

The Agency's activities in radioactive waste management

by D.K. Richter*

The use of nuclear energy implies the generation of radioactive wastes that have to be controlled adequately to protect man and his environment from the potential radiological hazard they pose at present and in future. Assurance that suitable systems exist to safely manage and dispose of all kinds of radioactive wastes has become a current issue in the further industrial development and acceptance of nuclear power.

Countries that use nuclear power have to decide on the techniques and responsibilities for:

- The handling and disposal of low- and intermediate-level wastes from nuclear power plants and their associated fuel cycle facilities; and
- The handling, storage, and disposal of high-level and actinide-bearing wastes from the management of the spent nuclear fuel.

Currently most countries using nuclear power have large programmes to develop and implement systems for the long-term management and disposal of their radioactive wastes, in particular for the high-level and actinide-bearing wastes. Extensive experience has already been gained in managing radioactive wastes during more than three decades of nuclear activity. Although the main and long-term issues in this field are the conditioning and disposal of high-level wastes, the management of low- and intermediate-level wastes has again become an issue and may currently be considered equally important. This is because these wastes constitute the largest volume and variety of waste from the nuclear industry, and because many related technical and regulatory matters are undergoing further development. These wastes come from nuclear power plants, from the decontamination and decommissioning of nuclear facilities (also from clean-up measures after incidents), and from the milling of uranium ores.

International co-operation in radioactive waste management includes exchanging information on experience, research, and approaches in national programmes; developing guidance and international recommendations for use by national authorities; considering waste management in the context of regional

or international nuclear fuel cycle facilities, and developing and executing responsibilities under international law for the protection of the environment. The International Atomic Energy Agency has been active in these areas since it was founded.

Scope of the IAEA programme

The Agency's programme on radioactive waste management is aimed at assisting national programmes and the international community to protect man and his environment adequately from radioactive wastes and effluents. The Agency does this by providing technical and regulatory information for the assistance and guidance of Member States on the safe handling, treatment, and disposal of radioactive wastes.

The programme covers both treatment technologies and environmental aspects, and it deals with radioactive wastes and effluents not only from nuclear power plants but also from nuclear fuel cycle facilities, including mines, uranium-ore mills, and spent-fuel reprocessing plants. Topics considered in the past were: treatment, storage, and disposal of solid, liquid, and gaseous radioactive wastes and effluents, nuclear power and its environmental impact, including the protection of the marine environment from the disposal of radioactive wastes at sea, and decommissioning of nuclear facilities. Activities in these areas are being continued but emphasis is now being placed on the following components:

- Handling and treatment of radioactive wastes and effluents at nuclear facilities;
- Underground disposal of radioactive waste, and
- Environmental aspects of the nuclear fuel cycle.

The radioactive waste management programme is closely linked with the Agency's other programmes: in particular those on radiological and nuclear safety and the nuclear fuel cycle. It has expanded and a variety of symposia, technical committee and advisory group meetings, and co-ordinated research programmes have been convened. These activities resulted or will soon result in the publication of proceedings, IAEA Technical Reports, Safety Series Reports, or unpriced Technical Documents. The following are highlights of some of the major activities.

* Head of the Agency's Waste Management Section, Division of Nuclear Fuel Cycle. This article was adapted from a paper presented by Mr Richter at the Global Waste Management Policies' Session of the 26th Meeting of the American Nuclear Society, Las Vegas, USA, 8-12 June 1980.



Model of a prototype container of vitrified nuclear waste, showing the borosilicate glass inside.

Handling and treatment of wastes at nuclear facilities

The objective of this part of the Agency's programme is to collect information and provide guidance on the technology of waste and effluent management and on volume-reduction and conditioning of wastes for storage and disposal. Areas covered are wastes from the mining and milling of radioactive ores, low-intermediate-solid wastes; liquid and gaseous wastes and effluents; high-level and alpha-bearing wastes; wastes from nuclear power plants, and decontamination and decommissioning of nuclear facilities. During the past five years, information was reviewed on the state-of-the-art of the technology and on the basis for the various methods of radioactive waste and effluent management.

High-level and alpha-bearing waste management was the subject of several meetings of a technical committee which, established in 1974, has served as a forum for the informal exchange of information between Member States who are involved in reprocessing. The techniques for storage and solidification of liquid high-level waste from aqueous reprocessing have been reviewed, and the handling of alpha-bearing waste was covered by an IAEA/CEC (Commission of the European Communities) Symposium held in June 1980. A co-ordinated research programme is evaluating the characteristics of solidified high-level waste forms, an area which is especially important in view of the relationship between waste forms, conditioning technology, and potential

disposal environments. Another co-ordinated research programme, on partitioning of transuranic elements from high-level wastes followed either by transmutation or separate disposal (performed 1976–1980), concluded that the value of this technique would be limited.* In the future, attention will be focused on the conditioning of these wastes for disposal and the handling and storage of conditioned high-level waste.

