the Public in Situations of Prolonged Radiation Exposure: The Application of the Commission's System of Radiological Protection to Controllable Radiation Exposure Due to Natural Sources and Long-lived Radioactive Residues, JAICRP 29(1-2), 1999.

International Commission on Radiological Protection: History, policies, procedures, JAICRP 28(Supplement 1), 1998.

ICRP Publication 81: Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste, JAICRP 28(4), 1998.

ICRP Publication 80: Radiation Dose to Patients from Radiopharmaceuticals: Addendum 2 to ICRP Publication 53, JAICRP 28(3), 1998.

ICRP Publication 79: Genetic Susceptibility to Cancer, JAICRP 28(1-2), 1998.

ICRP Publication 78: Individual Monitoring for Internal Exposure of Workers, JAICRP 27(3-4), 1997.

ICRP Publication 77: Radiological Protection Policy for the Disposal of Radioactive Waste, JAICRP 27(supplement 1).

ICRP Publication 76: Protection from Potential Exposures: Selected Radiation Sources, JAICRP 27(2), 1997.

ICRP Publication 75: General Principles for the Radiation Protection of Workers, JAICRP 27(1), 1997.

ICRP Publication 74: Conversion Coefficients for Use in Radiological Protection, JAICRP 26(3-4), 1996.

ICRP Publication 73: Radiological Protection in Safety and Medicine, JAICRP 26(2), 1996.

ICRP Publication 72: Age-Dependent Doses from Intakes of Radionuclides, JAICRP 26(1), 1996.

ICRP Publication 71: Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients, JAICRP 25(3-4), 1995.

ICRP Publication 70: Basic Anatomical and Physiological Data: The Skeleton, JAICRP 25(2), 1995.

ICRP Publication 69: Age-Dependent Doses from Intake of Radionuclides: Part 3, JAICRP 25(1), 1995.

ICRP Publication 68: Dose Coefficients for Intakes of Radionuclides by Workers, JAICRP 24(4), 1994.

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ICRP Publication 66: The Human Respiratory Tract Model, JAICRP 24(1-3), 1994.

ICRP Publication 65: Protection against Radon-222, JAICRP 23(2), 1993.

ICRP Publication 64: Protection from Potential Exposure, JAICRP 23(1), 1993.

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ICRP Publication SG1: Risk Estimates for Carcinogenic Effects, JAICRP 22(1), 1991.

ICRP Publication 61: ALIs Based on the 1990 Recommendations, JAICRP 21(4), 1991.

ICRP Publication 60: 1990 Recommendations of the International Commission on Radiological Protection, JAICRP 21(1-3), 1991.

ICRP Publication 59: The Biological Basis for Dose Limitation in the Skin, JAICRP 22(2), 1991.

ICRP Publication 58: RBE for Deterministic Effects, JAICRP 20(4), 1989.

ICRP Publication 57: Radiological Protection of the Worker in Medicine and Dentistry, JAICRP 20(3), 1989.

ICRP Publication 56: Age-Dependant Doses from Intakes of Radionuclides: Part 1, JAICRP 20(2), 1989.

ICRP Publication 55: Optimization and Decision-Making in Radiological Protection, JAICRP 20(1), 1989.

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ICRP Publication 53: Biokinetics and Dosimetry: General Considerations, JAICRP 18(1-4), 1987.

ICRP Publication 52: Protection of the Patient in Nuclear Medicine, JAICRP 17(4), 1987.

ICRP Publication 51: Data for Use in Protection against External Radiation, JAICRP 17(2-3), 1987.

ICRP Publication 50: Lung Cancer Risk from Indoor Exposures to Radon Daughters, JAICRP 17(1), 1987.

ICRP Publication 49: Developmental Effects of Irradiation of the Brain of the Embryo and Foetus, JAICRP 16(4), 1986.

ICRP Publication 48: The Metabolism of Plutonium and Related Elements, JAICRP 16(2-3), 1986.

ICRP Publication 47: Radiation Protection of Workers in Mines, JAICRP 16(1), 1986.

ICRP Publication 46: Principles for the Disposal of Solid Radioactive Waste, JAICRP 15(4), 1985.

ICRP Publication 45: Developing a Unified Index of Harm, JAICRP 15(3), 1985.

ICRP Publication 44: Protection of the Patient in Radiation Therapy, JAICRP 15(2), 1985.

ICRP Publication 43: Principles of Monitoring for the Radiation Protection of the Population, JAICRP 15(1), 1985.

ICRP Publication 42: A Compilation of the Major Concepts and Quantities in Use by ICRP, JAICRP 14(4), 1984.

ICRP Publication 41: Nonstochastic Effects of Ionizing Radiation, JAICRP 14(3), 1984.

ICRP Publication 40: Statement from the 1984 Stockholm Meeting of the International Commission on Radiological Protection, JAICRP 14(2), 1984.

