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Evolution of the System of Radiological Protection

Implementing the 2007 ICRP Recommendations

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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Foreword

The Committee on Radiation Protection and Public Health (CRPPH) of the OECD Nuclear Energy Agency (NEA) has actively supported the open process initiated by the International Commission on Radiological Protection (ICRP) to revise its general recommendations. In this process, the NEA member countries in the Asia-Pacific region have played an important role. The specific views of these members were addressed through four Asian Regional Conferences on the Evolution of the System of Radiological Protection, held in Tokyo, Japan, in October 2002, July 2004, July 2006 and December 2007. The results of these conferences were provided directly to the ICRP for consideration. With input from such stakeholder dialogues, the ICRP published the new ICRP recommendations in December 2007. The publication of these recommendations and the success of the previous Tokyo conferences led the CRPPH to organise a fifth Asian Regional Conference to discuss the implementation of the 2007 ICRP recommendations and to provide a dedicated forum for Asian views.

The fifth Asian Regional Conference was organised on 3-4 September 2009 by the OECD/NEA in collaboration with the ICRP, the Nuclear Safety Commission (NSC) of Japan and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, and was co-sponsored by the National Institute of Radiological Sciences (NIRS) of Japan. The conference addressed the following issues:

- the impact of the new system of radiological protection on international standards, as well as on national developments and regulation;
- views from Japanese academics and the nuclear industry on the implementation of the 2007 ICRP recommendations;
- future challenges and opportunities from the Asian perspective associated with the evolution of the system of radiological protection;
- securing and fostering the training of younger experts responsible for radiological protection.

The results of the conference, reported herein, will provide useful and practical approaches and experience for implementing the 2007 ICRP recommendations for NEA member countries in the Asia-Pacific region.

Acknowledgements

The CRPPH and the ICRP would like to thank Dr. Kenneth Kase for the preparation of this report.

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Executive summary

A little more than one year following publication of the ICRP recommendations the fifth Asian Regional Conference was organised by the OECD/NEA in collaboration with the International Commission on Radiological Protection (ICRP), the Nuclear Safety Commission (NSC) of Japan, and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, and was co-sponsored by the National Institute of Radiological Sciences (NIRS) of Japan. This followed four previous Asian Regional Conferences on the Evolution of the System of Radiological Protection, held in Tokyo, Japan, in October 2002, July 2004, July 2006 and December 2007. The results of the first three conferences were provided to the ICRP for consideration during the development of their recommendations. The fourth conference in December 2007 was held to begin consideration of the next step after the publication, the implementation of the new ICRP recommendations.

The objectives of this fifth forum, in Asia, following the publication of the new recommendations by the ICRP (2008), were to:

- discuss the potential impact of the recommendations on international standards and national regulations;
- receive the views from the Japanese academic community and the nuclear industry on the implementation of the 2007 recommendations;
- consider the evolution of the system of radiological protection and the challenges and opportunities for the future from the Asian perspective;
- discuss the serious concerns about securing and fostering young experts responsible for radiological protection.

The experts participating in this conference represented a broad group of stakeholder organisations from Australia, China, Japan, Russia, South Korea and the United States. The ICRP presented a review of the new recommendations and the IAEA gave an update on the development of the revision to its Basic Safety Standards.

The participating countries have, in general, accepted the recommendations of the ICRP as presented in the ICRP Publication 103 (2008). This acceptance was clearly facilitated by the dialogue that the radiological protection community had with the ICRP leading up to Publication 103, much of it arranged by the NEA. There is a broad expectation that ICRP Publication 103 will now be implemented and that implementation may be accomplished more quickly than for Publication 60.

The ICRP, represented by Dr. John Cooper, presented a detailed summary of the new recommendations, focusing on the reasons for new recommendations, new evaluation of the health risks, changes in the dosimetry, and the "new" system of protection.

The following discussion concerning implementation of the recommendations resulted in the identification of some key issues that must be considered:

- There is a general view that stakeholder involvement will be central to the implementation of optimisation in many countries.
- Stakeholder involvement is a function of cultural and national diversity, and has a distinctively different "flavor" in Asian countries than in European or North American countries. Asians should meet to discuss and exchange experience in stakeholder engagement in an Asian context.
- There is genuine concern about fixing numerical values of dose constraints in regulation. Concepts similar to dose constraints that appear in current regulations should be clarified in any future regulatory framework.

