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The Vinca-VIND Programme

The Vinca Institute Nuclear Decommissioning (VIND) programme was established to undertake the decommissioning activities and otherwise improve waste management capabilities at the Vinca Institute.

The IAEA supports the VIND programme with expertise from the Departments of Technical Cooperation, Nuclear Energy, Nuclear Safety and Security, and Safeguards.

The Institute of Research on the Structure of Matter (subsequently renamed the Vinca Institute of Nuclear Sciences) was founded at Vinca in 1948 in former Yugoslavia (now Serbia). The Institute is located 15 km southeast of Belgrade and a few kilometres from the Danube River.

A heavy water-moderated, zero-power critical assembly the 'RB reactor' was constructed at Vinca in 1958. In 1959, the 6.5-megawatt heavy water-moderated 'RA' research reactor capable of using uranium fuel enriched to 80 per cent U^{235} was commissioned. The RA reactor was shutdown in 1984. In 2002, the Serb Government decided to decommission the RA reactor and its ancillary facilities and a program was instituted to begin decommissioning activities of all nuclear facilities at the institute.

The goals of the VIND programme are to (1) improve nuclear security (remove the proliferation and radiological threat), and (2) arrest the environmental hazard currently posed by leaking spent fuel at the Vinca Institute by safely packaging and shipping it to the Russian Federation, where it will be reprocessed and dispositioned. In addition, VIND will ensure processing, conditioning and safe storage of wastes generated from spent fuel re-packaging at the site, RA reactor decommissioning, or retrieved from the existing degrading storage facilities. This includes conditioning and secure storage of more than 1200 sealed sources and the significant quantities of various materials currently stored in Vinca that will be conditioned and securely stored.

Waste stored and awaiting processing

To meet the overall goals, the VIND program is divided into three-projects, each with a specific objective:

- Project 1: To stabilize and prepare spent fuel from the Vinca RA research reactor for shipment abroad or long-term storage in a facility built in the country;
- Project 2: To improve the management of low and intermediate level radioactive waste in the Vinca Institute and upgrade its capabilities for radioactive waste conditioning and storage; and
- Project 3: To complete radiological characterization of, and prepare detailed decommissioning plans for, the RA facility at Vinca.

Completion of activities under Projects 1 and 3 are necessary preconditions for the activities needed to effect decommissioning and dismantling of the RA reactor.

For Project 1, Spent Fuel Removal, In October 2006, the IAEA contracted a consortium for repackaging, transportation preparations, and shipment of the waste. Work on the repackaging activities has started using funding from three sources: the Nuclear Threat Initiative (NTI), the IAEA Technical Cooperation Funds, and the USDOE/NNSA.

For Project 3, Radioactive Waste Processing and Storage, the Serb Government sought tenders for the design and construction of a waste processing facility and a new waste storage facility, which is to include a secure storage bunker for high-activity sources and safeguarded materials. The preliminary designs for both facilities are finished and the construction permit is in the final approval stage. Construction activities for the storage facilities should be completed in late 2007; the waste processing facility should be completed by the end of 2008.

Sludge separation vessel

The funds for the processing facilities and equipment have been secured from the Serb Government, Nuclear Threat Initiative (NTI), US Department of Energy/NNSA and other, anonymous, donors. Additional funding is required for the following activities:

- retrieval, characterization and conditioning of the waste stored in the existing, degrading storage facilities,
- retrieval and stabilization of the wastes that are currently in liquid form (not currently in the project scope), and
- permanent disposition of 'safeguarded materials' to an approved user in a developed nuclear country or returned to the Russian Federation.

With respect to Project 2, an estimate of $60M was made to decommission the Vinca nuclear reactors, RA, RB and waste facilities. Some of these funds have been reserved from the NTI grant and from the TC Fund. The focus for decommissioning activities in 2007 will be on completion of the characterization and decommissioning planning activities. This will optimally utilize existing funding until funds are in hand for the physical decommissioning of the RA facility.

The VIND programme is the largest single project with respect to funding ever undertaken within the Technical Cooperation Department of the IAEA. Very careful project management is required to ensure that multidisciplinary technical assistance coming from internal departments is well coordinated. The relationships with end-users and other external international stakeholders also require very extensive coordination. This includes mechanisms for careful control and management of in-kind contributions for the acquisition of equipment, services and funding from the external donors. Once completed, the VIND programme will be taken as a contemporary example of how the IAEA can meet its statutory obligations to its Member States with respect to complex projects.

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Message from the Director

Dear Reader,

This issue of the Fuel Cycle and Waste Newsletter is entirely devoted to the work performed within the Waste Technology Section of our Division. It covers the broad spectrum of activities from waste characterisation and conditioning to disposal, decommissioning and site remediation.

The safe and efficient management of radioactive waste is a prerequisite for the continued successful use of nuclear power. The management of low and intermediate level waste is a mature and evolving activity in most Member States with a nuclear power programme, although not all have operating disposal facilities. Suitable strategies and infrastructures can be developed in other countries and international work will continue on the safe disposal of disused sealed radioactive sources.

Progress in Finland, France, Sweden and the USA indicates that the first geological repository for High Level and Fuel Wastes may be in operation before 2020. However, the siting of repositories remains of concern and requires the involvement of all of the different stakeholders. Decommissioning of power reactors is a commercially mature technology. In this context, the transfer of experiences to countries with small nuclear systems or only research reactors and other research facilities will remain very important.

I hope that you will find this letter interesting and that you are stimulated further to learn more about the work. Finally, I should like to send Season's Greetings from all of us in the Division. This past year has been an exciting year in the nuclear field and we are looking forward to continued successful interactions in 2007.

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Waste Technology Activities

The Waste Technology Section (WTS) collects, analyzes and disseminates, through various technical publications, balanced and up-to date information on various technical and technological aspects of radioactive waste management. The information covers the planning, technologies and approaches needed for the safe and efficient management of different types of radioactive waste, including waste from nuclear power plants, nuclear fuel cycle facilities, non-power nuclear activities, decommissioning, and environmental remediation.

WTS efforts are currently focusing on three major areas: the development and implementation of mechanisms for better technology transfer and information exchange; the promotion of sustainable and safer processes and procedures; and the provision of peer reviews and direct technical assistance.

The WTS activities are closely coordinated with and complement those of the Waste Safety Section.

RADIOACTIVE WASTE MANAGEMENT

WTS projects cover technologies for management of all kinds of radioactive waste (e.g., historical, newly generated, decommissioning waste), from generation through processing and final disposal. Facility decommissioning and remediation of radioactively contaminated sites are also a consistent part of WTS activities.

PRE-DISPOSAL

The objective of the WTS activities in the predisposal area is to facilitate the implementation of safe and cost-effective technologies in order to strengthen the capability of Member States to properly and safely process and store radioactive waste. The activities in this area focus on the systematic building of an information base supporting an integrated approach to waste management.

