Technology transfer for safe management of radioactive waste: Tailoring the approaches

In response to wide-ranging needs, the IAEA has developed standardized packages and tools to assist countries in specific areas

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Most countries around the world do not have nuclear power plants. Of the IAEA's 121 Member States, for example, about 75% fit into this category. They apply nuclear technologies chiefly for research, medical, industrial, and other purposes. From the standpoint of radioactive waste mangement, this broad range of nuclear applications, as well as each country's own level of infrastructure and stage of development, creates a diverse set of challenges.

Through its programme on radioactive waste management, the IAEA provides assistance to countries that includes direct and indirect transfers of various types of technologies and services. The aim is to help countries effectively protect human health and the environment, now and in the future, from the radiological hazard of radioactive waste. The diversity of national needs and interests is reflected in the IAEA's programme, which incorporates technology-transfer projects that have been specially tailored to address specific types of requirements. This article reviews key elements and strategies of that programme.

Identifying the needs and strategies

To better understand the overall profile of countries, the IAEA has developed an internal classification that groups countries by the type and quantity of generated radioactive waste. *(See table and boxes, page 48.)* Countries are faced with a range of needs to solve specific waste management problems, a fact that has been clearly identified by the IAEA's Waste Management Advisory Programme (WAMAP) and other expert missions.

Currently, only a few developing countries are able to comply fully with the requirements for proper and safe waste management. For most developing countries, the situation varies from non-compliance to quasi-compliance. The requirements to be met by these countries include the establishment of a comprehensive waste management infrastructure. The infrastructure covers such elements as legal framework, regulatory body, operating organizations, resources, and trained personnel. Through the IAEA's Radioactive Waste Safety Standards (RADWASS) Programme, international consensus in these and other areas is being documented.

Through its entire range of programmes in the field of radioactive waste management, the IAEA aims to bring all countries to a minimum level of compliance and to develop necessary components to sustain a system. This is a long and time consuming process but one that will ensure an adequate level of safety to workers and the public.

In the past, the most obvious means of assistance was transferring waste management technology that already had been proven in industrialized countries. Although adequate technological proficiency is very important, experience has shown that this is not enough, since technology is only one of the necessary components of the required infrastructure. It cannot be sustained or implemented without the other supporting infrastructural elements. Even if the IAEA does not have the authority or legal responsibility to ensure that a country has the adequate infrastructure, a moral responsibility remains — especially in cases where the IAEA provides nuclear technology and equipment, or radioactive material itself.

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IAEA strategy for technology transfer

Many requests received from developing countries for technical assistance in radioactive waste management are similar in scope and objectives. The volumes, characteristics, and activity levels of the wastes generated, or expected to be generated, are also often quite similar.

Taking this into account, the IAEA embarked upon a strategy for providing technical assistance in the form of standardized packages for centralized waste management facilities, and supporting tools, techniques, and practices that can be easily modified to meet the needs of an individual country. These standardized packages and tools include the following:

- the Sealed Radiation Sources (SRS) Registry;
- a design for a Spent Sealed Sources Facility (SSSF);
- a design for a centralized Waste Processing and Storage Facility (WPSF);
- a series of Technical Manuals for processing and storage of radioactive waste arising from nuclear applications.

The SRS Registry. This computerized database is being developed within an IAEA programme covering spent sealed sources. The registry project's main intent is to create a basic management tool that would be useful to countries in their efforts to control and record information on sealed radiation sources on a national, regional, or local level.

Several practical requirements were established for the registry system. It should track lifetime information about a source — from cradle to grave (or its return to supplier); be useable by a wide range of organizations e.g. regulators, operators, laboratories, etc.; be easy to use and maintain; and it should not require special software or sophisticated equipment.

The registry has two basic functions. First, it maintains information on essential characteristics of a sealed radiation source, such as the name of the radionuclide, activity, source serial or other identification numbers, physical location, the user organization, the source owner, its supplier, its intended or dedicated use, and any associated housing or equipment type. Second, the registry enables the recording of pertinent information on the source when its useful life is over (i.e., becomes spent) so that proper processes or decisions can be determined. It must also provide complete archiving capabilities.

