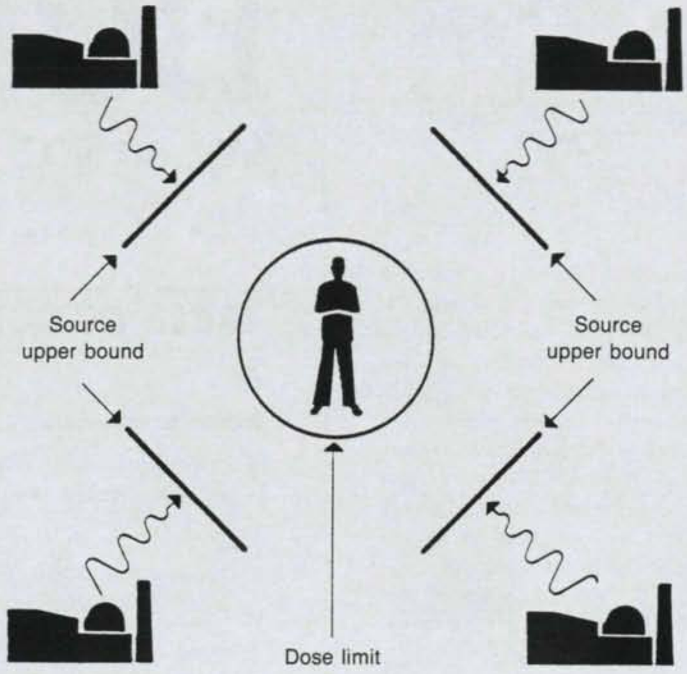
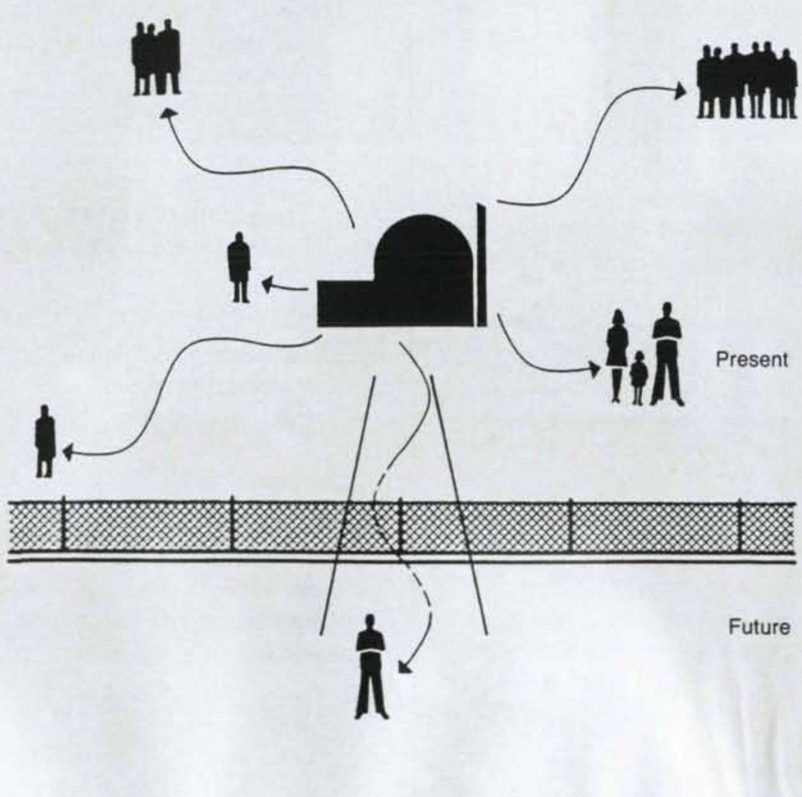
The IAEA's *Basic Safety Standards for Radiation Protection* ensure an adequate level of individual protection through an *individual-related requirement.* This establishes that no *individual* shall be exposed, as a result of controlled sources and practices, in excess of the *dose limits* set forth by the Standards. The total individual dose excluding natural background and medical exposure of patients must be considered. If exposure from several sources is possible, *source upper bounds* should be established; these are fractions of the dose limits, assigned to particular sources of exposure.