The major current topics in the predisposal waste management area are waste characterization, classification, minimization, retrieval and storage of radioactive waste.

Waste Retrieval at Solymár, Hungary, Repository

One WTS project is specifically aimed at effective strategies for characterizing radioactive wastes, with a particular emphasis on analytical and quality procedures for performing laboratory characterization activities and for developing scaling factors and correlation ratios.

WTS has developed a new technical document to address ‘operational waste categorization,’ which represents the first comprehensive revision of the IAEA categorization approach since 1971. The objective of this new effort is to undertake a comprehensive examination of waste categorization practices in Member States and to analyze why these practices were implemented.

Five projects are currently in progress or have been recently completed related to waste minimization. The first involves a comparison study among various PWRs to identify opportunities for improving waste minimization at WWERs. A second project focuses on the requirements, criteria and options for waste minimization at the *design stage* of nuclear facilities, with the objective of providing practical guidance to Member States considering new reactor designs.

It has long been recognized that selection of the optimum volume reduction technology for any given Member State, nuclear facility, nuclear program evolutionary state, and economic situation represents a significant challenge. In support of this important consideration, WTS has three projects in progress.

Many Member States have wastes that have been stored or disposed in a condition that does not meet current standards. Such wastes are being retrieved, conditioned, and stored or disposed in safer facilities.

WTS has two projects nearing completion on waste retrieval. One involves the retrieval of fluidisable wastes (wet solid wastes or dried wastes which can be converted to slurry). A complimentary project focuses on the retrieval of dry solid waste from old storage and disposal facilities.

A shift in thinking regarding waste storage has taken place around the world. There is now increasing acceptance of the reality that radioactive waste may be stored for upwards of 100 years; longer storage may apply for long-lived nuclides and HLW.

As such, efforts are in progress to capture lessons learned with long term storage of radioactive waste and to develop guidance on waste acceptance criteria for storage facilities. A major workshop on lessons learned with long term storage of radioactive wastes was held in early November 2006.

DISPOSAL

The current WTS disposal projects involve planning, design, construction and closure, and quality management for radioactive waste repositories for all types of radioactive waste.

There is a growing need for additional information and guidance in all aspects of near surface disposal. Corrective actions at current or former facilities are in some cases now required in order to enhance repository performance and safety. Many of WTS' current projects are directed towards Member States that are in the conceptual planning stage of developing LILW disposal facilities.

Disposal of Low Level Wastes, Centre de L'Aube, France

An issue of current interest in many Member States is the management, and, in particular, the *disposal of large volumes of 'very low specific activity radioactive waste'* — (activity levels that some Member States classify as exempt from regulatory control). In particular, decommissioning of nuclear facilities can give rise to large volumes of low-activity radioactive waste. International consensus on the management of this type of waste is still being sought and, thus, further actions will need to be taken.

Borehole Disposal Concept

Disused sealed radioactive sources (DSRS) with both long-lived and short-lived radionuclides (especially high-activity *and* long-lived), are of particular concern with respect to long-term safe management. The borehole disposal concept (borehole disposal of sealed sources, or 'BOSS') is an attractive and cost-effective option for the management of DSRS in many countries.

Positive results of an International Peer Review have encouraged the IAEA in developing procedures for BOSS and providing training to Member States from Africa, South America and South-East Asia.

Geological Disposal

WTS projects in the area of HLW/SF disposal are addressing scientific and technical issues in support of confidence-building for the deep geological disposal concept, including studies on natural and anthropogenic analogues, and safeguards and retrievability issues.

Collaborative activities are continuing through the IAEA Network of Centres of Excellence on Training and Demonstration in Underground Research Facilities (URFs). A number of IAEA Member States strongly support the continuation and if possible, the extension of Network activities. Sweden has recently joined the core group of donor countries and further actions will be undertaken to invite new countries with operational or planned URFs to join the Network. New coordinated research projects have started focusing on numerical modeling and bentonite performance to support site characterization and performance assessment.

Multinational Repositories

In recent years, an interest for multinational cooperation has been expressed by a number of countries that are not in a position to implement self sufficient national spent fuel/nuclear waste management programmes. The concept of regional disposal facilities for radioactive waste shared by several countries has been debated at several WTS-initiated conferences. The issue has also been discussed by the international Expert Group on Multilateral Nuclear Approaches (MNA).

DECOMMISSIONING OF INSTALLATIONS

The purpose of the WTS decommissioning projects is to foster safe, timely, and cost-effective decommissioning of all kinds of nuclear facilities. Emphasis is placed on the development of an integrated information base that will systematically cover all areas of interest. Special attention will be paid to the decommissioning of research reactors and to areas insufficiently addressed by the technical literature; i.e., niche markets of wide interest.

Containment Building Shell, Yankee Reactor Decommissioning Project Maine, USA.

A Technical Group on Decommissioning (TEGDE) was established to provide guidance to the IAEA on the development of harmonized policies and strategies for decommissioning and on its technical aspects; and to be a forum for the exchange of information on lessons learned and on the progress of national and international programmes in this field.

ENVIRONMENTAL SITE REMEDIATION

Worldwide, there are thousands of radioactively contaminated sites from past civilian and defense nuclear activities. The objective of WTS projects in this area is to increase the capability of Member States to plan and implement strategies, methodologies and technological approaches for environmental remediation. As result of these efforts Member States will eventually have in place a proper infrastructure and technologies for managing their radioactive legacies and resolve all related issues in a timely, safe and cost-effective manner. WTS has several projects in this area.

Remediation of a uranium mining site in Germany

WTS is in the process of developing and implementing an Internet-based worldwide Directory of Radioactively Contaminated Sites (DRCS) for sites that have been contaminated by radioactivity as a result of past practices and accidents. The DRCS will not be merely a listing of contaminated sites — it will also serve as a clearing house for information on relevant remediation measures. Uranium mining and milling sites and sites contaminated with NORM will also be included.

MANAGEMENT OF DISUSED SEALED RADIOACTIVE SOURCES

Sealed radioactive sources (SRS) are used extensively and widely in most Member States. The management of DSRS is currently one of the WTS high-priority areas. Activities include the development of the Radioactive Waste Management Registry (for keeping records of SRS), provision of direct assistance to Member States for conditioning DSRS, development of technical procedures and detailed designs for the management of high-activity and long-lived sources, and upgrading of the IAEA's International Catalogue of Sealed Radioactive Sources and Devices (the Catalogue), which now includes technical data on nearly 10 000 SRS, 10 000 SRS-conditioning devices and information on nearly 1 300 manufacturers and source suppliers.

WASTE MANAGEMENT INFORMATION SYSTEMS

WTS has several activities related to the collection, management, and dissemination of information for radioactive waste management. The Net-Enabled Waste Management Database (http://www-newmdb.iaea.org) is the IAEA's principal mechanism for management of information on national radioactive waste management policies and programmes, plans and activities, relevant laws and regulations, and radioactive waste inventories. Additionally, the NEWMDB is used to collect information about waste processing facilities and methods in Member States.