Key technical aspects that must be developed as a part of implementation were also raised in the presentations and discussions. Countries realise that the new ICRP recommendations will impact their regulatory systems. The key technical issues are:

- the possible introduction of dose constraints into the regulatory system;
- the concept of planned exposure situations;
- the type of guidance and regulation needed for existing and emergency exposure situations, in particular in setting reference levels;
- guidance for optimising medical exposures, and for fixing values of diagnostic reference levels; and
- concerns about developing optimisation criteria and methodology.

Participants expressed the opinion that sharing experiences on the resolution of these issues would be valuable.

The session of the conference devoted to securing and fostering the training of young experts responsible for radiological protection identified some important concerns related to education and training, outreach and funding. It is clear that there is a need to develop broadly educated experts as well as scientists with specific technical expertise in radiological protection. However, in many instances specificity is rewarded more than general and broad knowledge. This contributes to a deficiency in the ability to attract highly qualified students to radiological protection studies. Some specific issues are:

- The history of the development of radiological protection that has produced our current state of knowledge is not well enough included in educational programmes.

- Exchange of experience and knowledge management approaches needs to be further enhanced.
- There is a need for more "outreach" to foster student and researcher interest in radiological protection. Some suggested approaches include:
  - making information (schools, scholarships, cultural aspects, etc.) available on a national level; and coordinating such national-level programmes at the international level;
  - emphasising the relevance of radiological protection research to practice and to society.
- Young experts should be encouraged and supported to participate in national and international meetings and committees.
- The Japanese model of young researcher associations could be extended to other countries, and such organisations should communicate with each other (international meetings and committees, etc.).

The question of funding was raised. It is clear that there is a need to support these activities, but funding is severely limited. There is a need for further discussion, especially concerning the roles and responsibilities of government, industry and universities in developing and funding programmes and involvement.

In conclusion, the presentations and discussions that took place at this conference were of high quality and are constructive contributions to the debate that is essential to effective implementation of the ICRP recommendations in Publication 103. The contribution of young researchers to the consideration of the future of radiological protection was remarkable. These results should encourage the NEA to continue providing opportunities such as this conference for further dialogue on these important concerns, not only between the ICRP and its stakeholders, but also among the radiological protection community, industry and educational institutions.

Finally, the forum and its participants are grateful to the ICRP and the NEA as well as the NSC, the MEXT and the NIRS, for the organisation of this dialogue.

1. INTRODUCTION

The objectives of this fifth conference were to evaluate and discuss with experts from the Asian and Pacific area countries experience with the implementation of the 2007 Recommendations of the International Commission on Radiological Protection (ICRP) published as ICRP Publication 103 (2008). As stated by John Cooper of the ICRP Main Commission, "The Recommendations have been prepared after two phases of international public consultation." This public consultation included the four previous Asian Regional Conferences held in Tokyo in October 2002, July 2004, July 2006 and December 2007.

This fifth conference advanced the discussion to the implementation phase and began to consider the issues related to impacts on international and national standards and the nuclear industry, and implementation issues in general from the perspective of regulators. A session was also dedicated to the auxiliary concern of fostering the development of young experts in radiological protection.

As an international committee made up of nationally nominated radiological protection authorities and technical experts, the NEA Committee on Radiation Protection and Public Health (CRPPH) has for most of its history actively followed the work of the ICRP (NEA, 2007). The NEA organised seven international workshops and performed four detailed assessments of draft ICRP texts (in 2003, 2004, 2006 and 2007). The CRPPH record of this effort has been published and is available on the NEA website (www.nea.fr).

This conference is a natural follow-on to those that produced the "much improved" ICRP Publication 103.

2. THE NEW ICRP GENERAL RECOMMENDATIONS

2.1 Reasons for new recommendations

The primary aim of the ICRP in developing a new publication with basic recommendations for the system of radiological protection in 2007 was to contribute to an appropriate level of protection for people and the environment without unduly limiting the desirable human actions that may be associated with radiological exposure. To accomplish this aim the ICRP undertook first to consolidate the more than 30 different numerical restrictions that had been established in different ways and promulgated since the publication of its previous basic recommendations (ICRP, 1991). Secondly, the ICRP consolidated and clarified the over-elaborate terminology that had developed as part of these restrictions. Finally, the ICRP determined that there was an increasing need to include protection of non-human species in the system of protection in some way.

As part of the development of the new set of recommendations, the ICRP endeavoured to take account of new biological and physical information and of trends in the setting of radiological safety standards. There also was an effort to improve and streamline the presentation of the recommendations as well as to maintain as much stability as is consistent with the new scientific information.

2.2 Summary of health risks

The new assessment of health risks is largely based on new cancer incidence data for the Japanese atomic bomb survivors, which has become available since 1990. These data cover the population of all ages and both genders, with a wide range of doses and long follow-up. The cancer risks were considered in depth in ICRP Publication 99 (ICRP, 2005). For radiological protection purposes, the ICRP continues to judge it prudent to adopt a linear non-threshold model for stochastic risks. However, uncertainties in the assessment of risks at low doses are recognised.

