The International Systems of Radiological Protection: Key Structures and Current Challenges

by Edward Nicholas Lazo*

Introduction

Since the realisation, at the beginning of the 1900s, that exposure to ionising radiation could cause detrimental health effects, experts in the field have worked together to establish a scientific basis for describing radiation-related risks, to recommend practical principles for protection against radiation-related risks and to develop international standards and national regulations in this area.

In broad terms, the primary aim of radiological protection 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. To guide the implementation of this aim, three principles have been developed, namely the justification of activities, the optimisation of protection and the limitation of exposures. These three key principles have been elaborated by the International Commission on Radiological Protection (ICRP – which is described in more detail below) as follows:

The principle of justification

Any decision that alters the radiation exposure situation should do more good than harm.

The principle of optimisation of protection

The likelihood of incurring exposures, the number of people exposed and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.

The principle of exposure limitation

The total dose to any individual from regulated sources in planned exposure situations other than medical exposure of patients should not exceed the appropriate limits.

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* Principal Administrator with the OECD Nuclear Energy Agency, Radiation Protection and Radioactive Waste Management Division. Edward Lazo holds a PhD in Radiation Protection and Masters and Bachelors degrees in Nuclear Engineering. He has worked in the Radiological Protection field for several public and private sector entities in both the United States and France. The author alone is responsible for the facts and opinions expressed in this article.

I. Institutional Framework

Today, several international organisations contribute significantly to the establishment of a scientific and legal framework in the field of radiological protection. Although there is no "process" formally defined, the organisations work in the following fashion:

- The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) collects and assesses scientific literature regarding exposure to ionising radiation, assessing world-wide exposure trends.
- The International Commission on Radiological Protection (ICRP) uses the scientific data from UNSCEAR to develop pragmatic policy and application recommendations that can be used as a basis for the development of standards and regulations.
- The International Atomic Energy Agency (IAEA) develops international, broadly non-binding standards that may be adopted by its Member States and must be adopted by any state accepting the agency's assistance. These standards are based on the recommendations of the ICRP.
- The European Commission (EC) develops binding directives that must be transposed into national law by its Member States. These are based on the recommendations of the ICRP.
- The OECD Nuclear Energy Agency (NEA) explores new and emerging issues and challenges in the field of radiological protection, as identified and requested by its member countries, in order to share experience and develop approaches to addressing these issues. In particular, the NEA has worked in collaboration with the ICRP to "road-test" draft recommendations as to their implications for policy, regulation and application and thereby assisted the ICRP to develop recommendations that best address the needs of the radiological protection community.

This study presents a short history of the key organisations in this process and goes on to discuss their interactions and current issues in radiological protection.

1. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

In 1955, purportedly with the intention to deflect a proposal calling for an immediate end to all nuclear explosions, it was proposed to the General Assembly of the United Nations to establish a committee to collect and evaluate information on the levels and effects of ionising radiation. Subsequently on 3 December 1955, the General Assembly unanimously approved a Resolution[1] which established the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The original committee was composed of senior scientists from 15 designated UN Member States, namely Argentina, Australia, Belgium, Brazil, Canada, Czechoslovakia, Egypt, France, India, Japan, Mexico, Sweden, the United Kingdom, the United States and the USSR.

The first two substantive reports submitted to the General Assembly, in 1958 and 1962, presented comprehensive evaluations of the state of knowledge about the levels of ionising radiation to which human beings were exposed and of the possible effects of such exposures. Those reports laid the scientific grounds on which the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (Partial Test-Ban Treaty) was negotiated and signed in 1963.

1. Resolution 913(X), dated 3 December 1955, the founding resolution.

Over the decades that followed this important first achievement, the UNSCEAR became the official international authority on the levels and effects of ionising radiation, used for peaceful as well as military purposes and derived from natural as well as man-made sources. In the first UNSCEAR report of 1955, it had been recognised that medical diagnostic and therapeutic exposures were a major component of artificial radiation exposure globally, a fact that remains true today. The Committee has systematically reviewed and evaluated global and regional levels and trends of medical exposure, as well as exposure of the public and workers. These reviews have prompted significant reductions in unnecessary radiation exposure worldwide and continue to influence the programmes of international bodies such as the IAEA, World Health Organisation (WHO), ICRP and the International Labour Organization (ILO).