TECHNICAL COOPERATION

WTS has a strong role in the IAEA's Technical Cooperation activities, providing direct assistance to developing Member States in various areas of radioactive waste management. Increased emphasis is being placed on providing training opportunities to scientists and engineers in developing Member States. A series of training courses and topical workshops have been developed, including training material in support of the World Nuclear University. Some examples include the:

- Workshop on Decommissioning Strategies and Preliminary Planning — Istanbul, Turkey;
- Hands-on Training Course on Handling and Conditioning of Long-lived and Neutron Sealed Radioactive Sources — Pretoria, South Africa;
- Training Workshop on Implementation of the 'BOSS' System — Pretoria, South Africa; and
- Interregional Training Course on Methodologies for Geological Disposal of High Level Waste — Berkeley, USA and Yucca Mountain, USA.

Coordination of Multinational Assistance

A Contact Experts Group (CEG) was established in 1996 to provide points-of-contact to facilitate cooperation on environmental remediation of waste arising from earlier military activities in the Russian Federation. More recently, cooperation with the Russian Federation in the area of the nuclear legacy clean-up has been substantially expanded within the framework of Global Partnership Programme, initiated by the G8 countries, which covers the dismantling of Russian nuclear submarines as one of the major tasks. A number of Western donor countries have recently established the Northern Dimension Environmental Partnership Support Fund (NDEP), which will finance environmental and radioactive clean-up projects in the northwestern Russian Federation.

Dismantling a Delta-class submarine at the Zvezdochka shipyard in Severodvinsk, RF
(Photo: Courtesy of Zvezhdochka shipyard.)

An article in this Newsletter describes recent activities in this area by the WTS.

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Workshop on Planning and Design of Geological Repositories, IAEA, Vienna, 25–27 September 2006

The preparation of a technical report on the planning and design considerations for geological disposal of high-level long-lived waste and/or spent nuclear fuel (SNF) has been initiated. The objective of the task is to report to Member States (MSs) practical and updated information on the way a geological repository programme can be defined, planned and designed, with special attention to all aspects having an impact on the timing, including the assessment of safety. Both positive and negative experiences associated to the development of repositories may help elaborating the necessary guidance to interested countries on how to outline, implement or improve their national approaches when integrating all aspects for geological repositories.

A workshop on Planning and Design of Geological Repositories was convened to collect updated information and specific needs from Member States for discussion. 26 participants from 19 MSs attended the workshop. Both industrialized MSs with well advanced geological repository programmes and MSs just entering or still to start such programmes were well represented.

From their presentations, it was noticed that countries like Sweden or Finland expect to take over 4 decades from the first decision taken to initiate a waste disposal programme to the attainment of an operating repository.

Representatives from Germany noted that a severe setback in repository development has been experienced. Nevertheless, German experiences at the Gorleben site (salt rock) and Konrad facility (used iron-ore mine) are useful additions to the international data-base.

Due to the interruption of ‘SNF take-back’ agreements with the former USSR, new programmes have started in Bulgaria, Hungary and Lithuania. These three countries are in the preliminary planning of repository development for their SNF with implementation scheduled for the far future. Currently, the legal requirements and backgrounds to siting investigations through conceptual planning and design are being considered.

France, Switzerland and UK have also experienced some setbacks in repository development. Representatives expressed the opinion that they had successfully re-established their programmes. They underlined, respectively, the phased approach of repository design and implementation (2006 law), the demonstration of the feasibility of the disposal in Opalinus clay including technical review and stakeholder consultation, and the development of an underground repository, placing emphasis on the application of proven technology.

The Asian countries are at various stages of development of the use of nuclear energy. China, Japan and India have well planned and structured geological disposal approaches, with flexible planning including due consideration of a volunteering siting approach.

Brazil is currently developing expertise with respect to preliminary site investigations in crystalline and clay formations.

South Africa is now engaged in forming an appropriate legal and repository planning framework, which will accommodate the involvement of all stakeholders.

Discussions indicated that, to prepare its advice, the IAEA should consider the following topics: a) transitions from generic to site-specific design; b) programme planning and management processes; and c) design premises/processes for selection and optimization with respect to safety and other criteria.

Preliminary feasibility and safety assessment are a prerequisite to guide the level of details required in design. Host formations suitable for the construction of repositories and appropriate depths are now well identified. However, focus is still needed on site specific constraints as they relate to the time constraints bearing on safe performance of the repositories. Finally, a quality management system for data collection and model validation or verification will need to be developed.

The recommendations arising from the presentations and discussions of this workshop are the first building blocks, on which a report in the Technical Report Series (TRS) providing guidance on the planning and design of geological repositories will be written to be published in 2009.

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Contact Expert Group (CEG) – Workshops in 2006

The objectives of the Contact Expert Group (CEG) for International Radwaste Projects in the Russian Federation are to promote co-operation with and assistance to the Russian Federation in activities related to nuclear legacy clean-up and improvement of management of accumulated radioactive waste and spent nuclear fuel.

Two CEG workshops have been undertaken in 2006.

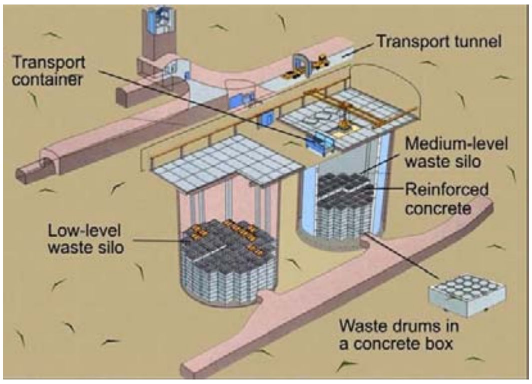
1. Strategic Aspects on Management of Radioactive Waste and Remediation of Contaminated Sites (26–27 April 2006, Stockholm, Sweden).
2. Isolation and Disposal of Radioactive Waste (28–30 June 2006, Olkiluoto, Finland).

At the first workshop contemporary practices relating to the organisation of state systems for management of radioactive waste as they have been developed by Western countries with advanced waste management programmes were reviewed. The lessons learned for application in the Russian Federation were extracted. Legislative aspects and state-of-the-art technologies for remediation of contaminated sites and facilities in the Russian Federation were identified and provided useful examples and relevant experience for application. Now, partly through the activities of the CEG, remediation of the hazardous nuclear facilities has been initiated in the Russian Federation.

At the second workshop, the following two major topics were discussed:

1. Predisposal and long-term storage of radioactive waste; and,
2. Regulatory aspects and practical experience in the radioactive waste disposal.

