SETTING THE RIGHT LIMITS

CONTROLLING DISCHARGES OF RADIONUCLIDES TO THE ENVIRONMENT

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Releases of radionuclides to the atmosphere or to surface waters from nuclear and other facilities using radioactive materials are generally strictly controlled to protect the health of people living in the local and regional environments. Since the 1970s, the IAEA has issued guidance on the control of discharges and, in doing so, it has elaborated upon the basic recommendations of the International Commission on Radiological Protection (ICRP).

Recently, the IAEA's guidance on discharge control has been reviewed and updated, and the Agency's programme on radioactive discharges as a whole has been expanded to respond to requests from States for information on the sources and amounts of materials entering the environment. This article summarizes the recent Agency advice in this subject area and describes developments in its programmes.

GUIDANCE ON DISCHARGE CONTROL

The new IAEA Safety Guide, *Regulatory Control of Radioactive Discharges to the Environment*, updates the previous guidance contained in Safety Series No. 77 issued in 1986. The update takes account the principles set out in the Safety Fundamentals on *Radiation Protection and the Safety of Radiation Sources* (Safety Series No. 120, 1996) and the *Principles of Radioactive Waste Management* (Safety Series No. 111-F, 1995) and interprets the requirements of the *Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS)* (Safety Series No. 115, 1996).

The basic concepts for discharge control remain based on current radiation protection principles. These state that:

- a practice which entails or could entail exposure to radiation be adopted only if it yields sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes or could cause (principle of justification of a practice);
- individual doses due to the combination of exposures from all relevant practices not exceed specified dose limits (principle of individual dose limitation);
- radiation sources and installations be provided with the best available protection under the prevailing circumstances, so that the magnitudes of exposures and the number of individuals exposed be kept as low as reasonably achievable, economic and social factors being taken into account, and so that the doses they deliver be constrained (principle of optimization of protection).

However, the new Safety Guide provides more practical guidance on the regulation of discharges than its predecessors. It explains the functions of the regulatory body, and the responsibilities of the operator, which relate to discharge control. It explains procedures for determining whether there is a need for an authorization, and approaches for establishing an appropriate form of authorization. Methods for setting discharge limits for new and existing sources are provided.

According to the BSS, any operator intending to introduce (or discontinue) a practice "shall submit a notification to the regulatory authority of such an intention" and shall apply to the regulatory body for an

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SUMMARY GUIDANCE ON REGULATORY REQUIREMENTS IN RELATION TO PREDICTED DOSES TO THE CRITICAL GROUP

REGULATORY REQUIREMENTS IN RELATION TO DISCHARGES	*Assessed future maximum annual dose to the critical group* ≤ 10 micro-sievert		> 10 micro-sievert
	EXEMPTION OR NOTIFICATION	**REGISTRATION**	**LICENSE**
Recommended conditions	■ Source inherently safe ■ No requirements on effluent or environmental monitoring ■ Practice to be kept under periodic review	■ Source not inherently safe ■ Discharge limits required ■ Effluent monitoring required ■ Practice to be kept under review ■ Recording of discharges required	Formal authorization with specific conditions attached to the authorization, on any or all of the following: ■ Discharge limits ■ Effluent monitoring ■ Environmental monitoring ■ Effluent and environmental monitoring records ■ Reporting of monitoring to regulatory authority
Example facilities	■ Research laboratories using radioimmunoassay techniques ■ Hospitals using xenon testing kits	■ Small hospitals and research and development facilities using limited amounts of radioisotopes	■ Nuclear reactors ■ Reprocessing facilities ■ Radiopharmaceutical production facilities

authorization which may take the form of either a registration or a licence. There are circumstances in which notification, and therefore also authorization, is not required (if exposures may be excluded from the BSS, or practices or sources may be exempted from its requirements*).

An authorization is thus a form of permit issued by the regulatory body which allows an operator to carry out a practice and to discharge radioactive materials to the environment. The form of authorization appropriate for a particular situation is determined by, among other things, the assessed risk to members of the public. Registrations can be granted for practices with low to moderate associated risks, and are usually expressed in somewhat generic terms. A license is accompanied by specific requirements and conditions.

For discharges to the environment, these conditions could take the form of annual and shorter-term limits on the discharges of particular radionuclides or an appropriately weighted sum of them. *(See table for examples of the conditions relating to different forms of discharge control.)*

**Exclusion refers to "any exposure whose magnitude or likelihood is essentially unamenable to control through the requirements of the Standards", while exemption implies that the radiation risks to individuals and populations caused by the exempted practice or source are sufficiently low as to be of no regulatory concern and that the exempted practices and sources are inherently safe.*

The Safety Guide also describes the responsibilities of registrants and licensees during operation. These include, where appropriate, the establishment and performance of monitoring programmes for effluents and environmental radiation. *(See table, which indicates when such programmes are likely to be necessary.)*

In summary, the Safety Guide prescribes a graded approach to regulatory control based upon the level of risk presented by the discharge.