A new methodology has been adopted by UNSCEAR to estimate hereditary risks (UNSCEAR, 2001), but it should be noted that while the risk of hereditary effects is included in estimated detriment, no such effects have been demonstrated convincingly in human populations.

The estimates of detriment have changed little since 1990. For the whole population the estimate is now 5.5 percent Sv^{-1} for cancer and 5.7 percent Sv^{-1} for total detriment. In the working population the estimates are 4.1 percent Sv^{-1} for cancer and 4.2 percent Sv^{-1} for total detriment. These values are lower, but

not significantly, than the corresponding values of 6.0 (7.3) and 4.8 (5.6) given in Publication 60 (ICRP, 1991). As such, the ICRP has recommended that its overall risk estimate of fatal risk coefficient of 5 percent Sv^{-1} remains appropriate for radiological protection purposes.

Non-cancer diseases

ICRP identified an increase in the risks of heart, digestive and respiratory diseases among Japanese A-bomb survivors. An increase in heart disease has also been observed among patients given radiological therapy to areas around the heart. Both ICRP and UNSCEAR have emphasized the difficulty in knowing whether the risks have increased at doses below 0.5 Gy.

2.3 Summary of changes to dosimetry

Changes were made to both radiological and tissue weighting factors, w_R and w_T. The weighting factor for neutrons was changed from a stepwise function to a continuous function of neutron energy, and that for protons was reduced from 5 to 2. The tissue weighting factor for the breast was increased from 0.05 to 0.12, and that for gonads was decreased from 0.2 to 0.08. Several organs were added to the list of remainder organs and the w_T for these organs was increased from 0.05 to 0.12. Other changes made include the specification of gender specific phantoms to be used and sex-averaging for calculating effective dose.

Finally, the ICRP clarified its recommendations on the intended use of ICRP dose quantities. Effective dose is a protection device that allows summation of doses from internally absorbed radionuclides and external sources. It is properly used for regulatory purposes, for comparison with dose limits and constraints, and applies to stochastic effects only. Effective dose should not be used for assessments of doses and risks to specific individuals, for epidemiological studies, nor for assessment of tissue reactions. For those purposes the appropriate dose quantity is absorbed dose in the organs and tissues of interest, the appropriate RBE values for those organs and tissues, and the specific organ and tissue risk estimates.

2.4 The "new" system of protection

In summary, the fundamental principles remain justification, optimisation, and the application of dose limitation. The major features of the new recommendations are:

- Updated radiological and tissue weighting factors.
- Updated radiological detriment based on the latest available science.
- Clarification on how the fundamental principles apply to sources delivering exposure and to individuals receiving exposure.
- An evolution from a process-based protection approach (practices and interventions) to a situation-based approach (planned, existing and emergency).

- The application of the principles of justification and optimisation of protection to all controllable exposure situations.
- Individual dose limits are maintained for all regulated sources in planned exposure situations.
- Optimisation is reinforced and is applied in a similar way to all exposure situations, with restrictions on individual doses and risks through dose constraints for planned exposure situations and reference levels for emergency and existing exposure situations.
- An approach for radiological protection of the environment is included.

2.5 Future publications

In the next several years, the ICRP plans to publish additional recommendations for applying the system of radiological protection. These include:

- Phantoms to be used for dose calculations for adults, children, pregnant woman and foetus.
- Radionuclide decay data.
- Occupational intakes giving dose coefficients and bioassay data to replace Publication 30.
- Dose conversion coefficients for external radiological.

2.6 Summary of new recommendations

Under the new recommendations the system of radiological protection applies to all exposure situations, and to all sources and exposures, including naturally occurring radiological. Justification is required for any increase or decrease in exposure. Optimisation is to be used to provide the best protection under the prevailing circumstances to maximise the margin of benefit over harm. A level of dose (or risk) is to be defined, depending on the situation (a constraint or reference level), which should not be exceeded.

Exposure situations are divided into those that are planned and those that already exist. Situations that are planned refer to exposures arising from normal operations and to potential exposures that would be expected to arise from practices. There has been no change to the recommendations for dose limits. However, in specifying dose the former “Critical Group” has been changed to the “Representative Person”. Situations that already exist include exposures from natural sources, exposures from residues from past practices, and exposures from emergency or accidental situations.