In general, it was recognized that proven technologies and experience in development, construction and operation of disposal facilities for low and intermediate level waste (LILW) exist. They are available in many countries and provide examples for application in the development of similar facilities in the Russian Federation.



Underground disposal facility for LILW in Olkiluoto
(Picture courtesy of POSIVA Oy)

Currently, there are no repositories in existence for the disposal of heat-generating fuel and high-level radioactive wastes. Guidance for the development of such facilities in the Russian Federation can be obtained by consideration of the 40 to 50 years of development in the USA and elsewhere of the scientific basis for radioactive waste disposal. It is generally recognized that geological disposal will be the most suitable method for the disposal of fuel and high level wastes. As in other Member States, the waste disposal facilities will have to be adapted to suit the special social conditions prevailing in the Russian Federation when the decision to proceed with disposal is made.

The workshop in Finland provided an opportunity for CEG Members to visit the underground repository for LILW in Olkiluoto and the nearby construction site of the proposed geological disposal facility for high-level waste at Onkalo. Exposure to these facilities provided insights to the special operating and safety conditions that will be encountered in underground waste disposal facilities.

Information and key presentations given at the workshops are available on the CEG website:

http://www.iaea.org/OurWork/ST/NE/NEFW/CEG/ceg_reports.html

The key findings and recommendation of the CEG workshops have been presented in Munich, Germany at the 20th CEG meeting. These recommendations will be accommodated in new international projects with the Russian Federation.

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Developments in Decommissioning

In general terms, the approach to decommissioning nuclear systems and the techniques used are straightforward and decommissioning projects can be managed in ways similar to other engineering projects of comparable sizes and complexities. The goals of the project management are to ensure safety and keep risks and costs to a minimum. Using experience and strategies to meet the goals include project planning and preparation, forming a project management organization with defined responsibilities, adopting the right technology for the job and ensuring that the appropriate specialists are available to obtain the desired safety-related effects.

With this simple and well-known approach to engineering project management, it has been possible to reach full awareness of the need for resources for and constraints of safe and cost-effective decommissioning. A significant number of decommissioning projects have been carried out in Member States. Lessons learned in the conduct of these works have led to the identification of a list of factors to be observed during the decommissioning processes. These lessons have helped the WTS to create information packages that can help future decommissioning projects.

With regard to the tools being used, the decommissioning business cannot yet be regarded as fully mature, and standard packages are not yet available for all decommissioning activities. However, together with the formation of the right organization, the developing technologies can be used to continue to reduce risks.

Handheld Mechanical Cutting Equipment (saw)
for Small Contaminated Pipes
(Courtesy of SCK-CEN, Belgium)

The technologies associated with decommissioning are not always the most advanced. The lesson of experience, and the principle to be applied, is to select techniques that are fit for purpose yet are the simplest required to achieve the task (see Figure above). Given this principle it is vital to recognize when specialist approaches and tools are required. The collective experience recorded by WTS is intended to provide this competence.

Lessons learned regarding the interlinked aspects of organisation, strategy and planning are diverse and complex. Over and above the selection of the right dismantling and decommissioning techniques, perhaps the most significant points that have been noted at the IAEA, relate to the choice of personnel, correct definition of the endpoints and clear definition of the decommissioning activities and their proper sequencing.

This sequencing should ensure, as far as possible, that upstream events do not adversely affect downstream ones. In common with all projects, contingency allowances for unforeseen events are absolute requirements in the planning processes as are the process of continuous project review and adjustment.

Staff who operated the facility during its working life can be transferred onto the decommissioning team, but training is required in order to reflect the change in discipline and attitude. Experience has shown that cooperation between the re-assigned operating organization and decommissioning experts with clear prior experience of organizing and discharging decommissioning projects is the most effective combination.

Decommissioning costs need to be incorporated into the life-cycle cost estimates of nuclear facilities. Without this inclusion, estimations of liabilities and the appropriate allowances for legacies on the balance sheet are not possible.

Using the lessons learned from the experiences of decommissioning projects carried out in technically advanced organizations in the Member States, the IAEA, along with other international organizations is working to develop standardized decommissioning cost models. This allows the IAEA to meet its statutory requirement to disseminate processes leading to the successful decommissioning of redundant nuclear facilities. Most specifically, along with the application of the most relevant technologies, costs to Member States are to be kept as low as possible.

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Singapore: Neutron Source Recovery, Conditioning and Repatriation to supplier

In 2005, Singapore approached the IAEA for assistance to solve a problem with a neutron source that had been at the National University of Singapore since the early nineteen sixties.

Through close work with Los Alamos National Laboratory (LANL), USA it came to be known by the IAEA's Technical Support Unit (TSU) that the US DOE was engaged in bilateral work with the Government of Singapore (the Mega Port Project) to detect illicit trafficking of sources or radioactive material. One of the Health Physicists in the USDOE team, from LANL, was contacted and it proved possible to engage his services for the repatriation of the neutron source in Singapore. IAEA costs were to be minimized by use of LANL's staff support.

In 2005, a specially constructed capsule and a type A package was shipped to Singapore as part of the cooperation with LANL to make it available for the operation.

QSA Global, Germany, the manufacturer of the neutron source, provided all of the necessary technical information of the design of the device and agreed that they would take it back. The packaging and repatriation operations were undertaken in March, 2006.

Information from QSA Global indicated that the source was totally embedded in a paraffin moderator, which was so unusual that the specialists from LANL proclaimed to never previously have had seen such a configuration. The source configuration and radiation output was confirmed by direct observations.

Examining the source

The final transport package

It was decided that the source was to be recovered by cutting the outer steel casing and cutting the paraffin in reasonably sized pieces until the central area was reached and the lead shield housing the source exposed. Special neutron shields were made ready to ensure safety.

When this was done in a specially allocated area of the Physics Department at the University, the inner source shield was exposed and the lid was removed. Smear tests were carried out to confirm that the source was not leaking or otherwise adversely affecting the environment.

The source was recovered and encapsulated in a special form capsule and packed in a certified type A package. Certified technical procedures developed by WTS were used in the process.

The package was closed and labelled according to international transport regulations. All required documentations were prepared and the package was picked up by the shipping agent.

Meeting all quality control measures, a protocol highlighting the main milestones of the work and indicating the conduct of the operation without incident was prepared and signed by the IAEA Technical Officer and other involved individuals. The Head of the Physics Department cleared the Protocol.

In summary, a neutron source at the National University of Singapore was recovered, conditioned for transport according to the International Transport Regulations and prepared for shipment back to the original supplier. The source arrived in Germany in April 2006 and the supplier has taken over its title. A long standing problem in Singapore has been resolved.

An approved methodology for dealing with neutron sources has been developed and confirmed and can be applied to other similar situations that are sure to be encountered in the future.