Gaseous effluent and waste treatment has been and continues to be of particular importance for protecting the environment from airborne radionuclide releases under both normal and accident conditions at nuclear facilities. The techniques for retention and removal of noble gases, tritium, iodine, particulates and other airborne radionuclides from reprocessing plants and from nuclear power plants were reviewed by several expert meetings and an IAEA/NEA (Nuclear Energy Agency) Symposium held in February 1980. Future activities will concentrate on testing, in-plant monitoring, and requirements for the operation of off-gas cleaning systems at nuclear facilities, including particulate filtration.

Low- and intermediate-level wastes is an area where considerable developments have been made in treatment and conditioning of both liquid and solid forms. Previous IAEA publications on these subjects are, therefore, being up-dated with a view to issuing documents on three major areas – solid waste treatment, liquid waste treatment and conditioning of waste concentrates. This will also include alpha-bearing waste. Handling of spent ion-exchange resins, of tritium-bearing wastes, and of specific intermediate-level wastes are areas which will receive further attention.

Management of waste from nuclear power plants is of particular interest to many countries. Present practices at various types of nuclear power plants have been summarized in a technical report. The subject was also addressed by a NEA/IAEA Symposium in 1979 and will be discussed again at an IAEA Seminar in October 1981. Experience exists now to proceed to the preparation of a Code of Practice.

Management of wastes from the mining and milling of uranium and thorium ores is described in an IAEA Code of Practice, published in 1976. As mining and milling of uranium ores will increase with the expanding use of nuclear energy, due attention will be paid to the related waste management aspects in the future programme, and the Code of Practice will be reviewed.

Decommissioning of nuclear facilities is one area which has evoked broad interest in the past and has therefore been included as a separate component in the IAEA waste management programme. An IAEA/NEA Symposium was held on the subject in 1978. Other related activities resulted in a publication on "Factors relevant to the decommissioning of land-based nuclear reactors" and "Decontamination of nuclear power plants in operation".

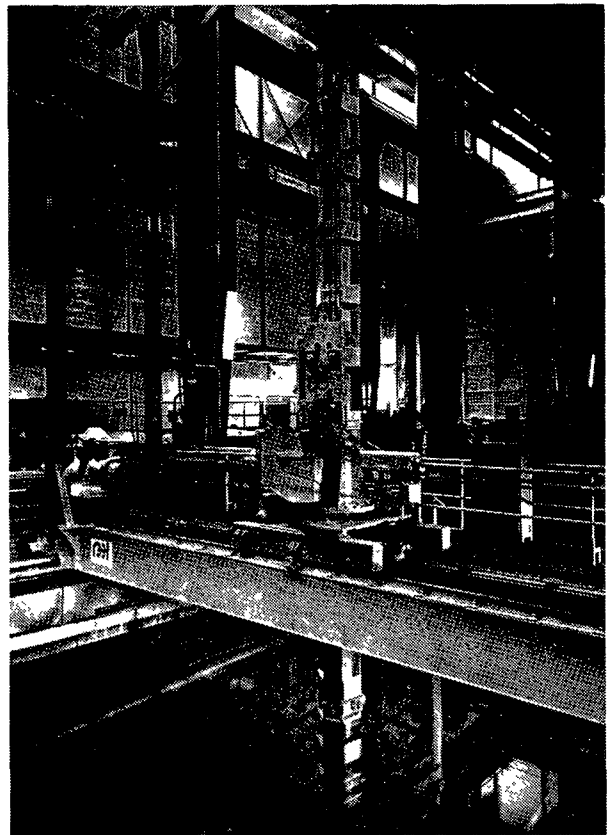
* See the article by H.A.C. McKay in this issue of the Bulletin.

Decontamination as well as decommissioning of nuclear facilities will continue to be addressed in the Agency's programme.

Underground disposal of wastes

Underground disposal of radioactive wastes is, with today's technology, considered to be the best method of safely disposing of radioactive wastes. Disposal of low- and intermediate-level wastes by shallow land burial, emplacement in abandoned mines, deep-well injection, and hydraulic fracturing has been practised for many years in various countries. Many countries are now studying whether the geological formations under their territory could be used as repositories for low-, intermediate-, high-level and actinide-bearing waste. An IAEA/NEA Symposium was held on this subject in July 1979.