The Committee has regularly evaluated the evidence for radiation-induced health effects from studies of the survivors of the atomic bombings in Japan and other exposed groups. It has also reviewed advances in scientific understanding of the mechanisms by which radiation-induced health effects can occur. These assessments have provided the scientific foundation used by the ICRP in developing its recommendations on radiological protection and by the relevant agencies in the UN system in formulating international protection standards.

Since its inception, the UNSCEAR has issued only 15 major publications, but these authoritative reports are principal sources of information. Twenty-one countries provide the present membership of the Committee and more than 50 national organisations as well as several international organisations provide considerable contributions in kind.

2. The International Commission on Radiological Protection (ICRP)

The International Commission on Radiological Protection (ICRP) was created in 1928, as the International X-ray and Radium Protection Committee, and restructured in 1950 in order to address protection from emerging health effects of radiation, mostly in researchers and patients from X-rays and radium treatments. The ICRP, which is registered as an independent charity and financed mainly by voluntary contributions from international and national bodies, is composed of a main commission and five standing committees, whose members are all elected (main commission) or appointed (committees) by the Commission itself under rules set out by the International Society of Radiology.

The ICRP works closely with the International Commission on Radiation Units and Measurements (ICRU), maintains important relations with various UN organisations (UNSCEAR, WHO, IAEA, ILO, UNEP) and works with the EC, OECD/NEA, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). It also has strong links with the International Radiation Protection Association (IRPA).

The ICRP has, since its inception, issued recommendations regarding protection against the hazards of ionising radiation. Since its 1950 restructuring, the ICRP has issued approximately 100 recommendation documents. The most fundamental of these, called the Commission's general recommendations, are issued approximately every 10 to 15 years to take into account new scientific evidence and managerial experience. The first of these general recommendations was ICRP Publication 1 (1959), which was followed by Publication 6 (1964), Publication 9 (1966), Publication 26 (1977) and Publication 60 (1990).[2]

2. www.icrp.org.

Historically, national and international organisations and practitioners involved in activities that produce or use radiation and/or radioactive materials have taken the recommendations and principles issued by the ICRP as a key basis for their protective actions. As such, virtually all national regulations and international standards addressing radiological protection are based on the recommendations of the ICRP. Currently, most national regulations are based on the recommendations of ICRP Publication 60. International standards, such as the International Basic Safety Standards, various ILO labour conventions and European directives on radiological protection are also based on ICRP Publication 60.

The Commission's new general recommendations were approved in March 2007 and are expected to be published soon. The evolutionary changes introduced by the Commission in its new recommendations, and the challenges that their implementation will pose are briefly elaborated in Section II of this paper.

3. International Atomic Energy Agency (IAEA)

The IAEA was created in 1957 in response to the deep fears and expectations resulting from the discovery of nuclear energy. In the context of the international system of radiological protection, the IAEA plays a special role in establishing international standards. This role is specified in Article III.6 of the Agency's Statute:

> "*To establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialised agencies concerned, standards of safety for protection of health and minimisation of danger to life and property (including such standards for labour conditions), and to provide for the application of these standards to its own operation as well as to the operations making use of materials, services, equipment, facilities, and information made available by the Agency or at its request or under its control or supervision; and to provide for the application of these standards, at the request of the parties, to operations under any bilateral or multilateral arrangements, or, at the request of a State, to any of that State's activities in the field of atomic energy*".

Since its inception, the IAEA has issued many standards, the International Basic Safety Standards being among those having had the most impact. The International Basic Safety Standards were undertaken in 1960, at which point the Board of Governors of the IAEA stated that, "the Agency's basic safety standards will be based, to the extent possible, on the recommendations of the International Commission on Radiological Protection (ICRP)". The Board first approved basic safety standards in June 1962, published by the IAEA as Safety Series No. 92 and revised in 1967. A third revision was published as the 1982 Edition of Safety Series No. 94[3] which was jointly sponsored by the IAEA, the ILO, the OECD/NEA and the WHO.