GUIDANCE ON DOSE ASSESSMENT

A Safety Report entitled *Generic Models for use in Assessing the Impact of Discharges of Radioactive Substances to the Environment* (Safety Reports Series No. 19) contains an IAEA methodology for assessing radiation doses arising from discharges to the environment. It replaces and expands on earlier Agency advice on modelling given in Safety Series No. 57 (1982).

Unlike the earlier report, this Safety Report is a self-contained manual describing a robust but conservative dose assessment methodology. It contains a complete set of the models and data needed to link a discharge rate to a dose, representative of those members of the public who are likely to be most exposed from a particular operation (the critical group).

Collective doses are also relevant, and the Safety Report provides screening factors that allow collective doses to be estimated for a given discharge. The assessment models described in this Safety Report are intended to be used in advance of a discharge actually being made, as part of the process of setting an authorization. As a result, this report and the previously described Safety Guide are closely linked.

The Safety Report provides a simple screening approach for assessing the impact of discharges to the atmosphere and to surface waters. It provides two levels of modelling for each type of environment, and a procedure to determine which type of modelling is appropriate. This procedure is based on the premise that, at very low doses, a very simple pessimistic dose estimate is likely to be sufficient but, as doses increase, a more realistic dose estimate will be needed, requiring more detailed modelling.

The first type of model is based on the assumption that the critical group is continuously located at the point of discharge and that their food also originates from that point. This is clearly a very pessimistic approach. The second model type takes account of the dilution and dispersion of material between the point of discharge and the location of the critical group or their food and the resulting transfers of material between environmental components (e.g. between water and fish).

Simple models for atmospheric dispersion are provided that allow the concentration of radionuclides in air, as a function of distance from the discharge point, to be estimated. From such concentrations, it is possible to predict both the external dose from radionuclides in the cloud, and the internal dose from inhalation, using habit data and dose coefficients also provided in the Safety Report.

The data needed to estimate the concentration of radionuclides on the ground, and the transfer of radionuclides through the food chain to man are also provided. Habit data and dose coefficients needed to estimate external doses from ground deposits and internal doses from ingestion are also given.

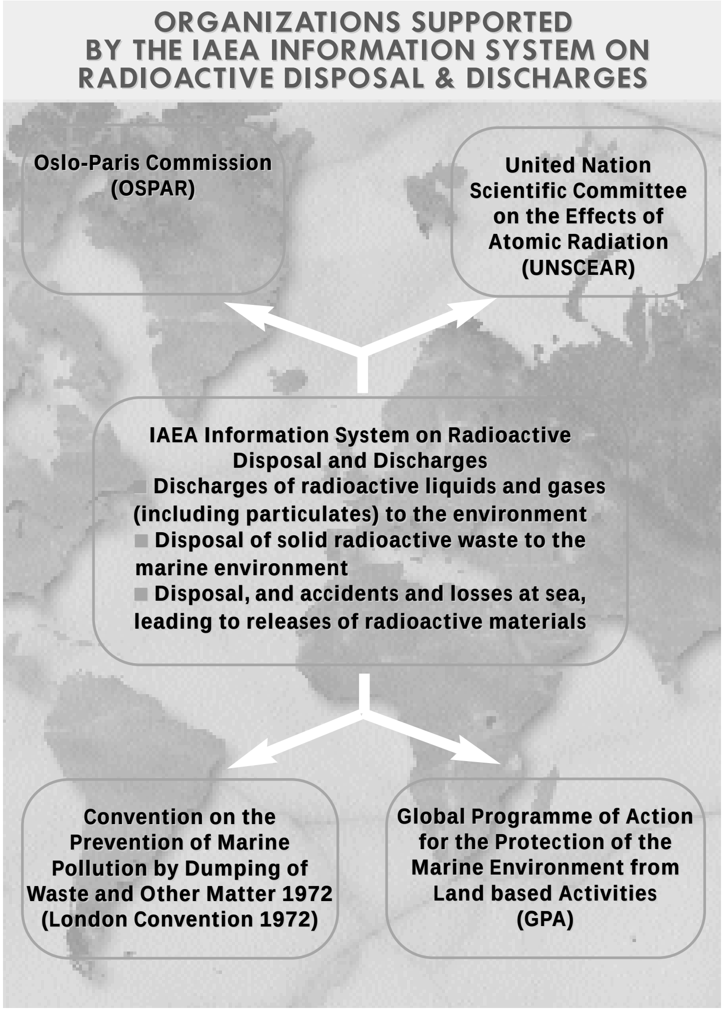
Simple models to take account of the dispersion of radionuclides in the following types of surface water bodies are provided: rivers, estuaries, coastal waters and lakes. These models allow the concentration of radionuclides in water to be predicted depending upon, among other things, distance from the point of discharge. This information can be used to assess doses from drinking water, abstracted from a particular point.