A version of the registry was released to several IAEA Member States for field testing which concluded in June 1994. Comments received thus far during the testing phase have been extremely positive. A number of Member States have already requested the database for immediate use, despite its developmental stage.Their rationale is that a nearly complete registry is better than none at all. A final version of the registry is expected to be available by January 1995.

The SSSF design package. In 1993, in response to the growing need to safely handle, condition, and store spent radiation sources before their disposal, the IAEA began developing a standard design package for a facility where all predisposal operations could be carried out in one unit. Such facilities are needed but do not exist in many developing countries, especially where radionuclides are used only in a few hospitals or research institutes. The SSSF design incorporates specific requirements, such as simplicity of technology, convenient maintenance, flexibility, economy, and safety. The standard facility is a single story building divided into a number of rooms and areas where spent sources can be received, monitored, stored for decay or until conditioning, immobilized if required, and prepared for transfer to interim storage.

The design package recommends a range of equipment and consumables required for performing the handling and immobilization of spent sealed sources. The interim storage facility may be adjacent to or on the same site as the SSSF, or it may be on a distant site requiring vehicular transport. Three types of construction design are available to suit warm arid, warm humid or cold climates.

The WPSF design package. This reference design package was specifically developed to facilitate the processing of different radioactive

Scene from an IAEA training course on radioactive waste management.
(Credit: C. Chan, IAEA)

Radioactive waste arisings

Apart from the operation of nuclear fuel cycle facilities, radioactive wastes arise from a range of activities. They include:

Nuclear research centres. Radioisotopes are produced in research reactors for different purposes by irradiation of special targets or in a particle accelerator from which the desired isotopes are subsequently extracted or processed in nearby hot cells or laboratories. Some installations are located in a nuclear research centre where radioisotopes also are used and handled. The volume of liquid and solid radioactive wastes produced by the individual users of radioactive materials in the centre is not likely to be large. Most of the radioactive wastes, solid and liquid, are contaminated with short-lived radioisotopes and are candidates for decay storage and subsequent discharge, or for disposal as non-radioactive wastes. Wastes containing long-lived fission products, including transuranic nuclides, are produced only by a few laboratories of developing countries. Only a very small part of the radioactive waste is contaminated with long-lived radioisotopes.

Hospitals. The application of radioactive materials in medical diagnosis and therapy is extremely important and continuously expanding. In many cases alternative methods are not available. The main areas of application are radioimmunoassay, *in vivo* and *in vitro* diagnostic techniques, radiotherapy, and medical research. These represent the use of not only unsealed sources, but also highly concentrated sealed sources housed in shielded assemblies.

Industry. Certain industries use radioactive material mainly in the form of sealed sources for non-destructive analysis or testing, quality control, evaluation of plant performance and development of products.The quantities of radioactive materials used depend largely on the development and level of the national technology.

Universities and other research institutes. Research establishments and universities are most commonly involved in monitoring the metabolic or environmental pathways associated with materials as diverse as drugs, pesticides, fertilizers, and minerals. The range of useful radionuclides is normally restricted and the activity content of the labelled compounds is usually low. However, some research establishments may use some rather exotic radionuclides. The radionuclides most commonly employed in toxicology studies of many chemical compounds, and their associated metabolic pathways, are carbon-14 and tritium, as they can be incorporated into complex molecules with considerable uniformity. Iodine-125 has proved to be very valuable in the labelling of proteins. A wide spectrum of radionuclides is available for research and investigation.

IAEA technical guidance and assistance

In a new series of IAEA technical documents in areas of radioactive waste management, nine documents have been issued:

- *Minimization and Segregation of Radioactive Wastes*
- *Storage of Radioactive Wastes*
- *Handling, Conditioning and Disposal of Spent Sealed Sources*
- *Handling and Treatment of Radioactive Aqueous Wastes*
- *Handling, Treatment, Conditioning and Storage of Biological Radioactive Waste*
- *Treatment and Conditioning of Radioactive Solid Wastes*
- *Treatment and Conditioning of Radioactive Organic Liquids*
- *Treatment and Conditioning of Spent Ion Exchange Resins from Research Reactors, Precipitation Sludges and Other Radioactive Concentrates*
- *Design of a Centralized Waste Processing and Storage Facility*

Classification of IAEA Member States by types and quantities of radioactive waste

To better understand the overall profile of countries, and to determine the best type of assistance package, the IAEA has grouped countries by the types and amounts of radioactive wastes generated. The first three groups are the focal point of this article.