In 1990, an important step towards international harmonisation of radiological protection and safety took place: an Inter-Agency Committee on Radiation Safety (IACRS) was constituted as a forum for consultation on, and collaboration in, radiation safety matters between international organisations. The IACRS initially comprised the European Commission (EC), the Council for Mutual Economic Assistance (CMEA);[4] the Food and Agriculture Organization (FAO), the IAEA, the ILO,

3. www.iaea.org.

4. Now defunct.

the OECD/NEA, the UNSCEAR and the WHO. The Pan American Health Organization (PAHO) joined subsequently.[5]

The objective of the IACRS is to promote consistency and co-ordination of policies with respect to the following areas of common interest:

- applying principles, criteria and standards of radiological protection and safety and translating them into regulatory terms;
- co-ordinating research and development;
- advancing education and training;
- promoting widespread information exchange;
- facilitating the transfer of technology and know-how; and
- providing services in radiological protection and safety.

Within this framework, the sponsoring organisations established a Joint Secretariat for the preparation of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (standards), contained in this publication. The Joint Secretariat was co-ordinated by the IAEA. The standards supersede the previous basic international standards and reflect knowledge gained subsequently, developments in radiological protection, safety and related fields.

The standards are based primarily on the recommendations of the ICRP. However, based on implementational experience, on new scientific data and on the new ICRP recommendations, the International Basic Safety Standards are currently in the process of being updated and revised, with the new version expected to be approved by all co-sponsoring organisations, through their own institutional mechanisms, in the timeframe between 2010 and 2011.

4. European Atomic Energy Community

Article 2 (b) of the Treaty establishing the European Atomic Energy Community (Euratom Treaty) stipulates that "*in order to perform its task, the Community shall, as provided for in this Treaty establish uniform safety standards to protect the health of workers and of the general public and ensure that they are applied*".

The requirements for radiological protection are laid down in Title II, Chapter 3 "Health and Safety", Articles 30 to 39 of the Euratom Treaty. Pursuant to the Treaty, a comprehensive set of directives, regulations, recommendations and decisions has been elaborated and adopted.

In particular, the European Atomic Energy Community (Euratom) has established its basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation, known as the European BSS Directive.[6] It is a legislative act addressed to the Member States of Euratom. They must implement the directive into their national legislation.

5. The ICRP, the ICRU, the IEC, the IRPA and the ISO have observer status on the IACRS.

6. Council Directive 96/29/EURATOM of 13 May 1996 Laying Down Basic Safety Standards for the Protection of the Health of Workers and the General Public Against the Dangers Arising from Ionising Radiation.

However, directives are binding as to the result without dictating the means of achieving it and leave to the national authorities the choice of form and methods of implementation [Article 161 of the Euratom Treaty]. If the laws of a Member State already comply with the European BSS Directive the state would only be required to keep its laws effective. If the national legislation does not adequately comply with the aims of the directive, the EC may refer the matter to the European Court of Justice.

As with the IAEA International Basic Safety Standards, the European BSS Directive is currently under review, with the intention to develop a new, updated version that reflects implementational experience, new scientific data and the new ICRP recommendations. The new European BSS Directive is expected to be adopted after 2010 and is planned to be coherent with the International Basic Safety Standards being developed by the IAEA.

5. The NEA Committee on Radiation Protection and Public Health (CRPPH)

The Committee on Radiation Protection and Public Health (CRPPH) of the OECD/NEA has the responsibility to study various aspects of radiological protection issues and take actions to support national authorities in the adoption and maintenance of high standards of protection in the use of ionising radiation.

Under its mandate, the CRPPH is responsible for radiological protection studies and experience exchange in light of the goals to:

- provide its members with a high-level, visible forum for exchange and discussion;
- seek common understanding of identified issues;
- advance the "State-of-the-art" in radiological protection theory, regulation and practice;
- advance policies that bring the system of radiological protection more in line with modern societal needs; and
- promote international co-operative projects.

By addressing these goals, the CRPPH is helping to establish a safe working environment for nuclear power and waste management operations as well as for medical, research and other industrial uses of ionising radiation. This is accomplished, in part, through the application of the ALARA principle (as low as reasonably achievable) to effectively manage public and worker exposures.