Individual-related requirements



The Standards provide additional protection through *source-related requirements* which establish the *justification of the practice* — for which the source is needed — and the *optimization of radiation protection* to be applied to the source. These take into account the sum of all doses — however small — delivered by the source regardless of location and time of the exposure.

Source-related requirements



Radiation protection in nuclear energy

Overview of the IAEA's conference in Sydney, Australia

by F.N. Flakus

Perhaps more than anticipated, lively and stimulating discussions characterized the IAEA's April 1988 conference on radiation protection in nuclear energy. Highlights included sessions on the interface between nuclear safety and radiation protection, the evolution of radiation protection principles, exemption rules, accident experiences (Chernobyl, Goiânia), and, in particular, the special session on the practical implications of the linear dose-response relationship. A recurring theme was the need to improve communication among experts and the general public. This article summarizes major points of selected sessions, starting with the special session on the dose-response relationship and its implications for nuclear energy.

Dose-response relationship

The linear dose-response hypothesis as applied in radiation protection has far-reaching consequences and is increasingly becoming a matter of considerable debate in many countries. To better appreciate the dose-response relationship and problems that exist with its application in practice, a special session was added to the scientific programme of the conference.

The discussion was restricted to the implications rather than the scientific validity of the current dose-response relationship.

Background. It was pointed out that the linear non-threshold dose-response relationship was the result of an evolutionary process over many years and not something imposed by radiobiologists from the beginning of radiation protection. While many cells need to be killed to make a tissue fail (non-stochastic effects), effects that depend upon transformation of one cell are, and continue to be, probabilistic (stochastic effects). One is never at zero dose. Owing to natural background radiation, a middle-aged person has accumulated a dose of the order of 70-100 millisievert (mSv) (7-10 rem). At a given age, the total risk is proportional to the addition of the "background dose" and any dose increment from other radiation sources. Linearity refers to the increments of dose and risk. The additivity of doses makes practical radiation protection possible. In that sense, linearity is almost a necessity for practical radiation protection.

Practical problems. It was recalled that probability in itself is a complicated quantity and that in plant safety assessment there are three distinct mathematically different types of probability involved: statistical quantities (component reliabilities), logical deductions from reasoning (e.g. fault and event trees), and expressions of degrees of belief (e.g. experts' judgement). These are combined to yield an understanding of the plant behaviour. Added to these are the probabilistic nature of weather patterns and of the dose-effect relationship. By the time one gets to risk, the concept of probability is well mixed, which causes misinterpretation. It was suggested to try to find alternative attributes for describing accident consequences.

In contrast to problems arising in the "low probability — high consequence area", other contributions referred to difficulties experienced in the "high probability — low consequence area", notably exemptions from regulatory control. The importance of arriving at an international consensus was underlined several times. *(See article on this subject in this edition of the Bulletin.)*

It was also illustrated that many measures are taken to decrease both collective (public) and individual (worker) doses through improvements to plant design and in operation planning, and enhanced motivation for dose reduction. What should be done, however, in cases where worker doses go up as a result of reduction of public doses, or when worker doses decrease and as a result "conventional" risks then increase?

High unneccessary costs arise when too much emphasis is placed on protection against risk that is considered trivial; those funds could otherwise have been more wisely used in saving lives.

One does not need to have a zero risk to accept something. One could have a sizeable risk and accept it in everyday life. We have a sizeable risk of being run over by a car and, yet, we walk in the streets. This risk is well known by counting bodies — a much better method than

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in radiation protection. The major issue is the legal concern. There are many risks in life which have no threshold. The fact that the ALARA principle is stressed as being of legal concern makes a big difference.* The wrong impression is given that non-threshold risks are something new in technology, although much in life is without a threshold. However, we have limits which determine action.