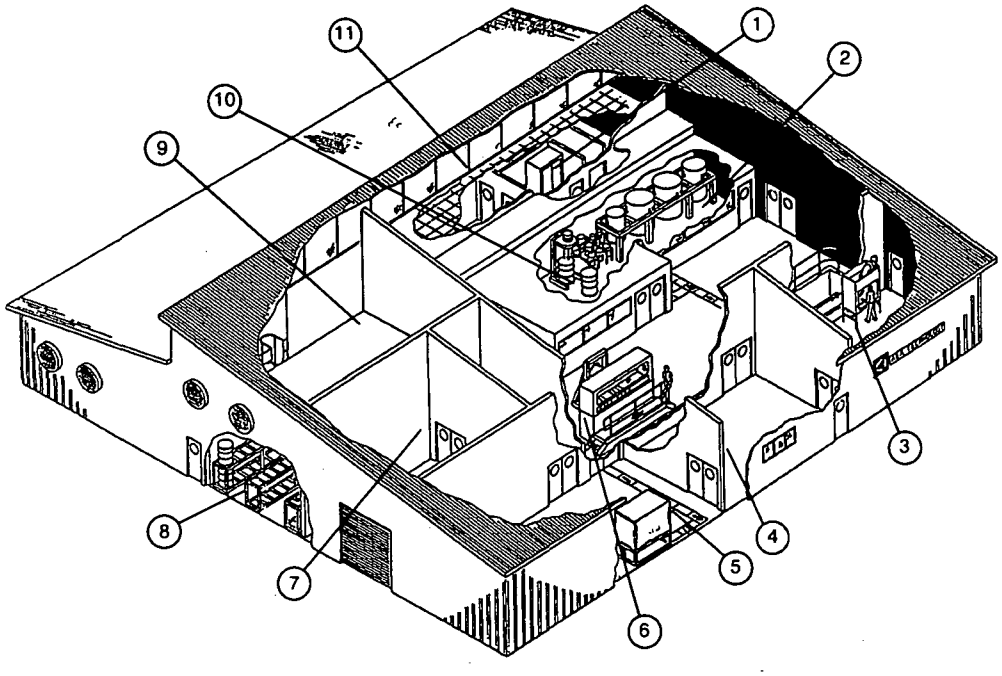
Group A: Countries with single use of radionuclides in hospitals and other institutions.

Group B: Countries with multi-use of radionuclides in hospitals and other institutions.

Group C: Countries with extensive use of radionuclides and with one (or more) nuclear research centre capable of indigenous production of several radioisotopes (in research reactors or particle accelerators).

Group D: Countries with extensive use of radionuclides and nuclear power plants planned or in operation.

Group E: Countries with nuclear power plants and fuel cycle operations.



Schematic of the WPSF waste processing building

1. Offices 2. Liquid effluent treatment plant 3. Laboratory with fume cupboard 4. Monitoring and counting room 5. Workshop and decontamination 6. Solid waste sorting and compaction 7. Receipt and dispatch bay 8. Interim storage 9. Ventilation services 10. Cementation area 11. Changing rooms

waste streams that have various activities, physical properties, and chemical composition, and that arise from multiple uses of radioisotopes and their production.

In preparing the reference design and to define its requirements, the IAEA carefully reviewed radioactive waste management techniques employed throughout the world. First, the processes selected for inclusion in the reference design had to be well proven and established, and be tolerant to changes in waste feeds. The equipment selected had to be robust, simple in design, and simple to operate and maintain. The design also had to incorporate appropriate radiological protection means to ensure safe operation. *(See schematic, which shows the type of facility that would result from the reference design package.)*

The design's recommended waste processes include liquid waste precipitation, solid waste compaction, and cementation of sludges. The design includes all supporting equipment and services necessary to safely operate the processing plant. The separate waste store is a large, simple building with no extra features other than lighting.

Benefits of reference design packages. By offering the above design packages, the IAEA and its Member States benefit in two important ways. First, the service promotes the availability of plant designs that can be modified according to national needs. Second, since the resources for providing technical assistance to developing countries are limited, there is considerable merit in developing an application or concept which meets the needs of several countries and can be used repeatedly.