Performing the work in close collaboration with other international organisations[7] assures that its efforts are complementary. The CRPPH is also helping to promote international co-operation and discussion leading to more efficient and cost-effective resolution of important radiological protection issues. The CRPPH publishes a document detailing its accomplishments and objectives,[8] and in 2007 celebrated its 50th anniversary with, amongst other things, a publication describing the Committee's history.[9]

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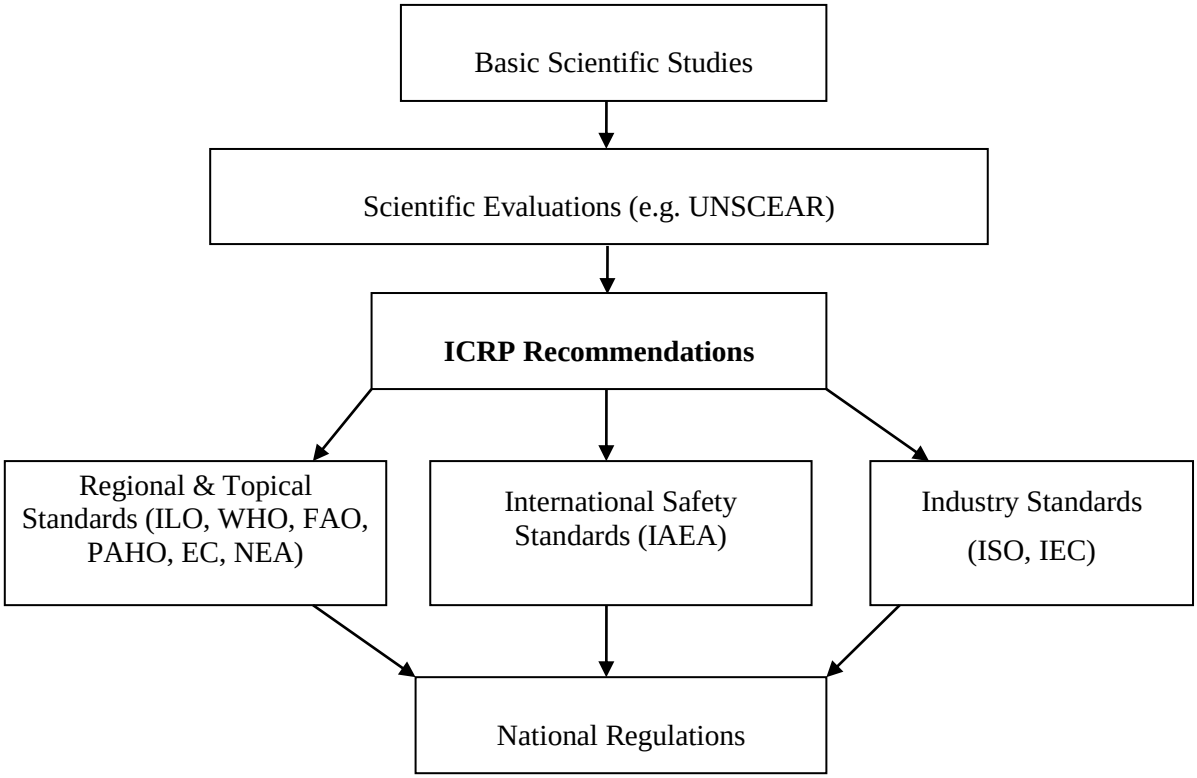
7. Particularly the IAEA, the EC and the ICRP, the IRPA, the ILO, the UNSCEAR, the WHO, the World Meteorological Organisation (WMO), the United Nations Office for the Co-ordination of Humanitarian Assistance (UN-OCHA) and the United Nations Development Programme (UNDP).

8. NEA/CRPPH(2007)5/REV1.

9. *Fifty Years of Radiological Protection*: *The CRPPH 50th Anniversary Commemorative Review*, OECD Nuclear Energy Agency, 2007.



II. The New ICRP Recommendations

As previously indicated, the ICRP reviews its recommendations periodically and issues updated general recommendations approximately every 10 to 15 years. Beginning in about 1999, nine years after the Commission had issued its last general recommendations as Publication 60, the ICRP Chair began to openly explore the evolution of the ICRP's recommendations, publishing a paper in the *Journal of Radiological Protection* titled, *"Control of low-level radiation exposure: time for a change?"*.[10] The evolution of the Commission's thinking was of great interest because most governments base their radiological protection policies and regulations at least in part on the recommendations of the ICRP.