Communication. A basic cause of unjustified fear of radiation, called "radiophobia", is due to the terminology that is used. Axioms such as "there is no safe level of radiation" are frequently heard. The word "risk", intended as a technical term, a number and a measure of the probability of occurrence of an unlikely event, implies "imminent danger". There are better alternative words than risk. Why not safety? Nothing in life is entirely safe, but something can be extremely safe. The fact that there is risk does not mean that there is not sufficient safety. The radiation protection community must begin a dialogue that will lead to a better understanding of radiation.

Nuclear safety and radiation protection

The interface between nuclear safety and radiation protection was a timely and important part of the conference in view of the considerable lack of communication between the engineers and those involved with radiation protection. This is illustrated when technical issues have to be addressed.

One paper discussed criteria for anticipated situations. These include exposures which are assumed to occur with certainty, uncertain exposures to which a probability of occurrence can be assigned, and unanticipated situations involving unforeseen radiation exposure. The paper analysed policy issues that the radiation protection community will face in the coming years. The protection policy developed through the years by the International Commission on Radiological Protection (ICRP) has the objective of protecting humans from the harmful effects of ionizing radiation while still allowing necessary activities from which radiation exposure might result. The policy is limited since it applies to anticipated situations only and not to the whole spectrum of situations. Additional undertakings are necessary to make radiation safety fully applicable. The necessary actions go beyond the ICRP framework and require the participation of national and international organizations with responsibilities in radiation safety.

Of the world's total estimated 2600 radiation protection standards, only 10% are international. However, the importance of international standards is growing and further harmonization efforts are necessary in view of the role of standards as instruments of technology transfer.

* ALARA means as low as reasonably achievable, social and economic factors being taken into account.

The session also addressed the general framework of waste disposal safety assessments; topics related to optimization and long-term aspects; and the significance of low probability events. It was concluded that the use of several approaches in parallel was the most suitable way of overcoming difficulties in performance assessments related to long-term environmental impacts and low-probability events.

Radiation protection principles

A new dosimetry system (DS86) for atomic bomb radiation was developed in March 1986 by the collaborative efforts of committees on dosimetry reassessment in the USA and Japan. This new system was used by the Radiation Effects Research Foundation to recalculate individual exposure doses for the survivors, which had thus far been estimated based on the tentative 1965 dose (T65D) system. The health data for survivors are being re-analysed using the new doses. Major results obtained to date were presented, but it was pointed out that further reassessment will continue jointly by the USA and Japan to refine any remaining uncertainties or inconsistencies in the new dosimetry. The question on the practical implications of the results could not yet be answered by the conference.

It has been advocated that data sets on cancer incidences in workers in the nuclear industry be combined to aid in the assessment of cancer risk at low doses and dose rates. There are, however, major difficulties in making these comparisons. The metabolic kinetics of endogenous radioprotectors play an essential role in the explanation of the linear-quadratic function of the dose-effect relationship that has been observed experimentally. Experimental studies have begun to confirm the extreme radiosensitivity of human neurons to low linear energy transfer (LET) radiation and the relative biological effectiveness for a typical alpha-emitter. Current radioecological and anthropological studies of plutonium contamination at Maralinga, South Australia, have shown that the concepts used in radiation protection criteria (based on urban living habits) may underestimate the exposure of nomadic aborigines due to their very different living habits.

Regulation of radiation protection

Regulatory practices from eight countries were reported covering a broad spectrum of topics. Experience from the successful integration of nuclear safety and radiological regulatory control functions in a single body was encouraging. In general, emphasis was given to questions arising during revision of radiation protection regulations.

A central focus of discussion was the question of practices exempted from regulatory control. Essentially, all natural materials in man's environment are, to some extent, radioactive. Given the widespread presence of naturally occurring radioactivity and its very low risk to man, the question was raised at what level of risk should society become concerned about radioactive materials in the environment? Results and recommendations of a study on determination of *de minimis* dose levels based upon risk acceptability were reported. In the last 2 years, various international discussions had been held to establish a consensus on principles for exempting radiation sources and practices from regulatory control. These international developments were described, but it became clear that further work in this area is needed. *(See article on this subject in this edition of the Bulletin.)*

Occupational radiation protection

Occupational exposures that arise in nuclear fuel cycle facilities were discussed, such as in operation and decommissioning of nuclear power plants and in nuclear fuel reprocessing. However, such exposures also occur in the phosphate and coal mining industries, and in outer space; these were also discussed.