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Training in & Demonstrations of Disposal Technologies in Underground Laboratories

By the turn of the last century much research and development related to the geotechnical science and nuclear engineering aspects of geological disposal had been completed. The early underground research laboratories had been closed and activities were being run down in the second generation facilities. This meant that much of the expertise that had been developed and focused at the research centres had to be maintained or transferred to another generation of scientists and engineers that are required to continue working on the controversial projects intended to ultimately lead to the solution of one of the nuclear industry's perennial difficulties — the safe and permanent disposal of heat generating and very long-lived radioactive wastes.

In 2001, under the auspices of the IAEA, a number of Member States in which working laboratories existed came together in a Network of Centres of Excellence and offered the use of their facilities for joint training, research and development activities with other Member States. Partially the purpose was to provide a means for the continuing use of these facilities. Underground Research facilities have been notoriously expensive to build and operate and have depended on international collaborations for funding. Historically, these collaborations had been between Member States with relatively advanced Waste Management Projects. The IAEA based Network allowed for the inclusion of Member States with less well developed programmes.

Since 2001, the core group of the Network has expanded to include facilities in the following Member States: Belgium, Canada, Sweden, Switzerland, the United Kingdom and the USA. All other Member States are invited to take part in the activities of the core group and, so far, over 25 other Member States have taken advantage of the opportunities that the Network provides. The Membership of the core group is dynamic and, as national programmes change and underground laboratories close or are developed, it is expected that the list of Member States in the core group will vary. For example, Sweden (SKB) joined the core group in 2003 when its own program had the facilities to offer. One of the founder Members, AECL Canada, is now closing its URL. However, still, Canada is able to offer services to the Network by providing expertise for training engineers and scientists from the Member States with developing waste management programmes.

Preparing a room for experiments at the
Canadian Underground Research Laboratory (URL)
(Photo: Courtesy of AECL, Canada)

To now, the Network has been unable to develop a joint experiment under its auspices. However, major national and multinational experiments continue to be undertaken at the underground facilities and these have become foci for Training Courses sponsored by the IAEA's Department of Technical Cooperation. In general, the Network core members provide both the physical facilities and the experienced personnel for the courses at no cost to the IAEA.

Since 2001, more than 150 people from over 20 countries have taken part in 11 training courses. A total of 8 more courses are planned for 2007 and 2008.

Initially, the courses focused on the historical developments of underground facilities and the associated fundamental aspects of geological disposal. Both the participating and core Member States have subsequently agreed that the courses should be extended to include subjects such as numerical modelling and its development and validation through underground work and, more generally, aspects of social acceptance in the development of geological waste disposal programmes.

The Network project provides feedback to the IAEA that has helped to develop its other projects. Relevant CRPs are described later in this Newsletter. Two of these on numerical modelling and swelling clays have been requested by the Member States through the Network. In this regard, the Network allows for synergies between the IAEA Departments which otherwise would not occur.

Further information on the Network and its activities is available at the following website:

(http://www.iaea.org/OurWork/ST/NE/NEFW/wts_network.html)

The means for gaining participation in future training courses and Fellowships at the Undergound Research Laboratories are described.

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Coordinated Research Projects (CRPs)

CRP on Innovative and Adaptive Technologies for Decommissioning

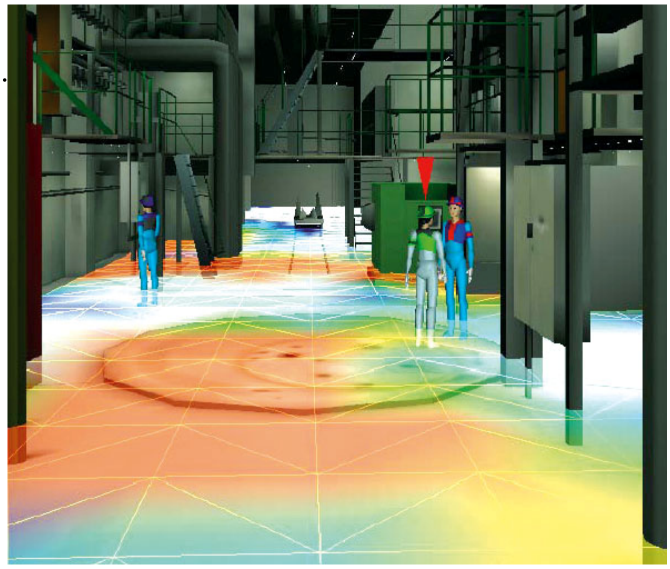
Although the state-of-the-art technology for decommissioning nuclear reactors is probably adequate to cope with most difficulties associated with the dismantling of such facilities, it is generally imperative to improve, adapt or optimise technologies for the specific needs of the reactor to be dismantled. Also, it may be possible in many cases to develop or adapt simpler decommissioning technologies rather than purchase costly equipment, e.g. remote handling equipment. Learning from others rather than re-inventing the wheel makes sense in today's globalisation context.

The overall objective of the CRP on Innovative and Adaptive Technologies for Decommissioning (2004–8) is to promote R&D activities, as well as the exchange of information and transfer of knowledge, in order to improve the technologies that are important in the planning and implementation of decommissioning. This should be achieved through a better understanding of the decision-making process in technology comparison and selection and relevant issues affecting the entire decommissioning process.

The specific objectives of the CRP include the following general aspects:

- To establish methodologies and data needs for developing concepts and approaches relevant to technology comparison and selection in decommissioning;
- To improve and expand the database on applications and performance of various types of decommissioning technologies; and,
- To address specific issues for individual decommissioning technologies and generate data relevant to their comparison and selection.

Immediately following approval of the CRP, prospective participants were invited to propose research contracts (partly supported financially by the IAEA) or agreements on relevant topics. The process of selecting and awarding agreements/contracts was completed by mid 2004. The following countries are represented: Argentina, Austria, Belgium, Brazil, Cuba, Czech Republic, Denmark, the Republic of Korea, Norway, Russian Federation, Slovakia, Ukraine and United Kingdom. Soon after the proposal selection, Norway's Institute for Energy Technology (IFE) was contacted and kindly accepted to host the first Research Coordination Meeting (RCM) at its Halden facilities (April 2005). IFE performs research in nuclear and other energy technologies. The Halden Virtual Reality (VR) Centre builds on IFE's vast experience in advanced graphical visualization technologies and human factors. The Figure below shows how VR helps to simulate and optimise activities in hostile environments, including decommissioning. The second RCM was hosted by UKAEA in the vicinity of the Windscale site, UK (Nov. 2006).



