The International Commission on Radiological Protection: Historical overview

The ICRP is revising its basic recommendations

by Dr H. Smith

Within a few weeks of Roentgen's discovery of X-rays, the potential of the technique for diagnosing fractures became apparent, but acute adverse effects (such as hair loss, erythema, and dermatitis) made hospital personnel aware of the need to avoid over-exposure. Similar undesirable acute effects were reported shortly after the discovery of radium and its medical applications. Notwithstanding these observations, protection of staff exposed to X-rays and gamma rays from radium was poorly co-ordinated.

The British X-ray and Radium Protection Committee and the American Roentgen Ray Society proposed general radiation protection recommendations in the early 1920s. In 1925, at the First International Congress of Radiology, the need for quantifying exposure was recognized. As a result, in 1928 the roentgen was adopted by the International Committee on X-ray and Radium Protection as a measure of exposure to X- and gamma-rays.

The recommendation on exposure limits gradually evolved over the next decade and, by 1937, it was considered that a healthy person could tolerate occupational exposure to X- or gamma rays up to 0.2 roentgen per working day without developing skin damage, anaemia, or incurring impaired fertility. At the time of the Sixth International Congress on Radiology in 1950, the International Commission on Radiological Protection (ICRP) and its sister body, the International Commission on Radiological Units (ICRU) were formed from previous committees. Each commission consisted of 12 members and a chairman. To cope with the considerable expansion in work with radiation sources and radioactive materials, the ICRP set up five subcommittees.The first recommendations of ICRP were published in 1951. The Commission reiterated its previously held view that the adverse effects of exposure to radiation included skin damage, cataracts, anaemia, and impaired fertility. In addition, malignant diseases in the irradiated person's children were included. The recommended permissible dose rate at this time was 0.3 roentgen per working week for penetrating X- and gamma rays; 1.5 roentgen per working week for radiation affecting only superficial tissues; and 0.03 roentgen per working week for neutrons.

Recommendations in the 1950s

By then, it was accepted that the roentgen was inappropriate as a measure of exposure. In 1953, the ICRU recommended that limits of exposure should be based on consideration of the energy absorbed in tissues and introduced the rad (radiation absorbed dose) as a unit of absorbed dose (that is, energy imparted by radiation to a unit mass of tissue). In 1954, the ICRP introduced the rem (roentgen equivalent man) as a unit of absorbed dose weighted for the way different types of radiation distribute energy in tissue (called the dose equivalent in 1966). The weekly recommended dose limits for X- and gamma rays to critical organs (a recognition of variable tissue radiosensitivity), still expressed in roentgen but abbreviated to R, were 0.6 R for skin and 0.3 R for blood-forming organs, gonads, and lens of the eye (with less restrictive limits for radiation with low penetration into tissues). The 1959 recommendations reflect an increasing understanding of the biologic basis of radiation-induced tissue damage. They included an age-related formula for workers above 18 years of age to calculate the maximum permissible dose (MPD) to the gonads, blood-forming organs, and the lens of the eyes; a weekly maximum dose of 0.1 rem to be used for planning and design purposes; a recognition that exposure was not necessarily at a constant rate but that a person's occupational exposure should not exceed 3 rem during any period of 13 consecutive weeks; for non-radiation workers the annual dose should not exceed 1.5 rem for the critical organs; and a setting of 0.5 rem as an annual dose limit for members of the public. Implicit in the use of these dose limits was that no appreciable bodily injury would occur from radiation during the lifetime of the individual even though that person might be exposed at the limit for tens of years.

Recommendations in the 1960s

Revised recommendations in 1964 included the use of a quality factor (QF), which is dependent only on the

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linear energy transfer (LET) of the radiation rather than relative biologic effectiveness (RBE), which is a ratio of absorbed doses of different radiations producing the same biologic end-point. They also included the recognition of increased radiosensitivity of the foetus, by recommending that women of reproductive age, should not be exposed while at work to more than 1.3 rem in a 13-week period and that all lower abdominal radiologic examinations that were not essential should be limited to the 10 days following the onset of menstruation, when pregnancy is improbable.