An overview was given of the IAEA's technical co-operation programme on radiation protection. It was emphasized that the IAEA Radiation Protection Advisory Team (RAPAT) missions, 30 of which have taken place already, are not inspections. Rather, they aim to discuss radiation protection problems and to assist in providing a systematic approach to improve radiation protection standards in the visited country. This is done through thorough planning of technical co-operation programmes, training for radiation protection specialists, and advice in setting up or improving the legal framework.

In a practical approach to monitoring workers for internal contamination, details were given of how newly derived investigation levels were estimated for bioassay results for the more commonly used radionuclides.

The exposure of workers in the phosphate industry and workers handling fly ash in the coal industry was discussed along with measurements using thermo-luminescence dosimeters (TLD), track-etch and urine bioassay, as well as assessment of chromosome aberration in blood. The results indicated that these workers should be considered occupationally exposed. These industries, however, are not currently covered by radiation protection legislation; these workers receive between 1 mSv and 10 mSv per year and chromosome aberration at dose levels of 20 mSv after 2 to 3 years' continuous exposure could be detected. This latter statement caused considerable interest.

Progress was reported on analysing dose distribution and trends by job category for nuclear workers. Exposure data is extracted from a national dose registry to assess compliance with regulations and to identify areas where improvement in control of exposures and in reporting of dose data may be needed.

A review of occupational monitoring at Sellafield, where nuclear fuel is reprocessed, was given. Personal air samplers are now employed on an extensive scale (worn by more than 2000 workers at the plant) and these measurements are complimented by whole-body monitoring and urine sampling.

In addition, data from some 50 cases of partial body autopsy have been studied to assess the distribution in the body (primarily in the liver and bone surface). Also, an epidemiological study of about 7000 past and present workers is under way, involving the reassessment of some 250 000 urine sample results.

Conference organization

At the invitation of the Government of Australia, the IAEA organized the International Conference on Radiation Protection in Nuclear Energy from 18–22 April 1988 in Sydney, Australia. The conference was convened to provide a forum for the exchange of international views on the principles of radiation protection for regulators and practitioners, to highlight issues of current importance, to examine the problems encountered in applying the principles of radiation protection, and, where possible, to identify generic solutions. The host organization for the conference was the Department of Primary Industries and Energy. The conference followed the 7th World Congress of the International Radiation Protection Association (IRPA) which convened at the same location. While the IRPA Congress was oriented to radiation protection practice, and featured many contributions on non-ionizing radiation protection, the IAEA Conference concentrated on radiation protection principles, criteria, and policy issues. The two meetings were linked by a reception on 17 April 1988, which was jointly sponsored by the Australian Government, IRPA, and the IAEA. At that occasion, the 60th anniversary of the International Commission on Radiological Protection (ICRP) was commemorated.

More than 320 experts from about 50 Member States and six international organizations — ICRP, IRPA, World Health Organization (WHO), Commission of the European Communities (CEC), International Electrotechnical Commission (IEC), International Organization for Standardization (ISO) — attended the IAEA conference. Eighty-two papers from 27 Member States (including eight papers from the host country Australia) and from four international organizations were presented.

The papers were presented in 10 scientific sessions covering the following subjects:

- nuclear safety and radiation protection (8 papers)
- evolution of radiation protection principles (8 papers)
- regulation of radiation protection (13 papers)
- optimization and decision aiding (12 papers)
- occupational radiation protection (9 papers)
- limitation of radioactive releases (5 papers)
- safe disposal of radioactive wastes (6 papers)
- radiological impact of nuclear facilities (5 papers)
- accident response planning (3 papers)
- accident experiences (8 papers)

In addition, a special session entitled "The dose-response relationship: implications for nuclear energy", with five paper contributions, and a panel on "Radiation protection education and training" were included in the conference programme.