The preliminary focus of the ICRP development has been on new general recommendations which will replace Publication 60 (see *Nuclear Law Bulletin* No. 77). As part of this process, the ICRP has also identified a need to clarify and update its views on the radiological protection of non-human species.

In 2000, based on national interest, the CRPPH began to actively focus on how the system of radiological protection could be made more responsive to decision makers, regulators, practitioners and the public. To achieve this, the relationship between the ICRP and the CRPPH was enhanced, with the CRPPH developing its thoughts as to how the system could be improved through the work of several expert groups.

10. *J. Radiol. Prot*., 19 No. 2, June 1999.

In a process that has been much more open than that for the development of the previous ICRP recommendations, the Commission has solicited input from a very broad spectrum of radiological protection stakeholders, ranging from government institutions and international organisations to NGOs. In this process, the NEA has also actively participated, primarily through the CRPPH, the expertise of its members and the Secretariat, by providing a fora and opportunities for interaction with interested authorities of member countries as well as the dialogue with other stakeholders. Since 1998, the CRPPH has organised eight international workshops,[11] performed four detailed assessments of ICRP draft texts[12] and has issued, in addition to conference proceedings documents, seven expert group reports proposing innovative approaches to the evolution of the ICRP's system of radiological protection.[13] These actions have been complemented by direct interactions with, and background briefings from the ICRP chairs and key members of the ICRP main commission and through the NEA Secretariat's expert participation in ICRP subcommittees and task groups.

The NEA's role has been to provide comments and feedback to the ICRP from key stakeholders such that the Commission's new recommendations adequately and appropriately address national issues and concerns, including those of policy makers, regulators and implementers. Several issues have been of particular concern to the NEA's constituency, and suggestions and comments from the NEA have resulted in significant changes in various draft ICRP recommendations. For example, as a result of NEA input the ICRP has maintained the concept of dose limits in its recommendations, has significantly and coherently clarified the nature and use of dose constraints and reference levels and has taken a much more "stepwise" approach to recommendations regarding the radiological protection of the environment.

In May 2003, the NEA Steering Committee for Nuclear Energy held a policy debate on the Evolution of the System of Radiological Protection, including a presentation by Prof. Roger Clarke, who was at that time the ICRP Chair. This policy debate concluded, *inter alia*, by appreciating the ICRP for its increased openness and encouraging continued efforts to work with OECD member countries to identify and address their concerns.

1. The current Radiological Protection Regulatory Scheme

Following the 1986 reassessment of exposures to victims of the Hiroshima and Nagasaki atomic bombs, the ICRP developed new recommendations in the form of Publication 60, implementing significant changes in dose limits and radiological protection policy.

Most importantly, worker dose limits were lowered from 50 mSv per year to 100 mSv over five years with a maximum of 50 mSv in any single year. Public dose limits had earlier been reduced from 5 mSv per year to 1 mSv per year. This was re-emphasised in the new recommendations.

The other significant change implemented in Publication 60 involved the management of radiological protection. Activities resulting in radiological exposures were divided into what the Commission called "practices", which increased exposures, and "interventions", which reduced exposures. The construction and operation of a nuclear power plant or a nuclear medicine clinic would be examples of practices, that is, new or ongoing activities that are subject to full regulatory processes

11. Taormina 2001; Tokyo 2002, 2004, 2006 and 2007; Lanzarote 2003; Washington D.C. 2006; Prague 2006, list of workshops see Annex.

12. In 2003, 2004, 2006 and 2007.

13. List of reports, see Annex.

and for which radiological protection decisions can be taken before an exposure is incurred. The post-accident situations or exposure to high natural levels of radon would be examples of interventions, where actions to protect exposed individuals are taken, but the situation already exists such that actions will, in effect, reduce exposures that would otherwise occur if no actions were taken.

Activities and protective actions were to be justified ("do more good than harm") and protection was to be optimised. Dose limits were applied only to practices and not to interventions because limits in intervention situations could have resulted in the need for protective actions that were excessively costly (i.e. not optimised).