The packages provide further support to the IAEA's technical assistance programmes in areas of handling, processing, and storage of low- and intermediate-level waste. Experts visiting developing countries can use the packages as the basis for providing an effective technical and economic approach to solve problems.

Technical support and training

Technical manuals. The IAEA has published technical reports and safety documents on radioactive waste management for more than three decades. These documents have provided Member States with basic reference material and comprehensive surveys of the state-of-the-art technologies.

A new series of technical documents recently was initiated to help countries that require straightforward and low-cost solutions to waste management problems. This series — entitled *Technical Manuals for the Management of Low-*

and Intermediate-Level Wastes Generated at Small Nuclear Research Centres and by Radioisotope Users in Medicine, Research and Industry — is intended to provide (1) guidance on maximizing practicable use of indigenous resources; (2) step-by-step procedures for effective application of technology; and (3) recommendations on technological procedures which can be integrated into an overall national waste management programme.

Currently, nine manuals in this series have been prepared and published as IAEA technical documents (TECDOCs). *(See box, page 48.)* Additional subject areas may be identified and covered in the future.

Technical assistance projects. Another avenue of support is a technical assistance project, which offers the opportunity for providing expertise, technology, individual training, and equipment for specific waste management needs. The objective of such projects is to offer the necessary support to develop the expertise for self-sufficiency in the safe management of radioactive waste. Since 1976, the IAEA has supported 60 technical co-operation projects on radioactive waste management in 42 countries. Currently, 36 countries receive different types of such technical assistance through more than 40 projects. In addition, there are currently five regional projects under way.

The assistance includes the provision of equipment and facilities. Among them are a solid waste compactor, equipment for chemical precipitation and waste cementation units, and various monitoring and measurement devices.

Model projects. Also being implemented is a model project to upgrade the waste management infrastructure in selected developing countries. The project recently started and includes the use of standard packages for upgrading the different parts of the waste management infrastructure.

Training. Many scientists and technicians have been trained through IAEA technical assistance projects in countries having established waste management programmes. Additionally during the last 4 years, nine regional and three interregional training courses have been held, with a total of 300 participants from 60 countries. Practical exercises and technical demonstrations included sessions covering chemical precipitation of liquid waste; compaction of solid waste; conditioning of spent sealed sources; and surface decontamination.

International meetings. Scientific meetings are an additional tool for the exchange of technical knowledge. In October 1994 in Beijing, China, the IAEA organized a seminar entitled Radioactive Waste Management Practices and Issues in Developing Countries. It was specifically designed for developing countries and focused on management practices and technologies for waste from operations not related to the nuclear fuel cycle. The IAEA also provides financial support to selected experts from developing countries for attendance at international conferences and symposia sponsored by professional and trade organizations.

Research support. While the IAEA itself does not conduct any research in the field of radioactive waste management, its co-ordinated research programmes (CRPs) encourage and foster it on topics of wide interest. Participation usually involves both developed and developing Member States, thus serving as an excellent forum for technology transfer.

Presently, CRPs on the use of inorganic sorbents for treatment and conditioning of liquid waste, and on treatment technologies for low- and intermediate-level wastes generated from institutional sources are of particular importance to developing countries. The studies include the adaptation of well-established processing technologies for the management of specific wastes in countries and for other local conditions.

Awareness of responsibilities

The use of the atom must be linked with the safe management of radioactive waste that is generated from various nuclear applications. A key aspect of the IAEA programme is therefore directed to creating an awareness among national authorities of their responsibilities to effectively plan, develop, and implement national waste management programmes. Its activities are helping to establish the necessary infrastructure and to transfer appropriate technologies.

The IAEA's ability to make an effective contribution to the safe management of radioactive waste requires a continuous evaluation of national needs to ensure that the allocation of resources and efforts are balanced to achieve the maximum benefits and results. This is a dynamic process. New model projects to upgrade the waste management situation in selected countries are now being developed. They will be implemented and evaluated to determine if their components offer the right mix of packages for building infrastructures and transferring technologies, with the aim of making them applicable to the needs of a broad base of countries. ❐