The official welcome address was given by the Honourable John Kerin, Minister of Primary Industries and Energy, and the conference was formally opened by IAEA Director General Dr Hans Blix. Proceedings of the conference will be published by the IAEA.

Excerpts from the address by the Honourable John Kerin, Minister for Primary Industries and Energy

"The health risks associated with radiation have been the subject of considerable debate and concern in many communities around the world, including Australia. The theme of this conference, radiation protection in nuclear energy, provides an opportunity to review the nature and performance of the protection systems we have in place. Australia's strong interest in radiation protection derives from its status as a producer of uranium, as a signatory to international and national agreements on the use of nuclear materials, and the prevention of nuclear weapons proliferation, and as a nation carrying out research and development in nuclear science and technology. These activities incidently span the range of radiation protection methods from those dealing with very long-lived radioactive substances, for example uranium, thorium, and radium encountered in the mining and milling of radioactive ores, to those applying to some of the very short-lived radioisotopes used in nuclear medicine.

"Australia has 29% of the western world's low-cost uranium reserves. While these resources have no domestic relevance as an energy source, the Australian uranium industry does provide 10% of the western world's uranium requirements and as such, the Australian Government is concerned to ensure maximum radiation protection throughout the nuclear energy industry. Additionally, the Australian Nuclear Science and Technology Organization (ANSTO) produces radioisotopes for use within Australia and throughout the Pacific Region. These products are applied in a wide variety of fields of routine importance in industry and medicine, for example, assessment of groundwater resources, improvements in food crops, movement of material through pipelines, control of environmental pollution, and in medical diagnosis and treatment.

"The work of the IAEA is fundamental to the safe use of atomic energy for peaceful nuclear purposes. The IAEA establishes and adopts safety standards for the protection of health, life, and property throughout the nuclear technology and nuclear industries. IAEA recommendations in the form of codes of practice, safety guides, form the basis of standards adopted by many countries for radiation protection of workers and the public. The IAEA is also responsible for the safeguarding of nuclear material from diversion into the nuclear weapons cycle. Responsibility of the IAEA in the area of nuclear safety has increased significantly over the years and nuclear technology application and nuclear power programmes have grown worldwide.

"Australia has been involved with the work of the IAEA from its inception. Australia was a member of the Twelve-Power working group which was set up in 1955 to discuss a draft statute for the proposed Agency. After 1956, Australia became a member of the Board of Governors of the new organization.

"Australia maintains a strong interest and involvement in the activities and goals of the IAEA. For example, Australia helped to develop, and is a party to, conventions on early notification and assistance in the event of nuclear accidents or radiological emergencies. We have also been active on IAEA committees and working groups established to develop other internationally agreed codes of practice including the Standing Advisory Group on the Safe Transport of Radioactive Materials, which produced the IAEA's very widely used regulations in this area, and the groups responsible for producing the IAEA's codes on radiation protection in the mining and milling of radioactive ores and on the management of mining wastes. Australia is also a contributor to the IAEA's publication on research into waste management and health issues and is involved in the Agency's programmes in such areas as occupational health and safety, and toxic elements in food. Through the IAEA's Regional Co-operation Agreement, Australia is helping to develop radiation protection infrastructure in countries in the Asian and Pacific Regions."

Limitation of radioactive releases

This session commenced with an overview of limitations on radioactive discharge in European countries. Although a common framework exists, the detailed application is up to individual Member States of the Commission of the European Communities (CEC). As a consequence, there is a significant variation in practices. However, all countries use the ALARA philosophy, but with variations. There has been debate between the alternative approaches of using an upper bound plus ALARA, or setting emission standards based on the best available technology. The ALARA approach is seen to be more equitable and efficient.

Other contributions dealt with models for estimating doses resulting from a research reactor and in the discharge to sea from a reprocessing plant. Policy and regulatory approach to the management of uranium mine tailings in one country was outlined.