Through various mechanisms, including national policies and regulations as well as international standards, the recommendations in Publication 60 have been broadly implemented in most countries, although in many countries they were only formally included in national regulations starting in 2001 and later.

2. Evolution of the Radiological Protection System in the New ICRP General Recommendations

The Commission had explained its decision to update its recommendations as being based on some evolution of scientific knowledge, but more broadly on the need to clarify and consolidate its older recommendations. It noted that, since Publication 60, it had issued approximately 40 other recommendation documents containing over 30 numerical criteria of varying bases and applications. Further, the Commission stated that the system based on practices and interventions had caused confusion and thus merited replacement.

In March 2007, as a result of discussions within the ICRP and with numerous other stakeholders, including the NEA, the Commission approved its new recommendations, which are expected to be published at the end of 2007.

The key aspects of the new recommendations that differ significantly from the 1990 Publication 60 recommendations are the following:

- **A situation-based approach**: Instead of organising the protection system based on the type of activity affecting the exposure (i.e. practices or interventions), the Commission now addresses radiological protection aspects based on the characteristics of the exposure situation, now defined as "planned, emergency or existing" and recommends that radiological protection be applied in the same way for each of these situations. Thus, in all exposure situations protection actions must be justified, protection must be optimised and exposures should be subject to appropriate limitation (dose limits, dose constraints, reference levels). The Commission says that these three exposure situations address all conceivable circumstances and defines them as follows:

  - *Planned exposure situations* are situations involving the deliberate introduction and operation of sources. Planned exposure situations may give rise both to exposures that are anticipated to occur (normal exposures) and to exposures that are not anticipated to occur (potential exposures).

  - *Emergency exposure situations* are situations that may occur during the operation of a planned situation or from a malicious act, or from any other unexpected situation and require urgent action in order to avoid or reduce undesirable consequences.

- *Existing exposure situations* are exposure situations that already exist when a decision on control has to be taken, including prolonged exposure situations after emergencies.

- **Dose constraints**: This concept intends to limit any inherent inequity that may be introduced when broadly optimising protection below the dose limit. Source-related dose constraints ensure that planning for protection will not allow the unequal distribution of doses among all those exposed. This concept has been very successfully used in practices, for example, in planning protection of workers at nuclear power plants. The Commission has now extended this to cover not just planned situations, but to cover all exposure situations.

  The dose constraint is not a regulatory guideline in the same sense as a dose limit. It is rather a planning tool for selecting protection options. Exceeding a dose constraint does not mean that a regulatory boundary has been passed, but that protective actions should be reviewed and modified if this would result in optimised protection under the circumstances at hand. In extending the application of dose constraints to emergency and existing exposure situations (called reference levels in these situations) as well as to planned exposure situations, the Commission now recommends a system of protection that is uniform in all situations.

- **More focus on optimisation**: The Commission states that its system applies equally to all exposure situations and that protection should always be optimised. By extending the concept of dose constraints to all exposure situations, the Commission is further emphasising that under all circumstances protection will be optimised. This does not mean that all exposures will be driven towards zero. Rather, it demonstrates the need to ensure that the benefits and detriments of any protective actions must be appropriately assessed in order to identify the "optimum" protection solution.

  It should also be noted that, for the first time, the Commission mentions the need to account for the views and concerns of stakeholders when optimising protection.

- **Updating risk estimation**: Based on the latest available scientific information of the biology and physics of radiation exposure, in particular from the Radiation Effects Research Foundation (RERF), the Commission's radiation and tissue weighting factors in the quantities equivalent and effective dose have been updated, as has the radiation detriment (relative risk per sievert of exposure). The detriment that radiation exposure can cause is in part a function of the type of radiation (e.g. alpha, beta, gamma, X-ray, neutron, proton, etc.) causing the exposure, with some radiation being more effective than others at causing an effect for an equal energy deposited. To account for this when assessing the total detriment caused by exposure to more than one type of radiation, radiation weighting factors are used so that all exposure components can be summed. Similarly, different body tissues (e.g. stomach, bone, thyroid, gonads, breasts, etc.) are more or less radiosensitive, such that the assessment of the "whole-body dose" requires the summation of effects on all organs and tissues. To do this, tissue weighting factors are used.