In summary, the system of protection is situation based and all conceivable exposure situations are included. Updated data on biological effects have been used to estimate risk, and tissue and radiological weighting factors have been adjusted. Dose constraints and reference levels are emphasised to guide optimisation under prevailing circumstances, but the fundamental principles remain, justification, optimisation and dose limitation. Optimisation is now more clearly the central protection principle.

3. COMMENTS ON IMPLEMENTATION OF THE NEW RECOMMENDATIONS

Following the review of ICRP Publication 103 and its recommendations, the conference was divided into four additional sessions:

- Impact of the new system on:
  - international standards;
  - national development and regulation.
- Views from Japanese academic society and the nuclear industry on the implementation of the 2007 recommendations.
- Evolution of the system of radiological protection: challenges and opportunities for the future from the Asian perspective.
- Securing and fostering the training of younger experts responsible for radiological protection.

Presentations and discussions on these topics led to the identification of some key issues and technical aspects that need to be addressed for the implementation of the recommendations. Finally, the views of young researchers identified some concerns and gave perspective to the task of preparing the next generation of experts in radiological protection.

3.1 Key issues

During the development of its new recommendations on the system of radiological protection, released as Publication 103, the ICRP promoted and participated in discussions and exchanges of ideas on its proposals for a number of years. Because of this openness and dialogue, there is a broad international agreement on the system of protection and an expectation that the recommendations in Publication 103 will now be implemented. Implementation will be designed to make the management of the system practical and to respect societal values.

Representatives of many countries indicated that they would accelerate the implementation of the new recommendations. Thus, the implementation of ICRP Publication 103 may be accomplished more quickly than the implementation of the 1990 recommendations in Publication 60 (which took ten or more years in many cases). However, it is likely that most countries will await the publication of the revised IAEA Basic Safety Standards (BSS) before changing their regulations.

In many countries it is expected that stakeholder involvement will be central to the implementation of optimisation as presented in Publication 103. There was some expression of concern about its realisation in Asia. Stakeholder involvement is a function of cultural and national diversity, and its use and methodology may be distinctively different in Asian countries than in European or North American countries. Asian radiological protection authorities should meet to discuss and exchange experience in stakeholder engagement in an Asian context.

Concerns regarding implementation centred on dose constraints, reference levels, criteria and methodology for optimisation, and limits on optimisation at low doses. Specific concerns were voiced with respect to fixing numerical values of dose constraints in regulation. In particular in Japan, the current regulatory language refers to "dose target" (used as guidance from the Nuclear Safety Commission), and Japanese utilities use "screening level" for the control of occupational exposure. These currently used concepts should be clarified, in the context of dose constraints, for use in any new Japanese nuclear safety framework.

Participants emphasised and repeated several times that dose constraints are for use prospectively in optimising radiological protection. The optimisation process is continuous and involves comparing performance with the constraints possibly leading to resetting the constraints and improving performance. However, there was a warning that optimisation could be wasteful of resources when the demonstrated doses at a facility are already very small.

3.2 Key technical aspects to be addressed for implementation

Implementation in regulation

Clearly there is concern among the various countries about the possible impacts of the new ICRP recommendations on their regulatory systems, especially the possible introduction of dose constraints into the regulatory system. Some countries reported on specific current national efforts to implement the recommendations in Publication 103. Other participants indicated that their countries are at various stages of implementation planning. However, almost all countries stated that they are awaiting the finalisation of the BSS revision before moving forward definitively.

Planned exposure situations

Those countries that have begun planning for implementation of the recommendations indicated a need for discussions to share experiences with the concept of planned exposure situations. Some specific aspects that need to be addressed are dose constraints for public and occupational exposures, fixing numerical values and introducing the concept into regulations. It was pointed out that dose constraints are a useful tool for planning protection of the public, but caution was expressed that they not be fixed too conservatively. Another aspect that requires sharing information relates to the establishment of guidance for optimising medical exposures, and for fixing values of diagnostic reference levels (DRL).

Existing and emergency exposure situations

Countries are working to determine the type of guidance and regulation to develop for existing and emergency exposure situations, in particular in setting reference levels. Further exchanges of ideas and experiences on this issue would be valuable.

Optimisation

There were concerns expressed over optimisation criteria and methodology. Sharing experiences, particularly with stakeholder engagement, would be valuable.

3.3 Practical implementation of dose constraints

Dose constraints are a practical tool for guiding the optimisation process. At nuclear power plants optimisation is "task-related" for worker protection and has been a strong focus for some time. This is consistent with the recommended use of dose constraints that are described by the ICRP as "source-related". Optimisation of protection using dose constraints must be applied to protection of both workers and the public for all planned exposure situations. For protection of workers dose constraints should be set at a reasonable level depending on the task. Dose constraints for public protection should be set below the public dose limit, but not too conservatively. Establishing a repository for collecting operational experience with establishing and implementing dose constraints could be useful.