Information on the distribution of radionuclides between the water and sediments is also provided, from which the concentration of radionuclides on the banks of the water body can be determined and used to assess resulting external doses. The report also provides factors which relate concentrations in water with those in fish and shellfish, and the habits and dose coefficients needed to relate concentrations and doses.

The Safety Report provides simple multiplication factors, calculated using the above models and some standardized assumptions about the discharge characteristics and the location and habits of the critical group. These factors allow critical group doses to be estimated in a single step from information about the predicted discharge rate or concentration. More detailed explanations and example calculations are also included to provide a simple and flexible assessment tool.

INFORMATION SYSTEM ON GLOBAL DISCHARGES

The IAEA is developing an information system on worldwide discharges of radionuclides to the atmospheric and aquatic environments, marine disposals of radioactive wastes and accidents and losses at sea involving radioactive material



and radioactive waste disposals; and residues in the terrestrial environment.

On the subject of marine disposals the IAEA has already published a document (*Inventory of Radioactive Waste Disposal at Sea,* TECDOC-1105). A similar document on accidents and losses at sea is in preparation.

An integral part of this information system will be the clearinghouse on radioactive substances that the Agency is developing as part of its commitment to the United Nations Environment Programme (UNEP) Global Programme of Action for Protection of the Marine Environment from Land-based Activities.

In 1996 the IAEA was designated by the 51st General Assembly of UN as a lead agency and clearinghouse for matters related to radioactive substances. A clearinghouse is a referral system intended to provide access to current sources of information, practical experience and scientific and technical expertise for preventing the degradation of the marine environment from land-based activities and to preserve and protect the marine environment.

Finally, the Agency's information system will serve to support the provision of technical advice to various organizations. *(See figure.)* These include the London Convention 1972 (Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter), the Oslo-Paris Commission, and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). *(See box, page 49.)*

PROTECTION OF THE ENVIRONMENT

To date, discharge policies have been designed with the objective of protecting human beings from the effects of ionizing radiation.

Following the UN Conference on Environment and Development in Rio de Janeiro in 1992, international attention is increasingly turning to the need to protect the environment, and more specifically, flora and fauna from potentially harmful pollutants.

Principles and criteria for protecting the environment from the effects of ionizing radiation can be expected to emerge from ongoing discussions, and the impact of such criteria on policies for controlling discharges of radionuclides will need to be evaluated.

Through its programmes, the IAEA is expected to play an important role in facilitating the constructive exchange of experience and views, and in the provision of factual information, as the international community addresses these and other challenges. ❐

UNSCEAR 2000 REPORT ON RADIATION LEVELS & EFFECTS

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) is the body within the UN system with a mandate to assess and report levels and effects of exposures to ionizing radiation. UNSCEAR results are used by the Agency in performing its statutory functions of establishing standards for radiation protection, and providing for their application. UNSCEAR is due to present a report to the UN General Assembly in Autumn 2000. The Committee's conclusions on the levels of exposure from man-made sources are of relevance to the current and future Agency work programme on the control of radioactive discharges to the environment, and are summarized here.

Releases of radioactive materials to the environment have occurred as a result of several activities, practices, and events involving radiation sources. The main contribution to the collective doses to the world population, from man-made releases of radioactive materials in the environment, has been from atmospheric nuclear weapon tests. This practice occurred from 1945 to 1980.

In preparing its 2000 report, UNSCEAR took account of new information on the numbers and yields of nuclear tests that has become available. UNSCEAR now estimate that the world average annual effective dose reached a peak of 150 micro-sievert in 1963 and that such exposures have since decreased to about 5 micro-sievert, from residual levels of radionuclides in the environment, mainly of carbon-14, strontium-90, and caesium-137. The average annual doses are 10% higher in the northern hemisphere, where most of the testing took place, and lower in the southern hemisphere.