- **Radiological protection of the environment**: Although the new Commission recommendations do not include specific recommendations for the protection of the environment, they do include an approach for developing a framework to demonstrate radiological protection of the environment. Committee 5 of the ICRP, addressing protection of the environment, was recently created to develop specific recommendations

in this area. The proposed framework includes the definition of a small number of what the Commission calls "Reference Animals and Plants", or RAPs. These are stylised models of 12 creatures: ducks, frogs, rats, deer, pine trees, seaweed, earthworms, flatfish, trout, bee, crab and grass. The intention is that these can be modelled and exposures can be assessed based on environmental contamination (in air, water and soil). In addition, for these creatures there exists biological evidence of radiation-induced damage that can thus be used to assess overall detriment from a given, modelled exposure. This framework is presented by the ICRP as a "tool" that can be used when developing environmental impact assessments.

3. Questions concerning the Implementation of new ICRP Recommendations

The international community is now seeking to acquire a deeper understanding of the new ICRP recommendations so that they can be appropriately implemented. This will certainly involve an assessment of the possible impacts on existing radiological protection frameworks and practices as well as on subsequent regulatory implementation.

Although the Commission stresses its concern to "maintain stability in its recommendations", the new system does present some potentially significant changes that will need to be closely considered by regulatory authorities. These elements are described below.

Policy aspects

- The Commission is now focusing on the radiological protection of the environment. The new recommendations do not contain any specific recommendations in this area. However, the Commission states its "intention" to make recommendations in the future. National and international bodies that want to base or amend their framework accordingly will need to consider whether the Commission's current text on this subject and its intention to go further into this area, will affect current policies and regulations regarding the radiological protection of the environment.
- The implementation of the new ICRP recommendations will most likely entail the need for at least some modification of existing national regulations and international standards. NEA member countries have in the past implicitly insisted on the need to have only one broad approach to radiological protection, based on the recommendations of the ICRP. However, with the new ICRP recommendations, governments will need to decide whether the changes recommended by the ICRP will result in sufficient safety improvement to warrant the change of national regulations and international standards.
- The first practical application, in which the discussion will be of significance, is the development of the new IAEA International Basic Safety Standards (BSS). Currently being revised by a Secretariat of co-sponsoring organisations, led by the IAEA and including the NEA, the shift from the ICRP Publication 60 system to the new ICRP recommendations may entail changes that could affect many of the IAEA's safety standards documents. The NEA standing technical committees have pushed to have the new BSS as a complete, stand-alone document reflecting the new ICRP recommendations.
- The European Commission is also revising its BSS Directive and will thus need to consider how to implement the new ICRP recommendations.

- Finally, the implementation process will show whether there will be a discussion of a "graded approach" to applying the Commission's recommendations, such that some flexibility will be taken with regard to how the new ICRP recommendations are applied in the various national and international fora, particularly in NEA member countries versus in non-NEA member countries.

Practical aspects

- Switching from practice/intervention to a situation-based system raises several questions that will need to be answered or interpreted for implementation. These questions are similar for the three newly defined exposure situations (planned, emergency and existing), yet will still require individual attention.

  Planned exposure situations

  – What will be the regulatory interpretation and use of dose constraints and what will be the regulatory relationship between dose limits and dose constraints?

  – What effects will the new recommendations have on regulatory organisations and on the nuclear industry and on the non-nuclear industry?

  – What effects will the Commission's new focus on optimisation and stakeholder involvement have on current implementation of the ALARA principle?

  Emergency exposure situations

  – How will the newly recommended reference levels (20-100 mSv per year band) be used in emergency exposure situations?

  – How will the focus on optimisation of protection strategies, rather than single countermeasures, effect emergency response planning and implementation?

  – What effects will the Commission's new focus on optimisation and stakeholder involvement have on optimisation?

  Existing exposure situations

  – How will the newly recommended reference levels (1-20 mSv per year band) be used in existing exposure situations?

  – What effects will the Commission's new focus on optimisation and stakeholder involvement have on the ALARA principle, for example, in the release of contaminated sites after clean-up?

  – What effect will the new reference-level concept have on regulatory approaches to protect against domestic and occupational exposures to radon?

