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Mobile Hot Cell for Conditioning Spent High-Activity Sealed Radioactive Sources

Radioactive sources provide great benefit to humanity primarily through their utilization in agriculture, industry, medicine and research. The vast majority of sources are used in well-regulated environments. Since the attacks of 11 September 2001, the perception of the threat to radioactive sources has changed. Consequently, there is a global trend towards increased control, accounting, and security of radioactive sources to prevent their malicious use. The IAEA and the Waste Technology Section are celebrating a significant milestone in source control with the unveiling of the new spent high-activity sealed radioactive sources (SHARS) mobile hot cell. *(Cont. p. 2)*

Staff loading spent HEU fuel in Uzbekistan

Support of Global Efforts to Remove Highly Enriched Uranium (HEU) from International Commerce

The IAEA has been involved for more than twenty years in supporting international nuclear non-proliferation efforts associated with reducing the amount of HEU in international commerce. IAEA projects and activities have directly supported the Reduced Enrichment for Research and Test Reactors (RERTR) programme, as well as directly assisted efforts to convert research reactors from HEU to low enriched uranium (LEU) fuel. HEU to LEU fuel conversion projects differ significantly depending on several factors including the design of the reactor and fuel, technical needs of the member state, local nuclear infrastructure, and available resources. To support such diverse endeavours, the IAEA tailors each project to address the relevant constraints. *(Cont. p. 3)*

Mobile Hot Cell cont'd.

Since 2003, the IAEA has been working on a SHARS Mobile Hot Cell that will allow the recovery, manipulation, and conditioning of high-activity sources (category 1 and 2) in developing countries. This represents the first mobile hot cell of its kind, which facilitates direct source recovery in those countries lacking the necessary facilities, including deployment to extremely remote areas. The work is funded through the US contribution to the Nuclear Security Fund of the IAEA. The first SHARS unit was manufactured by the Nuclear Energy Corporation of South Africa (Necsa), and the first pilot operation for testing was licensed by the South Africa Department of Health. The SHARS unit was subjected to a high-activity shielding acceptance test and operational review during March 2007 in South Africa. An International Peer Review Team from the IAEA attended the pilot testing and finalized the peer review work. The positive outcomes of the peer review will allow for the utilization of the SHARS unit initially in African Member States.

View of the Long-Term Storage Shield mated to the Hot Cell pass-through port

Manipulating the 2000 Ci source during testing.

The review team consisted of leading experts in radioactive source recovery, waste operations, hot cell design, and independent regulatory authorities from organizations including Los Alamos National Laboratory (LANL), NUKEM, Institute of Nuclear Materials Science (SCK-CEN), and the US Nuclear Regulatory Com mission (USNRC). Representatives from the Atomic Energy Commission of the United Republic of Tanzania and Sudan also participated in order to provide feedback from countries where potential operations are expected to take place.

Further, a long-term storage shield (LTSS) (storage cask) was designed to accommodate a wide variety of SHARS (particularly those frequently seen in developing countries) to give maximum flexibility to their handling and management. The LTSS has been designed with both safety and security in mind. It is designed to meet the type B container requirements, but has not been submitted to formally verify its compliance yet. Some Member States have shown interest in certifying the LTSS as a transport container as a type B(U). This outcome is highly desirable because it will make source re-use and repatriation much easier in the future.

A number of Member States have shown interest to have their sources recovered, conditioned and rendered safe. Over a dozen of countries in Africa recently expressed their interest for such operations at a regional meeting in Khartoum, Sudan. Several other countries with substantial nuclear infrastructure have expressed their interest to join efforts with the IAEA to develop similar capabilities in their region to help solve the problem associated with SHARS and disused sealed radioactive sources in general. With the international support and will of Member States it is expected that the problems associated with SHARS will be solved within 8 to 10 years. Given the chronic nature of this problem and its long history, achievement of this goal within a decade would be a major success.

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Message from the Director

Dear Reader,

The top stories in this issue of the Fuel Cycle and Waste Newsletter highlight some important activities of the Division to reduce the nuclear threats worldwide. It involves conditioning and possible repatriation of spent sealed radioactive sources, conversion of research reactors from high enriched uranium fuel to low enriched uranium and return of the fuel to the USA and the Russian Federation. These activities have great technical challenges and are connected with important legal and administrative work. The activities are performed in close and positive cooperation with the Office of Nuclear Security and the Department of Technical Cooperation, and with support of the Office of Legal Affairs. It also involves counterparts in many countries, e.g. Canada, Germany, the Russian Federation, South Africa and USA in addition to the countries were the operations are undertaken. This work is not only challenging for our staff but also very rewarding as very concrete results can be seen. In addition to these top stories, some other recent activities are described. As usual, we can only give some samples of the wide variety of activities in the Division. To get more information I encourage you to contact the scientific secretary mentioned for each article or to look in earlier issues of the Newsletter that are available on the web at http://www.iaea.org/OurWork/ST/NE/NEFW?nefw_newsletter.html .