ICRP Publication 39: Principles for Limiting Exposure of the Public to Natural Sources of Radiation, JAICRP 14(1), 1984.

ICRP Publication 38: Radionuclide Transformations, JAICRP 11-13, 1983.

ICRP Publication 37: Cost-Benefit Analysis in the Optimization of Radiation Protection, JAICRP 10(2-3), 1983.

ICRP Publication 36: Protection against Ionizing Radiation in the Teaching of Science, JAICRP 10(1), 1983.

ICRP Publication 35: General Principles of Monitoring for Radiation Protection of Workers, JAICRP 9(4), 1982.

ICRP Publication 34: Protection of the Patient in Diagnostic Radiology, JAICRP 9(2-3), 1982.

ICRP Publication 33: Protection against Ionizing Radiation from External Sources used in Medicine, JAICRP 9(1), 1982.

ICRP Publication 32: Limits for Inhalation of Radon Daughters by Workers, JAICRP 6(1), 1981.

ICRP Publication 31: Biological Effects of Inhaled Radionuclides, JAICRP 4(1-2), 1980.

ICRP Publication 30: Limits for Intakes of Radionuclides by Workers, JAICRP, 19(4), 1988; 8(4), 1982; 8(1-3), 1982; 7(1-3), 1982; 6(2-3), 1981; 5(1-6), 1981; 4(3-4), 1980; 4(3-4), 1980; 3(1-4), 1979; and 2(3-4), 1979.

ICRP Publication 29: Radionuclide Release into the Environment: Assessment of Doses to Man, JAICRP 2(2), 1979.

ICRP Publication 28: Principles for Handling Emergency and Accidental Exposures of Workers, JAICRP 2(1), 1978.

ICRP Publication 27: Problems Involved in Developing an Index of Harm, JAICRP 1(4), 1977.

ICRP Publication 26: Recommendations of the International Commission on Radiological Protection, JAICRP 1(3), 1977.

ICRP Publication 25: Handling, Storage, Use, and Disposal of Unsealed Radionuclides, JAICRP 1(2), 1977.

ICRP Publication 24: Radiation Protection in Uranium and other Mines, JAICRP 1(1), 1977.

ICRP Publication 23: Report of the Task Group on Reference Man (1975).

ICRP Publication 22: Implications of Commission Recommendations that Doses be kept as Low as Readily Achievable (1973).

ICRP Publication 21: Data for Protection against Ionizing Radiation from External Sources: Supplement to ICRP Publication 15 (1973).

ICRP Publication 20: Alkaline Earth Metabolism in Adult Man (1973).

ICRP Publication 19: The Metabolism of Compounds of Plutonium and other Actinides (1972).

ICRP Publication 18: The RBE for High-LET Radiations with Respect to Mutagenesis (1972).

ICRP Publication 17: Protection of the Patient in Radionuclide Investigations (1971).

ICRP Publication 16: Protection of the Patient in X-Ray Diagnosis (1969).

ICRP Publication 15: Protection against Ionizing Radiation from External Sources (1969).

ICRP Publication 14: Radiosensitivity and Spatial Distribution of Dose (1969).

ICRP Publication 13: Radiation Protection in Schools for Pupils up to the Age of 18 Years (1968).

ICRP Publication 12: General Principles of Monitoring for Radiation Protection of Workers (1968).

ICRP Publication 11: A Review of the Radiosensitivity of the Tissues in Bone (1967).

ICRP Publication 10: Evaluation of Radiation Doses to Body Tissues from Internal Contamination due to Occupational Exposure (1968).

ICRP Publication 9: Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965).

ICRP Publication 8: The Evaluation of Risks from Radiation (1965).

ICRP Publication 7: Principles of Environmental Monitoring related to the Handling of Radioactive Materials (1965).

ICRP Publication 6: Recommendations of the International Commission on Radiological Protection (As Amended 1959 and Revised 1962) (1964).

ICRP Publication 5: Handling and Disposal of Radioactive Materials in Hospitals and Medical Research Establishments (1964).

ICRP Publication 4: Protection against Electromagnetic Radiation above 3 MeV and Electrons, Neutrons and Protons (1964).

ICRP Publication 3: Report of Committee III on protection against X-rays up to energies of 3 MeV and beta- and gamma-rays from sealed sources (1960).

ICRP Publication 2: Report of Committee II on permissible dose for internal radiation (1959).

ICRP Publication 1: Recommendations of the International Commission on Radiological Protection: As Amended 1959 and Revised 1962.

Report on Decisions at the 1959 Meeting of the International Commission on Radiological Protection (ICRP).

Recommendations of the International Commission on Radiological Protection: Adopted September 9, 1958.

Report on Amendments during 1956 to the Recommendations of the International Commission on Radiological Protection.

Recommendations of the International Commission on Radiological Protection: Revised December 1954.

International Recommendations on Radiological Protection: Revised by the International Commission on Radiological Protection at the Sixth International Congress of Radiology, London, July 1950.