UNSCEAR estimates that the local and regional exposures from all nuclear fuel cycle operations (mining and milling, reactor operation, and fuel reprocessing) are presently around 0.9 man-sievert (gigawatts/year). With world nuclear energy generation of 250 gigawatts/year, the collective dose per year of this practice is of the order of 200 man-sievert. The corresponding average annual individual exposure is estimated to be less than 1 micro-sievert.

Further, UNSCEAR has estimated the collective dose from globally dispersed radionuclides to the projected maximum population of the world by assuming that the practice of nuclear power production is limited to 100 years at present capacity. The resulting maximum annual effective dose per caput to the global population would be less that 0.2 micro-sievert. These dose rates to individuals are far below natural radiation exposures.

There are industries which process or utilize large volumes of raw materials containing natural radionuclides. Discharges from such industries may lead to enhanced exposures of members of the public. The UNSCEAR report indicates that the maximum exposures arise from phosphoric acid production, mineral stand processing and coal-fired power stations. Annual doses of around 100 micro-sievert to a few local residents may occur although doses of the order of 1 to 10 micro-sievert are more common.

UNSCEAR concludes that, except in the case of accidents, in which more localized areas can be contaminated to significant levels, there are no other practices that result in important exposures from radionuclides released to the environment.

Possible future practices, such as weapons dismantling, decommissioning of installations, and waste management projects, can be reviewed as experience is acquired. But UNSCEAR suggests that these should all involve little or no release of radionuclides and should cause only negligible exposures.

Photo: At the request of its Member States, the IAEA has organized a number of studies to assess the radiological situation at former nuclear weapon test sites. (Credit: Pavlicek/IAEA)

WASTE MONITORING IN THE MARINE EVIRONMENT

The IAEA's Marine Environment Laboratory in Monaco has been carrying out several projects connected with waste management issues. They include studies of authorized releases of radioactive wastes from reprocessing plants into the marine environment and investigations of possible leakages from radioactive waste dumping sites on the sea bottom.

An innovation in the monitoring of marine radioactivity using stationary gamma monitors with satellite data transmission has been conceived at IAEA-MEL's Radiometrics Laboratory. The new monitoring system was deployed from April 1999 to February 2000 in Monaco Bay to test the performance of data transmission via satellite and to evaluate the results. The sensors were deployed a few meters below the sea surface on a structure attached to a floating buoy. They generated long-term continuous records of gamma-activity in seawater, salinity, temperature and current speed and direction. The monitoring system performed well over the testing period and reached the projected sensitivity of 4 Bq per cubic meter for caesium-137 concentration in water. It will be deployed in the summer of 2000 in the Irish Sea to investigate long-term transport of caesium in seawater released from the Sellafield reprocessing plant.

Further work recently completed in the Irish Sea is *in situ* gamma-mapping of seabed sediments from the Sellafield discharging point to about 15 kilometers from the coast. The total sea area covered was about 400 square kilometers. A high resolution map of the distribution of caesium-137 in the sediment was obtained. This would have required hundreds of sampling points and thousands of analyses of sediments if the data for the map had been obtained by laboratory work.

Work on the investigation of possible releases of radionuclides from radioactive waste dumping sites in the North West Pacific Ocean has been completed. The obtained results have shown that at the sites visited, no leakages which could be attributed to radioactive waste dumping were observed. Modelling and radiological assessment work covering impacts from both liquid radioactive wastes dumped on the sea surface, as well as solid wastes dumped on the sea bottom have shown that only negligible radiation doses could be delivered to local populations.

During the first meeting of the coordinated research project on "Worldwide Marine Radioactivity Studies", a geographical system for the assessment of marine radioactivity in the world oceans and seas was developed. Tritium, carbon-14, strontium-90, iodine-129, caesium-137, plutonium, and americium isotopes were chosen as representative of anthropogenic radionuclides in the marine environment and their main distribution patterns were established. The evaluation of sources of anthropogenic marine radioactivity has shown that global fallout is still the dominant source in the oceans, although in some areas releases from reprocessing plants (e.g. in the Irish and North Seas) and the Chernobyl accident (the Baltic and Black Seas) have exceeded the contributions from global fallout.

The Global Marine Radioactivity Database (GLOMARD) is under development, and will store all available data on the concentrations and distribution of radionuclides in the marine environment.

Photo: In August 2000, the Radiological Protection Institute of Ireland, in cooperation with the Environment and Heritage Service of Northern Ireland and the IAEA, deployed an experimental buoy in the Irish Sea, equipped with a radiation detector capable of continuously measuring radioactive contamination in seawater. (Credit: IAEA-MEL)