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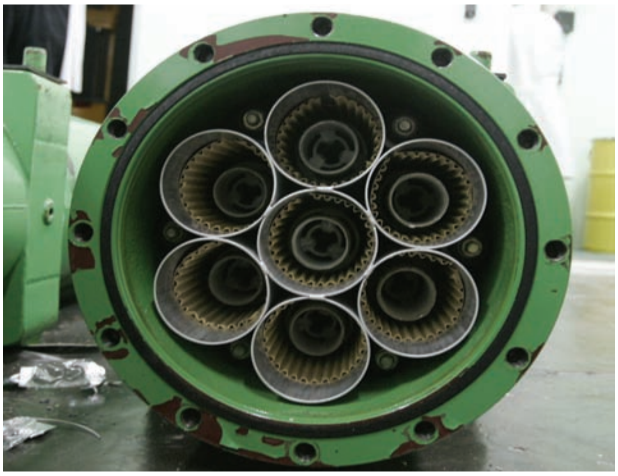
HEU cont'd.

IAEA support for HEU to LEU conversions is delivered through Technical Cooperation (TC) projects and Regular Programme and Budget (P&B) activities.

With IAEA TC support, the Chilean authorities developed a qualified, domestic LEU fuel manufacturing capability to facilitate the May 2006 conversion of the RECH– 1 RR. Also through TC, the IAEA supported the ongoing conversion of two RR cores in Tajoura, Libyan Arab Jamahiriya by facilitating the assessment of the proposed LEU fuel quality and implementation of poolside inspection capabilities. Through another TC project, the IAEA finalised a tri-partite contract for the conversion of the MARIA RR operated by the Polish Institute of Atomic Energy. The MARIA conversion involves a unique fuel design which required a phased contractual implementation. Similarly, the IAEA developed a tri-partite contract for the supply of LEU fuel to a Portuguese RR. Finally, the IAEA supported the HEU to LEU conversion of the 14 MW TRIGA-reactor in Pitesti, Romania. This final conversion took place while fuel supply operations were transitioning from General Atomics facilities in the USA to CERCA facilities in France. Despite the related challenges the reactor was fully converted by mid-May 2006.



Shipping container filled with fresh HEU Fuel

IAEA P&B efforts include support for the conversion of various families of research reactors. As with the facility-specific conversions, approaches are customised to address the relevant challenges. Examples include ongoing efforts to support the conversion of Chinese designed miniature neutron source reactors through an IAEA Coordinated Research Project and a collaborative activity with the purpose of studying the feasibility of using LEU in accelerator driven sub-critical (ADS) systems.

Furthermore, Technetium 99m, the daughter product of Molybdenum 99 (Mo-99) is used for approximately 20–25 million medical diagnostic procedures worldwide. Several commercial entities produce Mo-99 by irradiating HEU targets and recovering Mo-99 in dedicated processing facilities. In line with efforts to minimize and eventually eliminate the use of HEU in civil commerce, the IAEA supports ongoing efforts to shift the production of medical isotopes away from the use of HEU through P&B as well as extrabudgetary activities.

Separate from HEU to LEU conversion activities fuel take-back programmes are ongoing. In December 2005, the first shipment of spent HEU fuel under the Russian Research Reactor Spent Fuel Return (RRRFR) took place

Fresh HEU fuel shipment from Poland to the Russian Federation within IAEA TC Project RER/4/028

with the return of spent fuel from Uzbekistan to the Russian Federation. In 2006, the IAEA conducted several workshops to capture lessons learned from this first shipment. These workshops produced guidelines for use by States and institutions involved in the RRRFR programme. The IAEA also supported the RRRFR work in 2006 by purchasing ten high capacity dual purpose spent fuel casks for use in future shipments. The IAEA is also working to return fresh HEU fuel to the Russian Federation. Since 2002, the IAEA has arranged for the transportation of about 433 kg of fresh HEU fuel from nine States.

The removal of spent nuclear fuel from the research reactor at Serbia's Vinča Institute of Nuclear Sciences has been an ongoing activity for the IAEA since 2002. The largest TC project in IAEA history, Safe Removal of Spent Fuel from the Vinča RA Research Reactor, achieved a major milestone with the signing of a spent fuel repackaging and repatriation contract between the IAEA, a Russian consortium and Serbia. Under the contract, in excess of two metric tonnes of spent nuclear fuel from the Vinča RA Reactor will be repackaged and transported back to the Russian Federation.

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Waste Technology Section (WTS) Overview

The activities of the IAEA's Waste Technology Section (WTS) cover a broad spectrum of activities from radioactive waste characterization and conditioning to disposal, decommissioning and site remediation. Recognizing the IAEA statutory role '***to foster exchange of information on peaceful use of atomic energy***' among its Member States, WTS efforts are currently focusing on three major areas: the development and implementation of better mechanisms for better technology transfer and information exchange; the promotion of sustainable and safer processes and procedures; and the provision of direct assistance through the Technical Cooperation programme. The work 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. The WTS activities are closely coordinated with and complement those of the Waste Safety Section. Several joint activities are implemented.

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

There are an increasing number of requests for Technical Cooperation in various areas of radioactive waste management ranging from developments of waste management policies and strategies to detailed technical implementation of waste treatment techniques. Increased emphasis is being placed on providing training opportunities to scientists and engineers in developing Member States.

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. An important new project involves a comparison study and benchmarking exercise to identify opportunities for improving waste minimization at WWERs. A first consultancy was held in March 2007 to define a way forward building on the experience of a similar exercise for PWRs in the US and of the operators of WWERs. This will be followed up by a technical meeting in December 2007.