Disposal of radioactive wastes

Four papers related to radioactive waste repositories and two related to the potential impact of ocean disposal of radioactive wastes were presented. An international collaborative programme that is studying the migration of naturally occurring transuranics and fission products was described. In the first part of the study, migration around four uranium ore bodies was studied; over the next 3 years the study will concentrate on a single ore body. The conditions studied are considered to represent worst-case conditions for a deep depository. The results so far have indicated a movement of uranium of only 80 metres in one million years.

A programme was described for selecting a geologically suitable waste storage site. Sites in granite, clay, salt, and shale will be studied up to 1990 with the intention of issuing a license in 1995. (The design criteria for the storage include a public dose limit of 1 mSv per year and a 10^{-5}/a acceptable risk.) Studies suggest that intrusion is likely to be of little radiological consequence.

A thermo-syphon cooling system was suggested for stored nuclear waste that requires square metre permeability of 10^{-12} m^2 or greater (equivalent to close-packed sand) and the presence of water. It was claimed that such a thermo-syphon system could reduce waste-package temperature by a factor of two, thus reducing thermal stress. It has the advantage of having no moving parts. In addition, corrosion would be reduced and some actinides, if released from the package, would deposit in the thermo-syphon circuit.

Tests on the Australian Synroc (synthetic material) system were also described. A pilot plant is in operation by the Australian Nuclear Science and Technology Organization (ANSTO) at Lucas Heights. Some 3500 leach tests have indicated that the loss of matrix is equivalent to an erosion rate of about 1 millimetre every 100 years. A comparison was presented between storage of waste in Synroc in borosilicate glass, and as fuel elements. It was claimed that the performance of Synroc is superior to other systems and that its cost is expected to be lower than vitrification.

Other papers made the point that, despite statements to the contrary by the ICRP, protection of man does not necessarily protect all other species adequately. Dosimetric models were presented for marine animals that indicated dose rates that appear to be significant for these creatures. As an illustration of the potential problems for species other than man, the case was noted of a seal eating three tons of fish suitable for human consumption per year with a resultant dose rate of 36 milligray per year.

Accident response planning

The problems with setting derived intervention levels (DILFs) were described and the proposal for "maximum permitted radioactivity levels" was put forward as an alternative solution to this complex problem. The need for internationally-accepted DILFs for activity concentration in foodstuffs was discussed. Guidelines proposed by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO), if agreed by the Codex Alimentarius, should be published in 1989. These would provide a unified approach to protection of the public from contaminated foodstuffs.

It was stated that the Codex Alimentarius represents the views of health specialists and farmers, and that small levels of contamination were causing unnecessary concern in some countries.

The issue of universal values for derived intervention levels, in foodstuffs for example, has also illustrated a communication problem. Several speakers noted that public confusion and anxiety can be caused when different countries adopt different approaches. Communication between countries to work towards common strategies in these areas can have significant benefits to the public's understanding. The pertinent comment was made that if one is serious about communicating with the public, one needs to learn some communication skills. Public attitudes seem to be determined largely by perceptions of performance of the protagonists in public debates rather than by the intellectual content of their discussions. Protagonists are usually highly skilled in communication techniques — in handling the media. If one is going to engage in debate in the public arena, one has to learn how to do it and not to presume that superior scientific knowledge can triumph.

Accident experiences

An informative picture was given of radiological consequences of the Chernobyl accident in the Soviet Union and measures taken to mitigate their impact. It was pointed out that remedial actions substantially reduced external and internal exposure. They included large-scale protective measures, early evacuation of part of the public, stable iodine prophylactic, establishment of temporary standards for permissible radioactive contamination and limitation on the consumption of contaminated foodstuffs, and introduction of special agrotechnical measures. Radiation protection of the public and of emergency response teams within the 30-kilometre zone at the early stage and, even more so, in later periods, is only possible with serious preliminary pre-set exposure regulations. They guide those who are responsible for decision-making under complicated and difficult circumstances. A well-developed infrastructure must also be at hand, including a functioning network for radiological environmental monitoring equipped by necessary gamma-spectrometric, dosimetric, and radiometric facilities.