4. Emerging Challenges from Radiological Protection Science

The new radiation and tissue weighting factors will need to be implemented into dose assessment models. In that many countries use or reference specific dose assessment models in their

regulations, the work to incorporate the new weighting factors may require regulatory updates that could involve regulatory review processes. This would most likely be a burden to regulatory authorities, but also to licensees and expert bodies.

In addition to these new scientific results, which have been implemented in the new ICRP recommendations, several other aspects of radiological risk remain and continue to be studied, but have not as yet been the object of consensus. Regulatory authorities may wish to begin considering the potential impacts that these scientific developments could have. These include:

- new quantification of risk to the lens of the eye;
- new risks that ionising radiation may pose in terms of non-cancer effects, such as circulatory diseases;
- social and regulatory implications that could be posed by deeper scientific understanding of genetic susceptibility to radiation-induced diseases; and
- social and regulatory implication that could be posed by deeper scientific understanding of the age and gender-specific risks.

Many of these issues have been outlined in the NEA's report on *Scientific Issues and Emerging Challenges for Radiological Protection*.[14] Scientific challenges to the existing paradigm, like those listed above, will continue to arise as scientist's "do their job" of studying the causes and detrimental effects of ionising radiation. From the public health regulatory perspective, it will be important to continue following and sponsoring scientific developments so as to avoid, as best possible, being caught by surprise by new scientific results.

Conclusions

The system of radiological protection and the organisations that develop and implement it continue to evolve. This presents a challenge to the stability of regulation and to the smooth operation of regulated activities. In effect, the evolution of the system of radiological protection can be seen through the lens of the precautionary principle: changes, whether incremental or larger, occur when it is judged that changing will do more good than harm. Detailed interpretation of this will always remain in the hands of decision makers, who are advised by their legal and technical experts.

14. *Scientific Issues and Emerging Challenges for Radiological Protection*: *Report of the Expert Group on the Implications of Radiological Protection Science*, OECD Nuclear Energy Agency, 2007.

Annex

List of NEA Activities and Publications Related to the Development of New ICRP Recommendations

NEA Workshops

- *The Future Policy for Radiological Protection, A Stakeholder Dialogue on the Implications of the ICRP Proposals*, Prague, Czech Republic, 24-25 October 2006.
- *Evolution of the System of Radiological Protection, A Stakeholder Dialogue on the Draft 2006 ICRP Proposals*, Washington D.C., United States, 28-29 August 2006.
- *Evolution of the System of Radiological Protection, Third Asian Regional Conference*, Tokyo, Japan, 5-6 July 2006.
- *Evolution of the System of Radiological Protection*, Second Asian Regional Conference, Tokyo, Japan, 28-29 July 2004.
- *Asian Regional Conference on the Evolution of the System of Radiological Protection*, Tokyo, 24-25 October 2002.
- *The Future Policy for Radiological Protection, A Stakeholder Dialogue on the Implications of the ICRP Proposals*: 2nd NEA Forum in collaboration with the International Commission on Radiological Protection (ICRP), Lanzarote, Canary Islands, Spain, 2-4 April 2003.
- *Radiological Protection of the Environment*: *The Path Forward to a New Policy*? Taormina, Sicily, Italy, 12-14 February 2002.

NEA publications (available from www.nea.fr or www.oecdbookshop.org)

- *A Stakeholder Dialogue on the Implications of the ICRP Proposals* (Summary of the three 2006 NEA/ICRP conferences held in Tokyo, Washington D.C. and Prague), OECD/NEA (2008).
- *The Future Policy for Radiological Protection, A Stakeholder Dialogue on the Implications of the ICRP Proposals*, Prague, Czech Republic, 24-25 October 2006, Workshop Proceedings, OECD/NEA (2008).
- *Evolution of the System of Radiological Protection, A Stakeholder Dialogue on the Draft 2006 ICRP Proposals*, Washington D.C., United States, 28-29 August 2006, Workshop Proceedings, OECD/NEA (2008).
- *Evolution of the System of Radiological Protection, Third Asian Regional Conference*, Tokyo, Japan, 5-6 July 2006, Workshop Proceedings, OECD/NEA (2008).
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