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 and many of the projects are directed towards Member States that are in the conceptual planning stage of developing LILW disposal facilities The forming of a network for transfer experiences from operating disposal is planned, similar to the existing IAEA Network of Centres of Excellence on Training and Demonstration in Underground Research Facilities (URFs).

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 is paid to the decommissioning of research reactors. To enhance the cooperation, a network of organizations with particular experience and excellence in nuclear decommissioning is being established – the **IAEA Decommissioning Network (IDN)** (see separate article).

Worldwide, there are thousands of radioactively contaminated sites from past civilian and defense nuclear activities. The objective of WTS projects on *environmental site remediation* is to increase the capability of Member States to plan and implement strategies, methodologies and technological approaches for environmental remediation.

Sealed radioactive sources (SRS) are used extensively and widely in most Member States. The management of disused SRS (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 design of equipment for the recovery and conditioning of high-activity and long-lived sources (see separate article), and upgrading of the IAEA's International Catalogue of Sealed Radioactive Sources and Devices.

WTS is also providing the secretariat for a Contact Experts Group (CEG) with the task to facilitate cooperation on environmental remediation of waste arising from earlier military activities in the Russian Federation. This covers the dismantling of Russian nuclear submarines and environmental and radioactive clean-up projects in the northwestern Russia.

Dismantling a Delta-class submarine at the Zvezdochka shipyard in Severodvinsk, RF

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Nuclear Fuel Cycle & Materials Section (NFC&MS) Overview

The activities of the Nuclear Fuel Cycle and Materials Section (NFC&MS) encompass various processes and technologies related to exploration, mining and purification of uranium and to a limited extent thorium ores, manufacturing and quality assurance of fuel pins and fuel assemblies for nuclear power reactors, storage of spent fuel, reprocessing for recovery of 'fissile' and 'fertile' materials, as well as recycling of these materials. The Section's activities also include significant work to address fuel cycle issues unique to research reactors.

The Section's activities are intended to play a catalytic role by:

i. Fostering and promoting exchange of information and experience through technical meetings, international symposia and conferences;

ii. Maintaining, updating and analysing the uranium and thorium resource base through the popular Red Book, entitled Uranium Resources, Production and Demand, published biennially in collaboration with OECD-NEA and the web based integrated Nuclear Fuel Cycle Information System (iNFCIS);

iii. Identification of best practices, and encouraging cooperation among Member States and international organizations, through training, workshops and coordinated research projects (CRPs) on uranium exploration, mining and production cycle, low enriched uranium (LEU) based research reactor fuels and fuel cycle issues and back end options of power reactor fuels, including long term storage, partitioning and transmutation (P&T) and recycling of plutonium and minor actinides (Np, Am & Cm) in thermal and fast reactors.

Additionally, the section provides direct assistance to Member States through numerous IAEA Technical Cooperation (TC) projects.

High profile issues being addressed within the Section include:

1. Uranium exploration, mining and production within the context of an increasing demand and dramatic increase in uranium prices spurred by rising expectations for nuclear power throughout the world.

2. Innovation and optimization of uranium oxide and mixed uranium plutonium oxide (MOX) fuels for nuclear power reactors, including extended burn–up and minimization of fuel failures, longer fuel residence time, improved resistance to corrosion, and also greater operational flexibility; while still satisfying appropriate safety margins for normal, transient, and accident conditions.

3. Appropriate management of spent fuel including extended storage, treatment, reprocessing and recycling with focus on proliferation resistance, partitioning and transmutation (P&T) and efficient burning of plutonium and minor actinides (MA).

4. Support of research reactor highly enriched uranium (HEU) to LEU fuel conversion projects and programmes working to return fresh and spent research reactor fuel to the country of origin.

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The IAEA to Launch International Decommissioning Network

Around the world, a number of nuclear installations, including power reactors, research reactors and many other fuel cycle facilities have already ceased activity or are approaching the end of their operational lifetime and will be soon decommissioned. Many of these facilities are small and widely distributed geographically, e.g. ~300 ageing or shut down research reactors. Appropriate steps need to be taken to prepare for their future decommissioning. In developing Member States, decommissioning programmes are often influenced by the availability of resources, i.e. knowledge, experience, infrastructure, funding capabilities and consequently, decommissioning strategies need to be tailored to cope with those constraints.

Drawing on the recommendations of the IAEA International Conference held in Athens in December 2006 where the strengthening of international cooperation was strongly supported by the participants, the IAEA took the decision to enhance its arrangements for cooperating with Member States' decommissioning organizations. As a cooperative initiative between Waste Technology and Waste Safety, an International Decommissioning Network (IDN) will be established. Those working in the decommissioning field have strongly endorsed the value of a more 'hands on' approach to the sharing of decommissioning skills and knowledge, particularly between experienced organizations with proven areas of excellence and those facing decommissioning challenges for the first time. The IDN will be primarily organized along regional lines and will build on the lessons from the successful Network of Centres of Excellence for training and development in waste disposal technologies. The IDN should fulfill the following functions:

a. Support nuclear facilities in Member States, particularly those with less developed decommissioning activities, by providing access to decommissioning skills, knowledge and projects;

b. A mechanism whereby decommissioning organizations may exchange information under the aegis of the IAEA to pursue the promulgation of good practices and the longer term retention of knowledge in support of deferred dismantling.

