DEMONSTRATING PRACTICAL SOLUTIONS
TRAINING IN RADIOACTIVE WASTE MANAGEMENT

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Safe and sound management of radioactive waste is becoming more and more important worldwide. Regardless of a particular country's attitude to nuclear issues, there is broad acceptance of the need to safely manage accumulated and newly generated radioactive waste. The proper management of radioactive waste is one key factor influencing public perceptions of nuclear energy.

One way in which the IAEA assists its Member States in this field is to disseminate information through safety standards and technologically oriented documents, which are based on widely accepted standards and good operational practice.

Many countries are in the course of establishing waste processing centers. In countries where nuclear energy is used for power generation, these centers will serve for a particular plant or a group of nuclear facilities. If the country is operating only a few power reactors at the same site or if research reactor operation and isotope applications are the only sources of radioactive waste, one centralized facility for the entire country might be the preferred option. Less developed countries with limited economic resources and relatively small nuclear programmes often ask for IAEA assistance and support in the establishment of a centralized waste processing center.

Typically, IAEA support includes different types of technical assistance. Provision of verified and technologically sound information through IAEA documents, expert missions and training is the most common way. The necessary equipment and technologies are also often delivered to the country. Nevertheless, in many cases all this effort does not lead to the expected outcome. A very significant problem for many developing countries is the lack of practical experience and skills in properly operating the available equipment and facilities.

Recognizing this fact, the IAEA decided to organize systematic hands-on training for staff directly involved in the operation of facilities and/or specific equipment for the processing of radioactive waste. Typical subjects covered include the operation of waste processing facilities, special chemical and radioanalytical methods for characterization of raw waste and conditioned waste forms, and operational control of waste processing. Group training helps to facilitate the transfer of experience and good operational practice, not only from instructors to trainees but also between trainees. It has thus become the most efficient method to provide waste management operators with practical experience.

HANDS-ON DEMONSTRATIONS

In 1995, the IAEA's Waste Management Section launched demonstrations on "Predisposal Radioactive Waste Management Methods and Procedures", which since 1996 are funded and implemented through an IAEA interregional Model Project entitled "Sustainable Technologies to Manage Radioactive Waste".

The objective is to demonstrate to waste management staff in Member States selected waste management methods and procedures published in IAEA technical documents and widely accepted by the international waste management community. The demonstration complements the theoretical knowledge with practical experience through working with real radioactive waste in a real situation. The technical programme is

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IAEA WASTE DEMONSTRATION TRAINING

Students from 50 States have participated in the IAEA's demonstrations on pre-diposal methods and procedures for radioactive waste management. To date, 13 demonstrations have been carried out at four locations in Turkey, Chile, the Philippines, and Russian Federation.

■ *Participants in Turkey* were from Albania, Cyprus, Georgia, Ghana, Greece, Iran, Jamaica, Jordan, Lebanon, Former Yugoslav Republic of Macedonia, Moldova, Morocco, Romania, Saudia Arabia, Slovenia, Sudan, Syria, Tunisia, and Turkey.

■ *Participants in Chile* were from Bolivia, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela.

■ *Participants in the Philippines* were from Bangladesh, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Sri Lanka, Thailand, and Viet Nam.

■ *Participants in the Russian Federation* were from Armenia, Belarus, Bulgaria, Estonia, Georgia, Kazahkstan, Latvia, and Uzbekistan.

designed preferably for Member States having to manage small numbers of disused sealed radioactive sources and limited volumes of low- and intermediate level solid and liquid waste arising from the operation of research reactors and the use of nuclear techniques in medicine, industry and research. The demonstration aims at upgrading one or more operational components of the radioactive waste management systems to meet internationally accepted standards and criteria.

The project has been implemented on a regional basis, in operating waste processing and storage facilities of countries having the same problems as in the target countries. One aim is to show that radioactive waste can be managed according to real needs, within a given infrastructure, without resulting in unnecessary financial burdens or resorting to advanced technologies yet still meeting internationally accepted standards and criteria.

Demonstrations have been held in four facilities to date, namely at the Çekmece Nuclear Research and Training Centre, Istanbul, Turkey; at CEN Lo Aguirre, Santiago, Chile; at the Philippine Nuclear Research Institute, Manila, Philippines; and at A. A. Bochvar All-Russia Research Institute for Inorganic Material in cooperation with the Moscow Scientific and Industrial Association "RADON" in Sergiev Posad, Russian Federation.