Virtual Reality at Work, Halden, Norway

The quality of the decision-making process for selecting scenarios and technologies for decommissioning of nuclear facilities is strongly dependent upon the quality and extent of input data. To arbitrarily quote one example, the contribution to the CRP from DECOM Slovakia is to prepare and to perform a set of model calculations, to analyse the results, and to develop recommendations for supporting the decision-making process. The model calculations address the developing of inventory data for shutdown NPPs, typical decommissioning scenarios, and parameters of decommissioning technologies involved. The results of model calculations will be analysed and cost-benefit/multi-attribute analyses will be performed in order to assess the effects of using various decommissioning technologies, the effect of the radiological state of the NPP after shut down, and the effect of deferred dismantling and other parameters. Advanced costing methods and the newly developed computer code OMEGA for standardised calculation of cost and other decommissioning parameters will be used for model calculations. There is substantial and successful international collaboration in this area. The workshop called for these efforts to be enhanced and expanded on the basis of voluntary decisions by states interested in converting reactors or shipping spent fuel.

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CRP on Numerical Modelling in Support to Site Characterisation and Performance Assessment

The purpose of this CRP is to evaluate the use and performance in Member States of available numerical modelling tools as a means of integrating existing experimental data and of supporting/guiding the development of activities, more especially in the field of site characterization and performance assessment.

Technical as well as time and economic constraints result in sparse data sets available for site characterization. Extraction of information from these limited data sets and their incorporation into predictive models remains a complex and interdisciplinary process. The large range of spatial and temporal scales involved in a performance assessment study necessitates the use of a variety of conceptual and numerical models that a) capture the salient features of the geologic system as well as the potential impacts of the repository, b) are capable of explaining the current system state as represented by field observations, c) provide the basis for predictive calculations over long time periods, and d) are sufficiently robust and tested so their inherent uncertainties can be assessed.

The specific objectives of the CRP are aimed to assist Member States in:

- Evaluating the approaches and modelling tools used in the frame of their programmes;
- Broadening when applicable the databases previously been used for model validation; and
- Taking actions to decrease the level of uncertainty associated with numerical predictions.

By their nature, the codes are 'works in progress' and they are refined and improved continuously as the data sets derived from continuing site evaluations are enhanced. Underground Research Facilities are providing most of the information available for verification/validation. Most of the CRP participants have the opportunity to be trained on modelling approaches and codes through courses organized in the frame of the TC Project INT/9/173 'Training in and Demonstrations of Waste Disposal Technologies in URF'.

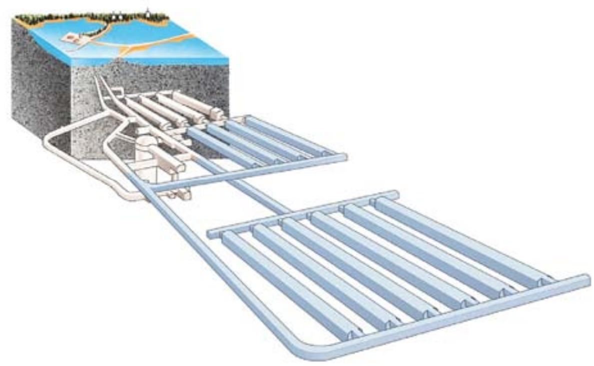
The first RCM took place in September 2006 in China and was hosted by BRIUG (Beijing Research Institute of Uranium Geology), with representatives of the 5 research contract holders (Brazil, China, Lithuania, Romania, Ukraine) and the 5 research agreement holders (Belgium, India, the Republic of Korea, UK, USA). The issue dealt with (numerical modelling) and the large area covered (site characterization and performance assessment) make coordination challenging, when referring to host rocks, models/codes but also near- versus far-field, level of development, etc. With a view of defining the work plan for the second year, extended discussions took place to identify, describe and plan common cases, required data sets, benchmarking, etc. Two test cases were defined, respectively for process modelling (to develop and compare defensible modelling approaches for a UKR-based generic site), and for performance assessment modelling (to develop and compare probabilistic and possibilistic — i.e. fuzzy logic — approaches).

Bernard Neerdael (b.neerdael@iaea.org>)

CRP on Disposal Aspects of Low and Intermediate Level Decommissioning Waste

Radioactive waste originating from decommissioning of nuclear facilities and installations needs to be managed in a manner which is compatible with internationally agreed principles and standards. The conditioning and disposal methods chosen should, in particular, be commensurate with the specific characteristics of this type of waste. Different repository constructions already used or planned to be used in a number of IAEA Member States, both in near surface and geological formations, provide suitable options for disposing each particular waste type.

To address the specific needs of national decommissioning programmes, the IAEA conducted the Coordinated Research Project on Disposal Aspects of Low and Intermediate Level Decommissioning Waste. Within this, information on, and experiences in, various countries from past and on-going decommissioning projects were compiled and evaluated. The following countries have taken part in this research project: Argentina, Canada, China, Germany, Hungary, India, the Republic of Korea, Lithuania, the Russian Federation, Slovakia, Sweden, Ukraine and USA. In addition, UK has participated as an observer.



Layout of the SFR repository extension for decommissioning waste (Photo: Courtesy of SKB, Sweden)

The objective of this project was to provide information on some national approaches in managing different kinds of radioactive waste arising during the decommissioning of nuclear facilities. Emphasis was put on specification of waste inventories, their characteristics, performance in disposal systems and on formulating appropriate strategies for their management. Also, the interaction between waste, safety assessment and repository design was highlighted and discussed. This information is important in particular for planning and designing a disposal facility accepting decommissioning waste.

Lumir Nachmilner (L.nachmilner@iaea.org)

CRP on Cementitious Materials for Long Term Storage and Disposal

The CRP will investigate the behaviours and performance of cementitious materials used for an overall waste conditioning system based on use of cement, [including waste packaging (containers), waste immobilisation (waste form) and waste backfilling, as well as, interaction and interdependencies of these individual elements (containers, waste-form, backfill)], during long term storage and disposal, and understand the processes that may result in the degradation of their physical and chemical properties. The CRP is planned to commence in the early 2007. Member States and institutions have been urged to submit their applications by the end of November 2006.

Exchange of information and research co-operation in resolving similar problems between different institutions in Member States will contribute towards improving waste management practices, its efficiency and general safety. The execution of the CRP will promote the exchange of advanced information on the ongoing research and development activities and facilitate access to the practical results of their application for conditioning or packaging of specific waste types.

The following topics will be considered:

- Cementitious materials for radioactive waste packaging: including radioactive waste immobilisation into waste form, waste backfilling and containers.
- Emerging and alternative cementitious systems.
- Physical-chemical processes occurring at production of cement compound (cement hydration) and their influence on the cement compound quality.
- Methods of production of cementitious materials for: immobilization into wasteform, backfills and containers.
- Conditions envisaged for packages (physical and chemical conditions, temperature variations, groundwater, radiation fields.).
- Testing and non-destructive monitoring techniques for cementitious materials.
- Waste acceptance criteria for waste packages, waste forms and backfills. Transport, long term storage and disposal requirements.
- Modelling and simulation of long term behaviours of cementations materials used for packaging, waste immobilisation and backfilling during long term storage and disposal.