In 1977 the Agency launched an integrated programme to develop internationally a series of documents giving guidance on the safe underground disposal of radioactive wastes. Disposal options addressed are the emplacement of solid waste in deep geological formations (newly mined repositories), rock cavities (for low- and intermediate-level waste) and shallow ground (for low- and intermediate-level waste). Some attention is also being given to liquid injection in deep permeable formations, and to fluid injection in hydraulically-induced fractures in impermeable formations. The documentation being prepared within this programme covers five major subject areas: generic and regulatory activities and safety assessments, investigation and selection of repository sites, waste acceptance criteria, design and construction of repositories; and operation, shutdown, and surveillance of repositories. Priority during the coming years will be on disposal of low- and intermediate-level waste in shallow ground and rock cavities because many countries need to establish repositories for these wastes. According to the responses of many governments to an IAEA inquiry made in 1977, an important aim of the programme is to arrive ultimately at internationally acceptable Codes and Guides. However in the first stage of the programme, which may cover 6 years, it appears more appropriate to develop a set of Technical Reports and Safety Series documents. These will then be re-examined in the light of experience so they can form the basis of Codes and Guides once the subject is sufficiently advanced in all areas. Work on the programme is well under way. Four documents have already been published and three others are awaiting publication: they contain basic guidance on underground disposal, guidance for shallow ground disposal, regulatory procedures for deep geological disposal, general safety assessment approaches, site selection factors for repositories for high-level and alpha-bearing wastes, site investigations for deep geological and shallow ground disposal. Others under preparation concern basic criteria, safety assessment for deep geological and shallow ground disposal, and general guidance for disposal in rock cavities. The Agency



The spent fuel storage ponds at La Hague reprocessing plant.

established a Technical Review Committee to advise on the programme and to examine the documents before their publication. The Agency provides a forum for continued international dialogue in this area.

Regional waste repositories, especially for high-level and actinide-bearing wastes, is a concept which has attracted interest because it is a way of meeting the waste disposal needs of countries with small nuclear power programmes and the needs of those which do not have suitable geological and hydrological conditions. Such installations were considered as part of regional or international planning of the nuclear fuel cycle (co-location of waste repositories and regional reprocessing plants) in the IAEA Study Project on Regional Fuel Cycle Centres published in 1977, and in the report of INFCE Working Group 7. The question of international co-operation in these fields keeps being raised. Obviously, a country that produces radioactive waste will first have to consider disposing of the waste in its own territory before seeking international solutions. Internationally accepted guidelines on underground waste disposal may, therefore, be an important step in proceeding from national to international projects.

Nuclear fuel cycle and the environment

With the increasing industrial use of nuclear power have come questions about its long-term effects on the environment from: actual or potential radioactive

emissions into the atmosphere and surface waters, including local, regional and global effects; the dumping of low-level solid wastes into the sea, the disposal of radioactive waste on land, and the mining and milling of uranium ores. Most of these questions are primarily of local interest and within the responsibility of the appropriate national authorities. They become of truly international concern when transboundary effects are involved or international water might be affected. Principles and procedures for establishing limits for the release of radioactive materials into the environment that are based on the ICRP recommendations, and prepared under the Agency's radiological safety programme, form the basis for consideration in the above areas. The objective of this part of the waste management programme is to discharge the Agency's responsibilities in protecting the marine environment, in considering the environmental dispersion and pathways of effluents discharged from nuclear facilities, and in establishing methodologies for assessing the related environmental consequences of nuclear facilities.

Marine environment protection. The London Convention on the prevention of marine pollution by dumping of wastes and other matter gave the IAEA the responsibility of defining high-level radioactive wastes unsuitable for dumping at sea, and of making recommendations for those radioactive wastes which could be dumped in the deep ocean. Similar considerations regarding the protection of the marine environment of regional seas, such as the Mediterranean (Barcelona Convention), also involve the Agency. Provisional "Definition and recommendations" were prepared in 1974 and reviewed during 1975-77. The Agency's revised "Definition and recommendations" have been operative under the London Convention since 1978. They describe the requirements on site selection and assessment, waste packaging, and operational control of dumping, which should be followed by national authorities when granting a special permit for dumping of radioactive waste. It is the responsibility of national governments to ensure compliance with the London Convention.* It should be noted that the Agency's "Recommendations" are not to be construed as encouraging the dumping of radioactive waste at sea. Nor has the Agency assumed a mandate to ensure that these requirements are adhered to in any dumping operation. The Agency's "Definition and recommendations" are kept under review and will be supplemented by guidelines for the selection, surveillance and environmental assessment of dumping sites. The Agency will also issue a definition of *de minimis* levels of radioactivity for waste which could be dumped, like non-hazardous wastes, under a general permit. The review

* The OECD Council established in 1977 a multilateral consultation and surveillance mechanism for sea dumping of radioactive waste to provide regional co-operation and further the objectives of the London Convention. The full text of the London Convention is reproduced in the IAEA document INFCIRC/205.

of the definition of radioactive waste unsuitable for dumping into the deep ocean has shown that improvements are needed in the oceanographic models used for this definition. This is being considered within the UN joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). Supporting research is also being performed by the Agency on the behaviour of radionuclides in the marine environment in its Monaco Laboratory**. The impact of radionuclide releases into the marine environment was subject of an IAEA/NEA Symposium in 1980.