The problems of organization, methodology, and instrumentation were addressed. There was a need to cover a dose-rate range of six orders of magnitude in the 30-kilometre zone around the damaged reactor. Many different instruments were used and thus there were problems with different energy responses and different calibration. Simple reliable compact instruments are needed in such situations. Transport of contamination from the inner zone by human movement was also a problem.

It was suggested that trust in nuclear power could only be regained if risk assessments of other industries are made in the same way as those in the nuclear industry and if some agreed position could be reached on the linear — non-threshold — hypothesis which was described as a defeat of common sense.

Two papers described the environmental monitoring system and the measurement and dosimetry of iodine-131. The environmental monitoring and control system was set up in the 1950's and 60's to measure weapons test fallout and was expanded and modified in the 70's with the development of nuclear power. After the Chernobyl accident, ion chamber measurements in Budapest were up to 400 mGy/per hour. Drinking of water from the Danube was banned and consumption of dairy products and vegetables was controlled.

Excerpts from remarks of IAEA Director General Hans Blix at the IAEA conference on radiation protection in nuclear energy

In his remarks, IAEA Director General Hans Blix paid tribute to the International Commission on Radiation Protection (ICRP), which marks its 60th anniversary in 1988.

"In today's world, responsibility for the safety of the individual in the most diverse fields is assumed by politically constituted bodies, above all governments. Against this background, it is welcome that the central international body concerning itself with scientifically-based principles of radiation protection is independant of governments and consists exclusively of scientists from around the world. And at a time when scientists are often criticized for penetrating the secrets of life and of matter without regard to consequences, it is striking that the scientists who have dealt with ionizing radiation were conscious not only of the positive potential of this radiation, but also of its risks, and from a very early stage proceeded, on a scientific basis, to lay down principles to be observed for radiation safety. So authoritative was this scientific body that its recommendations on radiation protection have gained world wide recognition.

"While the purely scientific and unbureaucratic nature of the ICRP has been and remains its greatest asset, it presupposes the existence of organizations charged with the more mundane task of translating principles into regulation and application: this is the job of governments and of intergovernmental organizations.

"I am happy to tell you that, from its inception in 1957, the IAEA has had very close and fruitful co-operation with the ICRP and has relied on its conclusions. The Agency has been the instrument in which governments have co-operated to transform the principles formulated by the ICRP into internationally agreed regulatory and practical requirements.

"The implementation of these requirements is left to the large community of radiation protection experts. I take this opportunity to congratulate the International Radiation Protection Association (IRPA) to which over 12 000 of these experts belong and which successfully completed its 7th World Congress. I can report to the members of the Association that the IAEA is significantly expanding the assistance and service it provides to Member States in drafting proper regulations and creating adequate machinery to supervise and ensure their application. If nuclear power and the full potential of ionizing radiation for many purposes in medicine, agriculture, and industry are to be made use of and to be accepted with confidence by a broad public, it is essential that prudent regulations are formulated and fully implemented.

"The radiation protection community can take much pride in the success which it has had in this regard, but it will not, I am sure, rest on its laurels, but rather help to further strengthen international co-operation in radiation protection. Success in harmonizing protection standards internationally will increase public confidence in them. Failure to achieve such harmonization will damage this confidence, as we witnessed when widely diverging intervention levels were set for foodstuffs following the Chernobyl accident. The radiation protection community must also, I submit, rise to the challenge — which is no small one for scientists — of explaining to the public in understandable language the benefits of the responsible uses of ionizing radiation and the measures which can and must be taken to make these uses safe. If we fail in this task, it may turn out that the public, nervous about many new threats to our world, will not tolerate the safe uses that we know can be made of nuclear energy and that we know are in its interest.

Iodine-131 was the main source of short-term exposure. Intakes were log-normally distributed with a median of about 200 becquerel. Interestingly, ingestion proved a more significant route than inhalation.

Simple measurements were found to be unsuitable for assessing health consequences. Media releases and discrepancies in measurements increased public anxiety.