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CRP on Upgrading of Near Surface Disposal Facilities

Many of the existing disposal facilities for low and intermediate level radioactive waste were developed and began operations long before current regulatory requirements took effect and IAEA requirements and guidance, safety assessment methodologies and recommendations for quality management systems became available. Pursuant to the Article 12 of the Joint Convention and respecting new developments in addressing safety issues of disposal facilities, both operational and long term, corrective actions have been carried out or are planned at those facilities which for some reason have not complied with the current standards.

The term ‘corrective action’, comprises all activities and measures undertaken to:

1. Achieve compliance with modified regulatory requirements;
2. Rectify an existing unsafe condition;
3. Prevent an unsafe condition from occurring in the future;
4. Respond to societal demands.

Even if the rationales for upgrading repositories are clear, the implementation of particular procedures, both administrative/managerial and technical need further investigation and systemization. Specific problems encountered in Member States carrying out corrective actions have required adoption of existing and developing new procedures. Knowing that sharing and exchanging the information on these outcomes and their dissemination through the IAEA may be of significant benefit to those Member States who have not completed the remediation activities, the IAEA will initiate a new CRP (to start in 2007) to summarize principles, decision schemes, technical approaches and specific procedures applied to upgrading of near surface disposal facilities in Member States. By solving problematic matters during the facility development, the experience gained will also be beneficial to those MSs who plan to, or are initiating construction of, new disposal facilities.

It is anticipated that the results of this CRP will be useful to scientists, engineers, managers and others involved in assessing and improving the performance of existing near surface disposal facilities; the lessons learned from the application and evaluation of corrective actions may also be relevant in the development of new ones.

The project is just being launched. Interested parties should make their proposals through the appropriate national liaison institutions.

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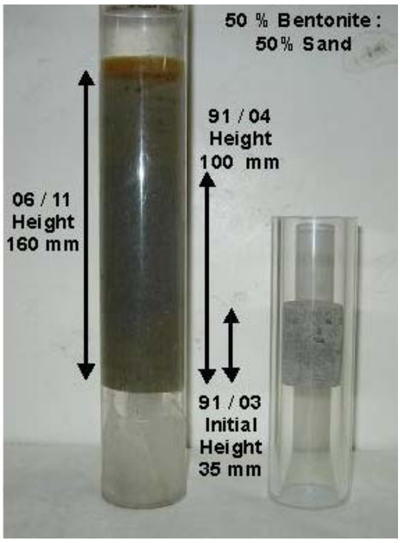
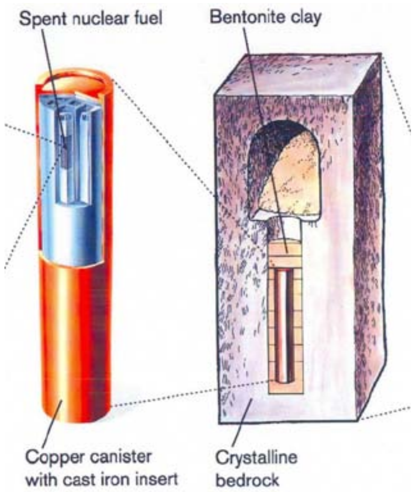
CRP on Swelling Clays

It is said that work tends to expand to fill the time available. Similarly, some clay materials, when exposed to water, tend to swell to fill the space available. Clays have a well known property of resisting water flows and in normal civil engineering practice are used extensively to create lowly permeable layers such as the cores of dams and linings for lakes, ponds, canals and domestic waste disposal sites. Combining this ability to limit water flows with the swelling capacity, it has been proposed that these special clays could be used to seal geological repositories for radioactive wastes.



A pellet of swelling clay material made in 1991 (RHS) and in 2006 (LHS) after continuous exposure to water

The preceding Figure shows how a dense mixture of a swelling clay (bentonite) and inert sand can swell to over four times its original volume. Mixtures like the one shown in the above Figure have been proposed as 'buffer' materials in a number of national geological disposal programmes. The following Figure shows part of the KBS3 disposal project where bentonite-based buffer and backfill are proposed to separate the waste-containers from the host crystalline rock mass. The term 'buffer' is used as, under particular circumstances, the clay not only provides a physical barrier against water flow and fills the excavated voids but may also sorb and thereby retard the movement of radionuclide contaminants released from a supposedly breached container.



The use of bentonite clay as a 'buffer' in the Swedish KBS3 geological disposal concept

The term bentonite is derived from the name of the town of Fort Benton, Montana, USA. Large deposits of swelling clays underlie large tracts of Montana and Wyoming. Formed from the volcanic ashes released during the formation of the Rocky Mountains these clays contain a mineral called smectite, which has particle sizes of less than 2 μm, is electrochemically negative and gives the clay its potentials for swelling and sorption.

Possible sources of similar clays are distributed throughout the Member States and for practical reasons (large quantities of these materials are needed for sealing geological repositories) it would be useful to have mechanisms by which suitable deposits can be identified.

In 2003, the IAEA initiated a CRP to create guidelines for the selection of appropriate materials by defining necessary characteristics. Member States that are part of the Network of Centres of Excellence — Canada and Sweden — (see earlier article) were joined with other Member States (China, the Czech Republic, India, Japan, the Republic of Korea, the Russian Federation, South Africa and Ukraine) to develop the guidelines and appropriate data bases. Each Member State represented will test the developed clay classification and selection criteria against deposits within its own borders.

The last research committee meetings for this CRP will take place in December this year and it is projected that the results of the work will be reported in a Technical Document (IAEA-TECDOC) which should be available for publication in late 2007. The methodologies and criteria recommended in this document are intended for application by all Member States with HLW management programmes.

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Recent Publications

Technical Reports Series No. 439
Decommissioning of Underground Structures, Systems and Components (2006)

Technical Reports Series No. 440
Dismantling of Contaminated Stacks at Nuclear Facilities (2005)

Technical Reports Series No. 441
Management of Problematic Waste and Material Generated During the Decommissioning of Nuclear Facilities (2006)

Technical Reports Series No. 442
Remediation of Sites with Mixed Contamination of Radioactive and Other Hazardous Substances (2006)

Technical Reports Series No. 443
Understanding and Managing Ageing of Materials in Spent Fuel Storage Facilities (2006)

Technical Reports Series No. 444
Redevelopment of Nuclear Facilities after Decommissioning (2006)

Technical Reports Series No. 445
Applicability of Monitored Natural Attenuation at Radioactively Contaminated Sites (2006)

Technical Reports Series No. 446
Decommissioning of Research Reactors: Evolution, State of the Art, Open Issues (2006)

Technical Reports Series No. 450
Management of Long Term Radiological Liabilities: Stewardship Challenges (2006)

IAEA-TECDOC-1478
Selection of Decommissioning Strategies: Issues and Factors (2005)

IAEA-TECDOC-1492
Improvements of Radioactive Waste Management at WWER Nuclear Power Plants (2006)