Environmental pathways of radionuclides. The assessment of environmental pathways of radionuclides to man is a necessary step in the evaluation of the radiological consequences of radioactive releases. The Agency reviewed short-range atmospheric and aquatic pathway models under its Nuclear Safety Standards (NUSS) programme related to the siting of thermal nuclear power plants***. Generic models and parameters for the environmental transfer of radionuclides to man for general non-site specific pre-operational assessments have been reviewed recently. The Agency has also encouraged the study of the environmental behaviour of nuclides of particular radiological concern. The behaviour of tritium in the environment was subject of a symposium in 1978 and of a co-ordinated research programme from 1974-78. Other research programmes concern the behaviour of radium in aquifers and waterways, the migration of radionuclides from the storage of radioactive waste in the terrestrial environment, the transuranic cycling behaviour in the marine environment, and carbon-14 from nuclear facilities. A forthcoming symposium will be devoted to the migration of long-lived radionuclides in the terrestrial environment.

Environmental impact assessments. A research programme performed over the years 1973-1978 considered the environmental effects of cooling systems and thermal discharges from nuclear power plants. IAEA has, as a joint effort of various units, co-operated with the United Nations Environment Programme (UNEP) in the preparation of a report on "The environmental impacts of nuclear energy"† and on the comparative assessment of the environmental impact of different energy sources. Radioactive substances in long-range transboundary air and water pollution are at present insignificant when compared to pollutants of other origins, but they might become of concern in some regions in the world with the increasing use of nuclear power. The effects of the release of some radionuclides into the environment, such as H-3,

** A. Walton *The work of the international laboratory of marine radioactivity* IAEA Bulletin, Vol. 23, No. 1 (1981) p. 24

*** *Atmospheric dispersion in relation to nuclear power plant siting* Safety Series No. 50-SG-S3.
Hydrological dispersion of radioactive material in relation to nuclear power plant siting Safety Series No. 50-SG-S6.

† See article by J. U. Ahmed and H. T. Daw, IAEA Bulletin, Vol. 22, No. 2 (1980) p. 23

Kr-85, C-14, and I-129, and their regional and global radiological significance will be addressed in the Agency's future programme. Atmospheric pathways, in particular, will be reviewed for the eventual preparation of recommendations for the control of such releases.

Co-operation with other international organizations

The Agency's waste management programme involves co-operation in the sponsoring of meetings, exchange of information and consultation with many inter-governmental and non-governmental organizations, such as UNEP, WHO, IMCO, UNESCO, UNSCEAR, the Nuclear Energy Agency of the Organization for Economic Co-

operation and Development (NEA/OECD), ECE, the Commission of European Communities (CEC), and the Council for Mutual Economic Assistance (CMEA), as well as ICRP, UNIPED, and ICSU.

Radioactive waste management will continue to be an important subject in the Agency's programme related to nuclear power and its fuel cycle. Plans are being made to hold in 1983 an international conference on radioactive waste management, which will be dedicated to considerations on the interrelationship of the various components of the radioactive waste management system, including technological, environmental, regulatory and policy aspects.



Forthcoming IAEA conferences...

Date	Subject	Place
1981		
27-31 July	IAEA/NEA/CEC International Symposium on Migration in the Terrestrial Environment of Long-Lived Radionuclides from the Nuclear Fuel Cycle	Knoxville Tennessee USA
28 September- 2 October	International Conference on Industrial Application of Radioisotopes and Radiation Technology	Grenoble France
19-23 October	IAEA/WHO/NEA/ICRP International Symposium on the Application of the Dose Limitation System in Nuclear Fuel Cycle Facilities and other Radiation Practices	Madrid Spain

... and seminars

31 August- 4 September	Seminar on Prospective Methods of Radiation Therapy in Developing Countries	Kyoto Japan
14-18 September	Seminar on Research Reactor Operation and Use	Julich Fed.Rep.of Germany
5-9 October	Seminar on the Management of Radioactive Waste from Nuclear Power Plants	Karlsruhe Fed.Rep.of Germany
9-13 November	FAO/IAEA Seminar on Food Irradiation for Developing Countries in Asia and the Pacific	Takasaki Japan
16-27 November	UNESCO/IAEA Seminar on the Use of Isotope Techniques in Water Resources Development in Asia and the Pacific	Colombo Sri Lanka
23-27 November	Seminar on Safety Review and Inspection of Nuclear Power Plants	Vienna Austria
30 November- 11 December	Seminar on Radiation Emergency Preparedness - Health Physics and Medical Aspects - for the Region of Asia and the Pacific	Kalpakkam India

Further information on these conferences can be obtained from the IAEA, or the appropriate body in each Member State: the authority responsible for nuclear matters, or the Ministry of Foreign Affairs.