4. VIEWS OF YOUNG RESEARCHERS

The issue of sustaining a workforce of radiological protection experts that is sufficient for the needs of society is a serious concern among industry and medical practitioners, and regulators. A portion of the conference was devoted to presentations on this subject from young researchers in radiological protection. Difficulties in promoting radiological protection as a career were identified and discussed. This led to several suggestions concerning education and training, outreach to students and researchers, and funding.

4.1 Education and training

Education and training of radiological protection experts and researchers must be designed to be both diverse and directed toward specific expertise. Broadly educated radiological protection experts are needed for planning, executing and regulating radiological protection efforts that cross disciplinary lines of physics, chemistry, engineering, biology, law, etc. However, experts in specific technical areas are also needed to deal with specialised activities in dosimetry, shielding, radiochemistry, biological and medical research, etc.

It is clear that many problems tend to be multi-disciplinary, and need broad knowledge to be addressed, however in radiological protection research and practice specificity is rewarded more than general and broad knowledge. This issue needs to be addressed to attract more talented individuals into applied and regulatory positions.

There is a concern that the history of development of radiological protection research and practice leading to our current state of knowledge is not well enough included in educational programmes. This leads to a deficit in the knowledge base and understanding of the fundamentals of radiological protection.

Knowledge management and exchange of experience need to be further enhanced in the educational and training system for the next generation of radiological protection experts and researchers.

4.2 Outreach

The participants agreed that there is a need for more outreach in schools and universities to foster student and researcher interest in the field of radiological protection. Centralised approaches to make education information available at the national level may be effective. This could include placing information in

schools, offering scholarships, supporting participation in science fairs, developing cultural aspects, etc. Coordination of such national-level programmes at the international level would also be useful.

An effort must be made to actively involve students at the graduate level, young researchers and young experts in national and international meetings and committees where radiological protection issues are discussed and decisions affecting the practice of radiological protection are made. This would provide incentives for young people to seek a career in radiological protection. The Japanese model of young researcher associations should be extended to other countries, and such organisations should communicate with each other through participation in international meetings and committees, etc.

Other aspects for extending outreach and increasing public awareness of the radiological protection profession should include a public emphasis of the relevance of research in the science of radiological protection to the practice of radiological protection and its value to society.

4.3 Funding

The question of funding for education and training, outreach activities, and participation in national and international activities was raised. It is clear that there is a need to support these activities, but funding is severely limited. Further discussion of these issues is important, especially concerning the roles and responsibilities of government, industry, and universities.

It could be valuable to collect information and coordinate dissemination about the opportunities for and support of students and young scientists with respect to educational and research programmes, information exchange, financial support and employment opportunities.

5. CONCLUSIONS FOR THE NEA/CRPPH

The presentations and discussions that took place at this conference were of high quality and are constructive contributions to the debate that is essential to effective implementation of the recommendations of the ICRP in Publication 103. The contribution of young researchers to the consideration of the future of radiological protection was remarkable. These results should encourage the NEA to continue providing opportunities such as this conference for further dialogue on these important concerns, not only between the ICRP and its stakeholders, but also among the radiological protection community, industry and educational institutions. These dialogues should be encouraged and supported in all regions of the world because the radiological protection concerns and issues discussed in this conference apply globally.

In particular, the fifth Asian Regional Conference on the Evolution of the System of Radiological Protection identified some potential new action for the NEA Committee for Radiation Protection and Public Health:

- The CRPPH could provide a good forum for promoting dialogue on the implementation of dose constraints and reference levels in regulation and in practice for all exposure situations.
- The CRPPH could also provide a forum for exchanging experiences on optimisation and stakeholder engagement. A particular point of discussion should be how to end the optimisation process and address the question of when no further actions are warranted.
- In addition, stakeholder involvement is a function of cultural and national diversity, and has a distinctively different “flavor” in Asian countries than in European or North American countries. The CRPPH should assist its Asian constituency, and their Asian colleagues as appropriate, to meet to discuss and exchange experience in stakeholder engagement in an Asian context.
- The CRPPH should continue the discussion opened at its May 2009 meeting concerning the issue of human resources in radiological protection.
- The CRPPH could effectively promote dialogue concerning education and training, outreach and funding for students and young scientists in radiological protection.
- The NEA should consider establishing a mechanism among its member countries for collecting information and coordinating dissemination about the opportunities for, and support of, students and young scientists with respect to education and research in radiological protection.

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