The IDN will also provide specialist advice and technical guidance on the IAEA's programme in the area of decommissioning.

Although decommissioning technology is relatively mature, and there are many commercial organizations around the world able to offer relevant services, many smaller facilities — usually associated with research, training or medical applications — are located in Member States unable to access these services.

A number of Member States organizations already involved in major decommissioning programmes, have already expressed interest to join the IDN and share their experience and knowledge with less advanced countries. Some organizations have offered their facilities undergoing decommissioning to serve as demonstration projects for practical training on the field.

Participants in recent exploratory meetings expressed their enthusiasm for the concept. These meetings involved a full range of relevant organizations—both those who through their experience and global perspectives, could be seen as 'donors' and also representatives from organizations with a recognized need. Indeed, participants noted that there was no absolute distinction between 'donors' and 'recipients', and that there were broad areas of likely mutual interest with wider benefits from sharing technical and personal perspectives.

The initial focus of the IDN will be on facilities such as research reactors and similar sized facilities where the needs are judged to be substantial and where an impact can be made on a reasonable timescale. In due course the IDN is expected to expand in response to the needs of its members, to cover a wide range of decommissioning activities.

Brookhaven Reactor Decommissioning - 2003

The official launching of the IDN by the IAEA Departments of Technical Cooperation, Nuclear Energy and Nuclear Safety and Security will take place during the General Conference in September 2007. It will be followed by a Technical Meeting to be held at the IAEA on 29–31 October where the Terms of Reference, modus operandi and 2008 programme of work, in particular training activities offered to MSs, will be finalized.

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Developing and Implementing Radioactive Waste Management Policies and Strategies

Every country should develop a policy and strategy for managing its spent fuel and radioactive waste to set out the nationally agreed position and plans. Although the words 'policy' and 'strategy' are often used interchangeably, a clear distinction can be made: policy is taken to mean the particular goals or aims of the different elements of radioactive waste management (*what*), while strategy defines the ways and methods used to implement the policies (*how*).

Among those working at the national level, there is often difference of opinion as to what constitutes policy versus strategy, including the roles and responsibilities connected with each. To advise the Member States, the Waste Technology and Waste Safety Sections are jointly working on a foundation document on development of policies and strategies for management of radioactive waste, which should be a valuable resource for formulating relevant national approaches. The IAEA assistance in creating conceptual waste management documents has also been included in a number of Technical Cooperation projects: Member States have asked for support in developing a systematic approach to managing waste through establishing their national policy and strategy. As an example, both Sections recently provided a joint seminar in Pakistan to focus on this issue.

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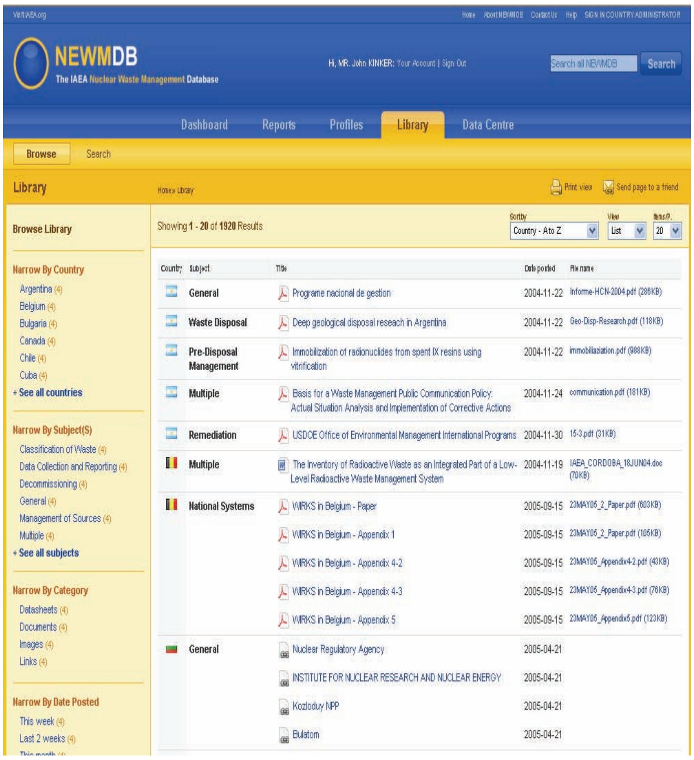
Net-Enabled Waste Management Data Base (NEWMDB): National Reporting Tool Update

The NEWMDB is the IAEA system for the collection and public dissemination of radioactive waste management information from our Member States. NEWMDB combines waste data submitted by IAEA Member States with access to publications, reports, and other data concerning radioactive waste management world-wide. The system which is 6 years old, is currently undergoing 'renovation' to make it easier to use and include new and more powerful features for both public users and for Member States.

The most important of these new features is a special re-



Look of the 'new' NEWMDB

port generator designed to facilitate the writing of national waste reports. The impetus for this feature was a desire on the part of Member State counterparts (Country Coordinators to the NEWMDB) to enable them to extract their data back out of the system in a way that complies with the guidelines and requirements for National Reporting under the Joint Convention for the Safety of Spent Fuel and for the Safety of Radioactive Waste Management (Joint Convention). We expect to have a working prototype for review by Member States by December of this year.