In both Turkey and the Philippines, the demonstrations were held in English and were attended by participants from Europe, West Asia, Africa and East Asia Member States. In Chile the demonstration was held in Spanish with participants from Latin American countries. In Russia, the demonstrations were held in Russian, mostly for participants from East European and former USSR countries.

Technical Content & Training Methodology. The main objective of the demonstration programme is to provide participants with practical experience in managing low-level solid and liquid waste and short-lived disused sealed sources. The demonstrated methods and technologies have been selected in accordance with specific needs of participants and their countries. They are relatively simple but internationally acknowledged as safe and economical.

The training programme is structured in modules, which provides sufficient flexibility to address country specific needs, to add alternative methods and procedures as well as to introduce the latest technological improvements. The entire waste management cycle is covered from the waste collection at the waste generators through segregation, processing, and storage of waste to record keeping, quality assurance and quality control. Related radiation protection and safety issues are also properly covered. Depending on the modules, the duration of the demonstrations is from two to three weeks.

The number of participants in each demonstration is limited so that every person is afforded ample opportunity to engage in as many aspects of the exercises as possible. Experience from the

demonstration courses conducted to date suggests that the maximum number of participants for any course should not be more than ten. Two participants from three to four countries are usually invited to a demonstration.

Each participant is expected to be trained in radiation protection and to have a basic understanding of nuclear sciences and techniques prior to attending a demonstration. Knowledge of the nuclear sciences and techniques does not necessarily have to arise from an academic setting. Many individuals at technician-level possess adequate knowledge to benefit from attending the demonstration.

Participants are provided with a set of documents prior to each demonstration with the aim to establish a basic understanding of the demonstration exercises to be performed. A set of forms used for registration of measurement results and record keeping is also provided. In particular cases, the experience and good operational practice, reflected in the provided documents, become a reasonable basis for implementation of proper waste management procedures in the trainees' home organizations.

The training is provided in the form of short lectures, classroom exercises, and "hands-on" practice. The emphasis is placed on the provision of practical, hands-on activities for all participants. To enhance active participation and learning, the demonstrations include problem-based learning scenarios involving facility specific equipment, techniques, and real radioactive waste.

Problem-Based Learning Scenarios & Practical Exercises. Problem-based scenarios are used as an efficient tool to guide participants through the particular demonstrations. The instructors simultaneously evaluate and assess the course participants' knowledge and understanding of the subject matter and provide the required modifications in the scenario to assure maximum effect of the training.

The standard scenario starts with a brief presentation of a problem or situation and a few site-specific remarks to increase participant interest and familiarity. The participants are then asked to answer a series of questions, either individually or in small groups, that are

Photo: Practical hands-on training in processing radioactive waste from nuclear applications is being supported by the IAEA through demonstration projects.
(Credit: V.Friedrich/IAEA)

designed to guide them through the desired thinking process. At the end of a training lesson, the instructor facilitates a discussion on various technical questions, making sure to fill in any information that was not identified by participants. Both basic and complex conceptual information can be effectively communicated with this active learning technique.

For example, in the learning scenario on the management of disused sealed sources, an introductory question asks the participants to identify potential radiological hazards and pathways of exposure to ensure that such basic issues are considered. Additional questions are suggested to identify information that may be necessary to safely and effectively handle and process the waste concerned. Such typical questions address the isotopic content, activity, and physical form of a disused sealed source and the participants are expected to obtain the information through estimation/calculation and measurements to complete the exercise.

To increase the decision-making ability and independence of trainees, each participant is required to write down his scenario individually using a special data sheet. Subsequently, the instructors make a concerted effort to involve each participant in the group discussion and set up correct solutions/answers. The required information is then obtained by the participants under direct supervision of the instructor and the learning process continues until the assignment is completed.

Ample time is allocated for the hands-on waste management exercises. The practical sessions represent an opportunity for each participant to receive, identify, characterize, process, or place into storage real radioactive waste in a supervised, yet operational setting. The practical exercises include the identification of common errors, problems, or deficiencies experienced. The scope of each exercise also covers associated practices, such as the use of appropriate personal protective equipment, dosimetry, and radiological health surveys. The completion of all necessary documentation associated with each procedure is considered requisite for each exercise. By the end of the course, each participant has a complete set of descriptions and data sheets documenting all activities carried out throughout the course, for later reference.