International Recommendations for X-Ray and Radium Protection: Revised by the International X-Ray and Radium Protection Commission at the Fifth International Congress of Radiology, Chicago, September 1937.

International Recommendations for X-Ray and Radium Protection: Revised by the International X-Ray and Radium Protection Commission at the Fourth International Congress of Radiology, Zürich, July 1934.

International Recommendations for X-Ray and Radium Protection: Stockholm 1929.

OBTAINING ICRP PUBLICATIONS

ICRP Publications are available from reputable booksellers or directly from the Commission's publishers, Elsevier Science:

Web sites: www.elsevier.com
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Composition of ICRP and Its Committees 2006-2008

Main Commission

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H G Menzel (C2 Chair from 2007)
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J-K Lee
Z Q Pan
J Pentreath (C5 Chair)
R J Preston (C1 Chair)
Y Sasaki
N Shandala
C Streffer (C2 Chair to 2007)
A Sugier (C4 Chair)

Emeritus Members:
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B Lindell
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W K Sinclair
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Scientific Secretary
J Valentin
C Clement*
** as of December 2008*

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ICRP Chairs and Scientific Secretaries in the First 80 Years (1928-2008)

Chairs of the Commission

1928-1931	Rolf Sievert	Sweden
1931-1937	René Ledoux-Lebard	France
1937-1950	Lauriston Taylor	USA
1950-1956	Sir Ernest Rock Carling	UK
1956-1962	Rolf Sievert	Sweden
1962-1969	Sir Edward Pochin	UK
1969-1977	Gordon Stewart	Canada
1977-1985	Bo Lindell	Sweden
1985-1993	Dan Beninson	Argentina
1993-2005	Roger Clarke	UK
2005-2009	Lars-Erik Holm	Sweden

Scientific Secretaries of the Commission

1950	Lauriston Taylor	USA
1950-1955	Walter Binks	UK
1956	Eric Smith	UK
1957-1962	Bo Lindell	Sweden
1962-1985*	David Sowby	Canada
1985-1987	Mike Thorne	UK
1987-1997	Hylton Smith	UK
1997-2008	Jack Valentin	Sweden
2008-	Christopher Clement	Canada

** The position of ICRP Scientific Secretary first became full-time in 1962*

SUMMARY FINANCIAL INFORMATION 2004-2008

Summary of ICRP Annual Accounts for the 5-year Period 2004 – 2008

ITEM	2008	2007	2006	2005	2004
INCOME STATEMENT					
Incoming Resources					
Grants Received	412 100	472 703	231 592	310 100	300 422
Royalties	84 596	112 589	127 176	88 048	117 211
Interest	5 935	14 996	15 862	11 605	8 678
Other Income	1 516	925	1 044	861	1 156
Total Incoming Resources	504 147	601 213	375 674	410 614	427 827
Resources Expended					
Promotion of Radiological Protection	326 444	386 541	361 434	229 876	248 494
Governance Costs	140 175	152 942	145 498	165 526	179 926
Other Resources Expended	33 418	(13 079)	(35 396)	31 796	(32 851)
Total Resources Expended	500 037	526 404	471 536	427 198	395 569
Net Movement in Resources	4 110	74 809	(95 862)	(16 584)	32 258
Total Funds Carried Forward	**503 922**	**499 882**	**425 073**	**520 935**	**537 519**
BALANCE SHEET					
Assets					
Tangible Fixed Assets	3 109	1 516	2 895	4 562	2 884
Cash Held at Bank and in Hand	520 130	509 000	439 149	535 217	545 943
Debtors and Prepayments	9 166	2 375	74	0	11 173
Total Assets	529 296	511 375	439 223	539 779	560 000
Creditors (falling due within the year)	(28 413)	(13 009)	(17 045)	(18 884)	(22 481)
Net Assets	**503 992**	**499 882**	**425 073**	**520 935**	**537 519**

All amounts expressed in USD

This table is summary of the annual financial statements of ICRP as audited by Tudor John Chartered Accountants, Epsom, UK.

ORGANISATIONS PROVIDING GRANTS TO ICRP 2006-2008

Commission of European Communities

International Atomic Energy Agency

International Radiation Protection Association

International Society of Radiology

OECD Nuclear Energy Agency

Australia: Australian Radiation Protection and Nuclear Safety Agency

Canada: Canadian Nuclear Safety Commission

China: Chinese Society of Radiation Protection

Denmark: National Board of Health

Finland: Säteilyturvakeskus

France: Institut de Protection et de Sûreté Nucléaire

Germany: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Iceland: Geislavarnir Rikisins

Japan: Japan Atomic Energy Agency

Norway: Norwegian Radiation Protection Authority

Russia: Burnasyan Federal Medical Biohysical Center, Federal Medical Biological Agency

Spain: Consejo de Seguridad Nuclear

Sweden: Miljödepartementet

USA: Nuclear Regulatory Commission & Environmental Protection Agency

CONTACT INFORMATION

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