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Spent Fuel Performance Assessment and Research

Spent fuel storage technology (particularly dry storage) is undergoing evolution, with modified/new fuel and material designs and increasing target burnup levels.

Increased burnup implies higher strains and increased cladding hydriding and oxidation. The Coordinated Research Project on spent fuel performance assessment and research (SPAR-II, 2004–8) addresses objectives related to surveillance and monitoring programmes for spent fuel storage facilities, fuel materials performance evaluation for wet/dry storage, and collection and exchange of spent fuel storage experience. Participants include representatives from Canada, France, Germany, Hungary, Japan (two institutions), the Republic of Korea, Slovakia, Spain, USA, and the European Commission. Sweden attends with observer status and participation by the United Kingdom and Argentina is pending.

Tour of CRIEPI cask testing facility Gunma Region, Japan

The second SPAR-II research coordination meeting (RCM) was hosted in Japan by their Central Research Institute of Electric Power Industry (CRIEPI) and the Japan Nuclear Energy Safety (JNES) Organization from 6 to 10 November 2006. Seventeen representatives from 14 organizations participated in the meetings in Tokyo, as well as a tour to the Akagi test centre in the Gunma region on 8 November to tour relevant facilities including CRIEPI's cask testing facility.

The RCM discussions focused on status updates regarding national activities as well as a review of work since the 2005 RCM relevant to subsequent documentation of SPAR-II results.

Tour of Akagi test centre in the Gunma region, Japan

In May 2007 five of the CRP participants serving as authors of the SPAR-II technical document met in Vienna to review and update the latest draft, and also to prepare plans for the next RCM. The third and final RCM will be held in Budapest, Hungary 2–6 June 2008.

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Spent Fuel Treatment Options

The IAEA continues to give a high priority to safe and effective implementation of spent fuel management. As the options for spent fuel management may in a long term diversify due to evolving requirements and new priorities in strategic criteria, it is worthwhile identifying viable technical options for spent fuel treatment and their applicability to broader spent fuel management. In June 2006 during the International Conference on the Management of Spent Fuel from Nuclear Power Reactors, held in Vienna, the scope of spent fuel management was broadened to include policy, safety and security aspects.

Substantial global growth of nuclear electricity generation is expected to occur during this century, in response to environmental issues and to assure the sustainability of the electrical energy supply in both industrial countries and less-developed countries. This growth carries with it an increasing responsibility to ensure that nuclear fuel cycle technologies are used only for peaceful purposes. Recently, proposals have been set forth by the IAEA Director General ElBaradei, US President Bush, and Russian Federation President Putin for the internationalization of the nuclear fuel cycle. These proposals entail an implied need for the development of innovative means for closure of the nuclear fuel cycle as advanced reactors (Gen III and IV) are deployed and as the quantities of material in the fuel cycle increase to several times present levels. Such increases can cause stress to the international non-proliferation regime and create undue problems for nuclear waste disposal if not dealt with through open and comprehensive international collaboration.

A consultants meeting on Spent Fuel Treatment Options with participants from France, India, Japan, the Russian Federation and USA was held in Vienna to provide the latest update on development in nuclear reprocessing technologies in the light of new developments on the global nuclear scene.

Spent fuel treatment options have evolved significantly since the start of nuclear energy application. There is a large body of industrial experience in fuel cycle technologies complemented by research and development programs in several countries.

A number of options exist for the treatment of spent fuel. Some, including those that avoid separation of a pure plutonium stream, are at an advanced level of technological maturity. These could be deployed in the next generation of industrial-scale reprocessing plants, while others (such as dry methods) are at a pilot scale, laboratory scale or conceptual stage of development.

Next-generation spent fuel reprocessing plants are likely to be based on aqueous extraction processes that can be designed to a country specific set of spent fuel partitioning criteria for recycling of fissile materials to advanced light water reactors or fast spectrum reactors. The physical design of these plants must incorporate effective means for materials accountancy, safeguards and physical protection.

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FUMEX (FUel Modelling at EXtended Burnup)

Significant improvements in the capability to model fuel temperature, fission gas release and dimensional change have been achieved, and with the recently completed FUMEX-2, the range of fuel burnup that is capable of being analysed accurately has increased to around 60,000MWd/tU in support of the extended burnups in modern LWR fuel cycles.

The IAEA has supported the development and improvement of computer codes for the modelling of fuel behaviour since 1981. The Coordinated Research Projects (CRPs) DCOM (1981–1985), FUMEX (1993–1996) and FUMEX-2 (2001–2006) have provided opportunities for model development, validation and verification. The approach used, particularly in the FUMEX series of CRPs, in cooperation with the OECD/NEA, has been to provide modellers with well qualified data from fuel experiments and reactor operation and to allow them to compare and discuss their modelling of this data.

The demands on fuel performance and its modelling continue to develop; with new cladding materials and designs introduced, and concerns with transient behaviour at high burnup which need to be addressed. The IAEA is proposing to use the FUMEX approach for a third time for a new CRP, FUMEX-3, to start in 2008, which will address concerns with high burnup transient behaviour, consequences of the rim effect observed at high burnup and will also consider fuel behaviour in advanced PHWR fuel cycles with high ratings and extended burnup.