Main Achievements. To date thirteen demonstrations have been carried out, five in Turkey, four in Chile, two in Philippines and two in Russia. By the end of 2000, more than 100 participants from 50 countries had attended demonstrations. Based on available information, the majority of them are still working as waste management operators or in the National Regulatory Authorities. A number of the participants have kept in contact with the IAEA as to further technical advice on waste management subjects or by contributing to particular IAEA activities.

A number of participants have been using the obtained knowledge and skills in national projects, particularly in the establishment of their waste processing centers. They are often providing an efficient communication channel between the IAEA and the Member State. Several national technical cooperation projects have been initiated by former participants of demonstrations, which bring additional benefits to their country.

Work is proceeding to broaden the scope and methodology of the demonstrations. Plans include introduction of an upgraded version of a demonstration course that emphasizes quality management and quality control issues in radioactive waste management.

ANALYSIS & CONTROL OF RADIOACTIVE WASTE

Alongside the demonstration courses for pre-disposal waste methods and procedures, the IAEA also offers hands-on training to improve the control and characterization of radioactive waste.

A sound knowledge of raw waste characteristics is essential for the selection of proper processing technology. The characteristics of waste that has been conditioned is equally important, particularly for declaration of the waste package's compliance with storage and future disposal requirements.

Other waste flow streams at nuclear facilities also have to be carefully controlled from the standpoint of radionuclide content. Typical examples are discharges from nuclear facilities that have potential

adverse impacts on the environment and population.

No single technology can satisfy all these demands. Though commonly used, gamma spectrometry does not have the capabilities to meet the rising expectations and requirements of regulatory authorities. More complicated alpha spectrometry, low-level alpha-beta counting, liquid scintillation and other specific methods are needed to obtain the required information. These methods rely upon proper instrumentation and, at the same time, detailed knowledge and skills of staff involved in radiochemical preparation of samples for measurement.

The IAEA has been following a systematic approach to improving the capability of selected analytical laboratories -- for example, through the organization of intercomparison tests -- to provide correct and verified radioanalytical information. Nevertheless, for various reasons, only a limited number of laboratories from developing countries could take part in these exercises. Recent expert missions clearly indicated that, with their available instruments, most of the laboratories are not able to carry out correct and verified "pre-measurement" operations to get reliable results. Because the laboratories lack experience and skills for the preparation of samples, analyses are often performed only in a formal way, with no guarantee for correctness and accuracy.

In some countries, the lack of proper radioanalytical capabilities even has led to the lowering of some principal regulatory requirements to nuclear facility operators and/or waste generators; this holds possible negative and irreversible consequences for the future.

To help countries upgrade their analytical capabilities for waste management, the IAEA initiated hands-on laboratory training for a range of personnel. They include staff directly involved in radiochemical analysis in waste laboratories as well as those working at control laboratories of nuclear facilities.

Training Content & Scope. The technical content and scope of this hands-on training is based on detailed analysis of the situation in the target countries, addressing their specific needs. The training programme is tailored to the equipment on-site and provided by the Agency.

The training courses are scheduled over a two-month period, in view of the special knowledge and skills being addressed. The trainees are carefully selected based on fellowship applications to the IAEA from countries participating in technical cooperation projects. In all cases, the IAEA takes into account advice received from its experts pertaining to the candidate and his or her place of work.

The training is arranged in two parts. The first part is largely oriented to theoretical aspects and the provision of basic skills in radiochemical analytical techniques. It features lectures and practical laboratory exercises, supervised by experienced instructors. The second part is oriented mostly to practical hands-on training of various radiochemical techniques. This is done in operational laboratories using real samples of waste as well as other media that the participants would be expected to deal with as a matter of practice. Information about specific types of nuclear facilities and laboratory organization, operation, safety and management is also provided.

Integral to the programme are courses on record-keeping and quality assurance. The participants are also trained in the development of operational manuals for their laboratories and in the preparation of analytical procedures for each specific purpose. They are also provided with the set of basic documents, which can be used in the process of establishment and initiation of work in their laboratories.

The IAEA introduced this training in early 2001, scheduling a course in the Czech Republic for seven participants from three countries. Results will be evaluated as part of steps to further implement the training approach.

So far, the IAEA's experience has shown that demonstrations and other forms of hands-on training are effective ways to transfer technical information and knowledge about the safe and sound management of radioactive waste. Such group training in particular enables participants to share experience and establish working contacts among themselves, and with instructors and lecturers -- practical benefits of considerable importance to States working to strengthen the management of radioactive waste. ❐