IAEA-TECDOC-1504
Innovative Waste Treatment and Conditioning Technologies at Nuclear Power Plants (2006)

IAEA-TECDOC-1505
Data Processing Technologies and Diagnostics for Water Chemistry and Corrosion Control in Nuclear Power Plants (DAWAC) (2006)

IAEA-TECDOC-1508
Spent Fuel Management Options for Research Reactors in Latin America (2006)

IAEA-TECDOC-1515
Development of Specifications for Radioactive Waste Packages (2006)

IAEA-TECDOC-1516
Viability of Inert Matrix Fuel in Reducing Plutonium Amounts in Reactors (2006)

IAEA-TECDOC-1518
Retrieval of Fluidizable Radioactive Wastes from Storage Facilities (2006)

IAEA-TECDOC-1521
Characterization, Treatment and Conditioning of Radioactive Graphite from Decommissioning of Nuclear Reactors

IAEA-WMRA-30
Waste Management Research Abstracts, Volume 30 (2005)

RWM Status and Trends
Radioactive Waste Management — Status and Trends, Report No. 4 (2005)

Radioactive Waste Managem. Profiles No. 7
A Compilation of Data from the Net Enabled Waste Management Database (NEWMDB) (2005)

STI/PUB/1259
Uranium Production and Raw Materials for the Nuclear Fuel Cycle — Supply and Demand, Economics, the Environment and Energy Security (2006)

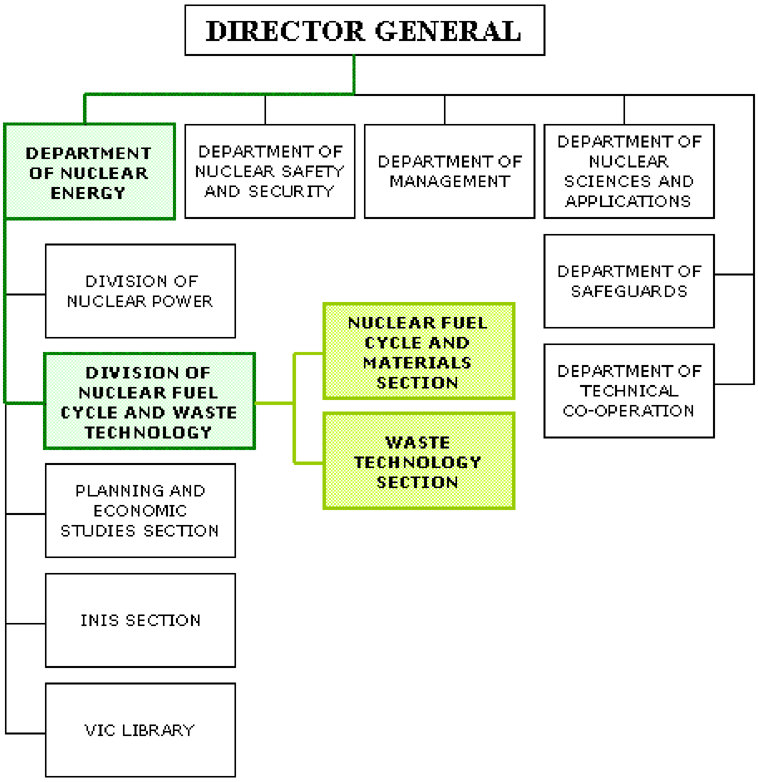
Meetings in 2006

Date	Title	Place	Contact
11–15 December	International Conference on Lessons Learned from Decommissioning of Nuclear Facilities and the Safe Termination of Nuclear Activities	Athens, Greece	M.Laraia@iaea.org

Meetings in 2007

Date	Title	Place	Contact
5–8 March	Technical Meeting on Conventional and Innovative Fuels for Fast Reactors	Idaho Falls, USA	C.Ganguly@iaea.org
12–15 March	Technical Meeting on Developing Research Reactor Coalitions and Regional Centers of Excellence	Vienna, Austria	I.Goldman@iaea.org
19–22 March	Technical Meeting of the International Working Group on Research Reactors (TWGRR)	Vienna, Austria	P.Adelfang@iaea.org
16–20 April	International Radioactive Waste Technical Committee (WATEC)	Vienna, Austria	J-M.Potier@iaea.org
23–26 April	Technical Meeting on Status and Trends in Water Reactor Fuel Performance and Technology (annual TWGFPT meeting)	Vienna, Austria	V.Inozemtsev@iaea.org
9–11 May	Technical Meeting on the Training in and Demonstration of Waste Disposal Technologies in Underground Research Facilities — An IAEA Network of Centres of Excellence	Vienna, Austria	M.N.Gray@iaea.org
14–18 May	Technical Meeting on Review of Sealed Source Designs and Manufacturing Techniques Affecting Disused Source Management	Vienna, Austria	J.Balla@iaea.org
21–24 May	Workshop to Update Waste Management Information in the Net-Enabled Waste Management Database	Vienna, Austria	J.Kinker@iaea.org
11–15 June	40^{th} Joint OECD/NEA-IAEA Uranium Group Meeting on Recent Developments in Exploration Resources Production and Demand	Vienna, Austria	J.Slezak@iaea.org
9–13 July	Training Meeting on Water Quality Management for Research Reactors	Ljubljana, Slovenia	P.Adelfang@iaea.org
3–5 September	Technical Meeting on Research Reactor Availability and Reliability	Chalk River, Ontario, Canada	E.Bradley@iaea.org
5–9 November	International Conference on Research Reactor: Safe Management and Effective Utilization	Sydney, Australia	P.Adelfang@iaea.org
12–16 November	TM on Lessons Learned by Member States in Using the Catalogue of Sealed Radioactive Sources	Vienna, Austria	A.Kahraman@iaea.org
19–22 November	TM on LEU Fuel Utilization in Accelerator Driven Sub-critical Systems	*TBD*	P.Adelfang@iaea.org
26–28 November	TM on Technical Challenges in Initiating International Ownership of Nuclear Fuel Cycle Facilities	Vienna Austria	C.Ganguly@iaea.org

Division of Nuclear Fuel Cycle and Waste Technology WebSite Links
Division Introduction NEFW home: http://www.iaea.org/OurWork/ST/NE/NEFW/index.html



Nuclear Fuel Cycle and Materials Section (NFCMS)

- Main activities
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_home.html
- Technical Working Group on Nuclear Fuel Cycle Options (TWGNFCO)
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_twgnfco.html
- Technical Working Group on Water Reactor Fuel Performance and Technology (TWGFPT)
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_twgfpt.html
- Databases (NFCIS, UDEPO, VISTA, PIE)
  http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_infcis.html

Waste Technology Section (WTS)

- Main activities
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_home.html
- International Radioactive Waste Technical Committee (WATEC)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_watec.html
- Technical Group on Decommissioning (TEGDE)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_tegde.html
- Databases (NEWMDB, DRCS)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_information.html

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