The programme will continue to cooperate closely with the OECD/NEA in the provision of data for the modellers to use.

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FUWAC (FUel and WAter Chemistry)

Water chemistry is a key issue for the operation of nuclear power plants, and again the IAEA has been supporting Member States with a series of CRPs, starting in 1981. Water chemistry has its main influence on nuclear power plant operation through the transport and deposition of corrosion products including crud on the fuel as well as corrosion of the fuel itself. Operational events and strategies in operating plants have varied, and the condition of the primary circuits of older plants is not always well characterised. For this purpose the IAEA started a CRP, FUWAC, in 2006 to examine the interaction between fuel operation and water chemistry regimes. The main objectives include monitoring, maintaining and optimising the water chemistry regime in the primary circuit of water-cooled power reactors, taking into account high burnup operation, mixed cores and plant aging. The main research objectives are to understand the causal mechanisms and identify mitigating strategies for the following issues:

- Deposit Composition and Thickness on the Fuel;
- Crud Induced Power Shift (CIPS) and Power Limitation;
- Fuel Oxide Growth and Thickness;
- Corrosion Related Fuel Failure;
- Crud Induced Localized Corrosion (CILC);
- Radioactivity build-up in RCS.

Sixteen Member States organisations are participating, representing utilities, fuel vendors, universities and research organisations. Studies are under way for PWR, BWR, WWER and PHWR reactor types.

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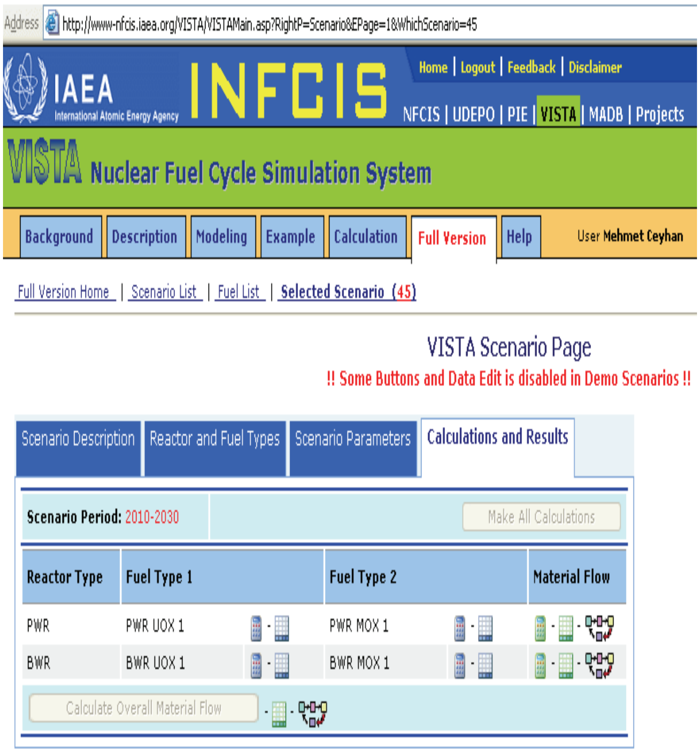
Integrated Nuclear Fuel Cycle Information Systems (iNFCIS)

The IAEA has been supporting its Member States, from the beginning of its life, by providing reliable and up-to-date information on the different aspects of utilizing nuclear energy in consideration of the entire nuclear fuel cycle. The IAEA has published many technical documents as well as developed and disseminated many databases on nuclear fuel cycle topics throughout its history.

From the beginning of 2004 it was decided to disseminate nuclear fuel cycle related databases in one central web site. The integrated Fuel Cycle Information Systems (iNFCIS) was established. One internet application developed to host a number of nuclear fuel cycle related databases and simulation systems. The below list gives the list of information sources which is currently published on the iNFCIS web site:

- **Nuclear Fuel Cycle Information Systems (NFCIS):** A directory of civilian nuclear fuel cycle facilities in the world.
- **World Distribution of Uranium Deposits (UDEPO):** A database on technical and geological information about the uranium deposits in the world.
- **Post Irradiation Examination Facilities Database (PIE):** A catalogue of worldwide post irradiation examination facilities.
- **Nuclear Fuel Cycle Simulation System (VISTA):** A tool for estimating long term nuclear fuel cycle material and service requirements. An IAEA-TECDOC has been published in 2007 to introduce the tool to the interested people within Member States (IAEA-TECDOC-1535, Nuclear Fuel Cycle Simulation System, 2007). An internet application was developed to enable authorized users to use full capabilities of VISTA in the iNFCIS web site (see photo below). The full version will be announced soon.



View of the Nuclear Fuel Cycle Simulation System (VISTA)

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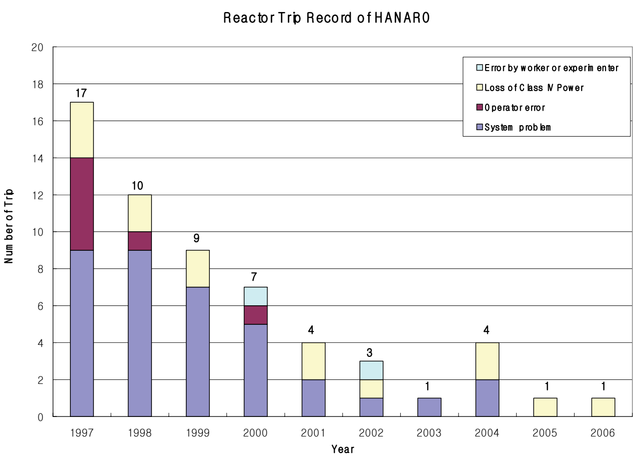
Research Reactor Availability and Reliability

Demand for research rector (RR) services is strong and diverse. In the coming decades they are expected to make important contributions in the further development of peaceful uses of nuclear technology, in particular for advanced reactors and fuel cycles, fusion, high energy physics, basic research, materials science, nuclear medicine, biological sciences, as well as training and education.