The 1966 recommendations established the need to prevent the acute effects of radiation and to limit the risk of cancer and genetic abnormalities in the offspring of irradiated parents to an acceptable level. Implicit in this recommendation is the acceptance of a linear dose-response relationship for cancer and genetic abnormalities without a threshold dose but with a dose-rate effect. By now, the MPD expressed on an annual basis (quarterly doses from the total intake of radioactive materials were restricted to half the MPD) were 5 rem for uniform whole-body irradiation or the irradiaton of the gonads and red bone marrow — these being the most radiosensitive tissues; 30 rem to skin, thyroid, and bone; 75 rem to the extremities; and 15 rem to all other organs. Annual dose limits for members of the public were one-tenth of the workers limits.

The Commission structure had by now become well established and committees were created on radiation effects, internal exposure (now secondary standards), external exposure (now protection in medicine), and application of the Commission's recommendations.

Recommendations, objectives in the 1970s

Numerous reports were issued between 1959 and 1977 relating to the scientific basis of radiation protection, monitoring for incorporated radionuclides, and the application of recommendations. However, the basic recommendations were not revised until 1977 reflecting the evolution of ideas expressed in early reports. In the report, it was considered necessary to limit the incidence of radiation-induced fatal cancers and serious genetic disorders in the offspring (so-called stochastic effects that have a statistical dose-related probability of occurring at any level of radiation) to a level accepted by society. This level should be at least comparable, in the case of workers, to the incidence observed in industries having high standards of safety, and to prevent other harmful effects (so-called non-stochastic effects, the severity of which increases with dose and for which there is a threshold dose below which the effects can be avoided). These objectives could be achieved if:

- no practice was adopted, unless it produced a net positive benefit;
- exposures were as low as reasonably achievable, economic and social factors being taken into account; and
- the dose equivalent to individuals did not exceed the recommended limits for particular circumstances defined by the Commission.

In determining an estimate of the stochastic risks, derived from reviews by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the Biological Effects of Ionising Radiations Committee (BEIR) of the US National Academy of Sciences, it was assumed that each organ or tissue contributed a certain fraction of the total risk (estimated to be 1.65×10^{-4} per rem, or $1.65 \times 10^{-2} Sv^{-1}$ in the SI system of units, following irradiaton of the whole body). The effective dose equivalent weighted for susceptibility to the harming of different tissues (as defined in a subsequent statement in 1978) was used to estimate the contribution of the organ or tissue dose to the whole-body equivalent dose. For a radiation worker, the limit on annual effective dose equivalent for uniform irradiation was 5 rem (50 millisievert). For individual members of the public, a limit of 0.5 rem (5 millisievert), as applied to critical groups, was considered to provide an adequate degree of safety, in that the application of this limit was likely to result in average annual effective dose equivalents of less than 0.05 rem (0.5 millisievert).

Current developments

The Commission is presently revising its basic recommendations which were presented in 1977 and in a number of subsequent statements and amendments as well as in other ICRP reports.

The objective of the revision is to review and update these policy statements for consistency and to produce a single set of basic recommendations, presented as clearly and unambiguously as possible, supported by explanations and references to current scientific information. The revised recommendations are expected to be completed by 1990 after preparatory work by the Commission's committees and a number of ad hoc task groups. This work includes review and reassessment of the complete system of dose limitation, including the values of the dose limits.

In this connection, current work on assessing the cancer risk is being carried out, for example, by UNSCEAR and by the BEIR committee, as well as by the Commission's committee on biological effects. The results of several studies are expected to be available in less than two years.

Since the risk data on cancer and inherited disorders are yet far from conclusive, the Commission will await the result of the comprehensive evaluations of its sources of epidemiological information that are currently being made, before judging the consequences for the revision of its system of dose limitation. In the meantime, it will be prudent to follow the present recommendations on dose limitation as they were intended to be interpreted. When this is done, the value of the dose limits, in most cases, will not be the controlling factor in the restriction of doses; therefore, the final judgement on the choice of dose limits can await full scientific review without any serious consequences. A review is also in preparation on the effect of the new dosimetry on the estimate of risks of severe mental retardation being caused by exposure of children to radiation during their development *in utero*.

This effect might be caused during the period of 8–15 weeks after fertilization, and, with less sensivity, from 16–25 weeks after fertilization, but without detectable sensitivity for induction of these effects at other periods of pregnancy. ICRP published a document estimating a zero threshold dose of causation of these effects in the earlier, 8–15 weeks period, although indicating rather wide confidence intervals for this estimate. This matter is still under review.