Measurements of radioactive caesium-137 in 42 Viennese citizens were described using a shadow shield whole-body counter. The highest levels were reached in April–May 1987, when the maximum individual value was 67 kilo-becquerel. Other measurements indicated higher uptake by athletes, an indication that children and athletes are groups most at risk.

The most recent major accident at Goiânia, Brazil, which involved a radiotherapy caesium-137 source, was also discussed at the conference. About 112 000 people were checked, of which 249 were found to be contaminated. The highest doses were in the range of four to seven gray. The extent of the contamination and the difficult conditions under which the monitoring had to be carried out impressed the conference participants. Unfortunately, this is a type of accident that could occur in any country. Information was given on the patients; radiological monitoring of the population of Goiânia; source recovery; identification, characterization, and isolation of contaminated areas; preparatory work for clean-up and decontamination operations in Goiânia City; occupational exposure of persons involved in the operations; environmental and individual monitoring; and technical co-operation and assistance by various organizations.

As a consequence of the accident in Goiânia, four persons died by 31 December 1987 because of severe overexposure; and one patient lost his right arm by amputation. Some smaller surgeries have been performed on patients with radiodermitis. Fifty persons are subjected to a medical follow-up programme. In the meantime, the originally contaminated areas in Goiânia are accessible again to the public with the exception of some small zones. Many of the evacuated people are back at their original residences.*

Facilities do exist for international assistance. The radiation emergency assistance centre and training site of the WHO was described. It provides a local, national, and international emergency response capability for medical management of radiation accidents. In 1980, it was designated as WHO's Western Hemisphere Collaboration Centre for Radiation Emergency Assistance.

A historical world review of accidents involving sealed sources from 1944 to March 1988 was given. In accordance with the Oak Ridge Radiation Accident Registry of the Radiation Emergency Assistance, approximately 48% of 296 radiation accidents have been the direct result of misadventures with sealed radioactive sources. Public awareness of the danger of such sources, better technical training of radiographers, and complete governmental control of all radioisotopic products and devices are all needed to put an end to these unfortunate experiences, it was pointed out.

Conclusions of the conference

- Although a session on optimization and decision aiding did not yield any new developments, it revealed that optimization of radiation protection is increasingly used and that this is a growing field.
- There seems to be a clear trend towards lower estimated collective doses per unit practice over time, despite an increase in nuclear power capacity.
- Very few data are published in the open literature on occupational doses to workers.
- Levels of radionuclide concentrations following Chernobyl, and consequent doses, are less than anticipated.
- Training programmes should focus on a "train-the-trainers" approach. Development of a training material data base is highly desirable.
- Movement towards regulatory strategies that exempt practices and sources causing insignificant individual and collective doses are desirable.
- Radiation protection regulations must be designed so provisions are not too specific to keep pace with changes.
- The important role of international agencies (IAEA and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development) in the development of exemption criteria was repeatedly stressed.
- A review was presented of the Hiroshima/Nagasaki survivors' dosimetry. However, the issue of what the results will imply for radiation protection could not be sufficiently addressed during the conference.
- The question of how to incorporate probabilistic ideas into risk assessment methodology will need to be further explored.
- While the scientific basis of the linear dose-relationship was not debated in detail — it had been pointed out that practical radiation protection would be impossible without this assumption — it was made clear that every risk in life is without established thresholds, and that the non-threshold concept is not new. Nevertheless, it was noted that thresholds and limits are used in everyday life and that some kind of threshold needs to be introduced in radiation protection to avoid continuous misunderstandings.
- It was concluded that regulatory bodies are as yet unprepared to consider fully a number of the above concepts and that it was up to the nuclear safety and radiation protection communities to improve this situation.

The main conclusion drawn from the conference is that more activities are necessary to provide further clarification on the implications of the linear non-threshold dose-response relationship; to search for, and elaborate, more practical concepts (for example, the introduction of a "risk-threshold"); to contribute to solving the existing communication problems; and to clarify the implications of the new Hiroshima/Nagasaki dosimetry.

* Based on a review conference of international experts held in Brazil in July 1988, the IAEA is preparing a comprehensive report on the Goiânia incident.