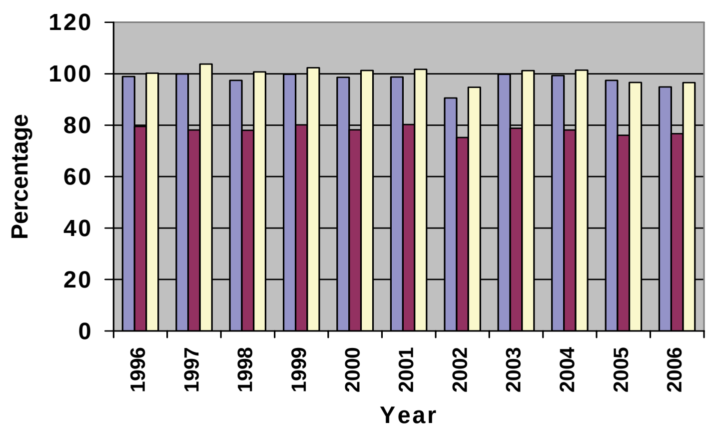
The future of many RRs is in question due to ever increasing competition for limited Government research and development funds, increased emphasis on safety and security of nuclear facilities, and a more economically competitive marketplace. For a select (and growing) population of RR organizations; an unplanned, forced, or otherwise inadvertent reactor shutdown is a significant event –– so significant that they are willing to proactively invest resources to reduce these occurrences to a minimum. Many facilities are working to optimise operations through the implementation of Availability and Reliability Programmes (ARPs) to adapt to the challenges of this changing operational context.

Based on input from interested Member States, the IAEA organised a series of meetings in 2006 and 2007 to assess research reactor availability and reliability. Participants included Operations and Maintenance (O&M) managers from highly utilised facilities of various size, design and mission, with demonstrated operational excellence. Discussions identified 10 areas of research reactor O&M important to near– and longer-term availability and reliability as well numerous best practices within each area. The 10 areas included configuration management, fuel cycle management, maintenance, performance monitoring, regulatory issues, consideration of modification & new plant design, staff requirements, customer requirements, public relations and management enhancement programmes.

This effort will rely on the input from – and aims to initially benefit – representatives from O&M organizations associated with heavily utilized research reactors that are highly sensitive to inadvertent automatic shutdowns, unplanned power reductions, forced outages and/or unplanned outage extensions. However, longer term benefits could be achieved by any RR organisation looking to make more dramatic improvements or specific changes in a few particular areas.



HANARO Research Reactor Operations Performance



HFR Petten Research Reactor Performance

- *Days at power / (days at power + days unscheduled shutdown)*
- *Number days at power / 365*
- *Days at power / scheduled operational days*

Some brief examples of identified RR O&M best practices include:

- Identification, advance procurement and warehousing of long lead time critical spare components;
- Trending operational performance and events;
- Identifying root and contributing causes to unplanned reactor trips, outage extensions or other operational upsets and then subsequently tracking and completing required actions to prevent recurrence;
- Negotiating economic and stable fuel supply contracts;
- Developing robust plans to address issues associated with the back-end of the fuel cycle;
- Reflecting changes in plant configuration in relevant documentation such as procedures and engineering drawings.

Participants noted that these practices were typically implemented within the reactor O&M organisation, but were often integrated with, and built upon, existing programmes originally created to monitor and improve facility safety and security performance.

The results of the meetings are being compiled into an IAEA document, tentatively entitled Research Reactor Availability and Reliability – Recommended Practices. The final document should be useful for other highly utilised facilities looking to optimise overall performance as well as lesser utilised facilities seeking improvements related to specific activities.

Edward Bradley (E.Bradley@iaea.org)

Research Reactor Coalitions

Many research reactors are underutilized and are faced with critical issues related to their sustainability and future operation as they must justify their relevance in order to maintain governmental support and in many cases increase revenues from commercial or other outside activities.

Greatly enhanced international and regional cooperation appears to be an attractive means not only to assure the survival of the most capable reactors, but also as a means to provide high-quality research reactor capabilities to countries without national research reactors. Enhanced cooperation could also serve to improve access of potential customers to the international research reactor community.

Consequently, the IAEA is undertaking expanded activities to enhance research reactor utilization. This includes a new Technical Cooperation Project on Enhancement of the Sustainability of Research Reactors and their Safe Operation Through Regional Cooperation, Networking, and Coalitions and activities being carried out under a grant from the Nuclear Threat Initiative (NTI) to coordinate a two-year pilot project on Research Reactor Coalitions and Regional Centres of Excellence. Through the IAEA's Cross-Cutting Coordination Group for Research Reactors, the IAEA will pursue integrated activities to address research reactor sustainability.