In deciding to revise its basic recommendations, the Commission has to strike a balance between the desire to incorporate the most recent data and thinking on radiation protection with the requirement to maintain a stable system of limitation. For this reason, new sets of basic recommendations are produced at intervals of about 10 to 15 years. Thus, any new recommendations developed by 1990 would be expected to apply until the early years of the 21st century.

IAEA's 1988 General Conference, 19–23 September 1988

High-level governmental representatives from the IAEA's 113 Member States were to convene in Vienna from 19–23 September for the 32nd regular session of the IAEA General Conference Major items on the provisional agenda concerned:

- *The IAEA's 1989 regular budget and extrabudgetary resources* As recommended by the IAEA Board of Governors in June 1988, the regular budget for 1989 called for expenditures of US $157 5 million This represents zero growth in real terms Additionally, the Board recommended a target of US $42 million for voluntary contributions toward the Agency's technical assistance programme
- *Measures to strengthen international co-operation in nuclear safety and radiological protection.* A report by the IAEA Board of Governors and Director General prepared for the General Conference addressed topics including liability for nuclear damage; revision of the IAEA's Nuclear Safety Standards (NUSS), sharing of nuclear safety-related information, protection of nuclear installations against armed attacks (also the subject of a supplementary item proposed for the agenda), and the status of international conventions under the IAEA's auspices These are the *Convention on the Physical Protection of Nuclear Material, Convention on Early Notification of a Nuclear Accident, Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency,* and *Convention on Civil Liability for Nuclear Damage* (Vienna Convention)
- *Israeli nuclear capabilities and threat.* A report by the Director General was prepared in connection with a resolution adopted by the General Conference in 1987 The resolution *inter alia* demanded that Israel "place all its nuclear facilities under IAEA safeguards"
- *South Africa's nuclear capabilities* The General Conference in 1987 *inter alia* resolved to consider and take a decision during its 1988 regular session on a recommendation by the IAEA Board of Governors to suspend South Africa from the exercise of the privileges and rights of membership in the Agency

Special meetings

In connection with the Conference, several special meetings were scheduled

- *Special Scientific Meeting on Radiation Protection.* Four scheduled sessions addressed current issues; control of radiation sources, IAEA activities in the field, and communicating information on radiation protection Scheduled keynote speakers at the opening session were B Lindell, Former Director of the State Radiation Protection Institute, Sweden, R H Clarke, Director, National Radiological Protection Board, United Kingdom, D J Beninson, Director, Licensing of Nuclear Installations, National Atomic Energy Commission, Argentina, O. Ilari, Deputy Head, Division of Radiation Protection and Waste Management, Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (NEA/OECD), and L A Buldakov, Deputy Director, Institute of Biophysics, Ministry of Health, USSR Chairman and Rapporteur to the General Conference was Sir Edward Pochin, former Chairman of the International Commission on Radiological Protection (ICRP) Also scheduled was a joint meeting of radiation protection and nuclear safety regulations
- *Meeting of senior nuclear safety officials* Senior officials of nuclear regulatory and safety agencies were scheduled to meet for closed informal sessions focusing on basic safety principles for nuclear power plants, operational safety, and severe accident management Selected as session chairmen were M Laverie of France, L Zech of the USA, and S Havel of Czechoslovakia
- *Conference on the Relationship Between the Paris and Vienna Conventions,* jointly organized by the IAEA and Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (NEA/OECD) Governments were expected to adopt a joint protocol that establishes a link between these two international conventions, which are directed at civil liability for nuclear damage
- *Journalist Encounter on IAEA Safeguards and Nuclear Non-Proliferation* Preceding the General Conference, international experts and invited journalists participated in a series of topical briefings and panel discussions Expected participants were IAEA Director General Hans Blix, Mr Jon Jennekens, IAEA Deputy Director General for Safeguards, Mr Mikhail Ryzhov, Acting Head, International Relations Department, USSR State Committee on the Utilization of Atomic Energy; Mr Myron Kratzer, Senior Associate, ERC International, USA, Mr Bertrand de Galassus, Assistant to the Director, International Relations, Commissariat à l'énergie atomique, France, Mr Reinhard Loosch, Director, International Relations, Federal Ministry for Research and Technology, Federal Republic of Germany, Mr Mitsuho Hirata, Director General, Ohrai Research Establishment, Japan Atomic Energy Research Institute, Mr Djali Ahimsa, Director General, National Atomic Energy Agency, Indonesia, and Mr Peter Tempus, Special Advisor, Federal Board of the Institute of Technology, Switzerland