Thus, the IAEA is promoting formulation of specific ideas for regional and international coalitions, focused on different thematic areas. The IAEA is supporting efforts to improve strategic and business planning at research reactors. In doing so, the IAEA helps to identify synergies or complementary capabilities between reactors as the basis for coalitions or networks. The IAEA is also identifying instances where individual facilities are at, or over, capacity for various irradiation services, and is helping to find 'partner' reactors which can share work through cooperative agreements or commercial ventures. The IAEA is also providing training, including to assist reactors to manage commercial isotope sales, is working to expand awareness of potential customers, and is increasing contacts between prospective customers and research reactor service providers.

Ira Goldman (I.Goldman@iaea.org)

Upcoming Training Course on Research Reactor Water Quality Management

A Training Course on Water Quality Management for Research Reactors and Research Reactor (RR) Spent Fuel Storage Facilities will be conducted from 10 to 14 December 2007.

The purpose of the training course is to present RR and RR spent storage facility operators with a comprehensive set of good practices for water quality management. The training course is based on the operating experience and lessons learned from a number of relevant facilities and organisations, the results of three completed IAEA Coordinated Research Projects (CRPs) and the output of an IAEA regional Technical Cooperation Project.

Internationally accumulated experience clearly indicates that when water quality is properly controlled and maintained, fuel elements, pool liners and other reactor structures show few, if any, signs of either localized or general corrosion, even after more than 30 years of exposure to research reactor water. In contrast, in facilities where water quality was allowed to degrade, the fuel clad and other reactor components have been degraded through significant corrosion.

The course will:

1. Provide basic information on the corrosion of different types of research reactor and research reactor spent fuel storage facility materials in a wet environment;
2. Provide basic understanding of the water chemistry that affects corrosion in the reactor cooling system, in particular, the effect of different factors on the development and growth of corrosion;
3. Provide specifications and requirements for water purification systems of research reactors, taking into account the primary cooling system, the secondary cooling system and water reservoirs;
4. Discuss operational and maintenance procedures for water purification systems of research reactor and research reactor spent fuel storage facilities, taking into account the primary cooling system, the secondary cooling system and water reservoirs;
5. Define recommended parameters and techniques applicable to monitor water quality in research reactors and research reactor spent fuel storage facilities;
6. Emphasize the particular relevance of maintaining water quality in connection with aluminium clad fuel elements and other aluminium components;
7. Present examples of good practices for water quality management and water chemistry control in research reactors.

Pablo Adelfang (P.Adelfang@iaea.org)

Ongoing Activities related to Advanced Fuel Cycles (AFC)

The recent global developments have made advanced fuel cycles (AFC) one of the principal influencing factors for the future growth of nuclear energy. AFC has the potential to reduce volume, radio-toxicity, the mass of weapons-usable material, and decay heat of high level waste. In addition, AFC will also facilitate effective utilization of natural uranium resources, which will also contribute to reduce legacy wastes, such as depleted uranium from uranium enrichment. With respect to recent global research, the Nuclear Fuel Cycle and Materials Section is addressing the following subject-areas: liquid metal cooled reactor fuel cycle, coated particle fuel, inert matrix fuels, minimization of losses in partitioning processes, minor actinide (MA)-fuel and target, MA-property databank and reprocessed uranium management.

Fast reactor fuel cycles

It is expected that fast reactors (FR) and their respective fuel cycle will become one of the key elements in future nuclear energy systems. The superiority of a fast spectrum in actinide transmutation and spent fuel radiotoxic inventory reduction is well recognized. All actinide isotopes are, in principle, fissionable and in a high flux neutron spectrum function as neutron producers. There is notable operating experience with uranium-plutonium mixed oxide fuel (MOX) and considerable knowledge on alloy fuel as well as mixed carbides and nitrides of plutonium. For the short term prospectus (2025-2030) the MOX fuel is the first option (Japan, France, India, China, Belgium) for liquid metal cooled fast reactors. In long term plans different dense fuel types are under consideration: metal (Japan, India, China, the Republic of Korea) and nitride (the Russian Federation, France). Inert matrices fuels for actinides utilization are of great interest (the Russian Federation, France, EC, Japan). Regarding fabrication and reprocessing technologies, advanced aqueous methods are considered to be the principal approach for MOX fuel in the short term. The IAEA is preparing state-of-the-art review documents on fuels, fuel cycles and structural materials for fast reactors. The IAEA also plans to conduct an international conference on fast reactors and its fuel cycle in 2009.

Minimization of losses in partitioning processes

Minimization and precise evaluation of actinide elements in the waste from the separation process can contribute considerably to improved environmental protection. In this context a Coordinated Research Project (CRP) was initiated in 2003 with an aim to understand the environmental impact considering losses in the partitioning and transmutation (P&T) steps. The objectives of this CRP is to enable Member States in developing methodologies for reducing radiotoxic discharge to the environment from nuclear fuel cycle activities and pave the way for sustainability of nuclear energy. The following Member States have joined this CRP: China, the Czech Republic, Germany, India, Japan, the Republic of Korea, the Russian Federation and the USA. Advanced fuel cycle technologies demand considerable R&D initiatives and international collaboration to developing these complex technologies, innovative materials and process control equipment.

Basic factbook on HTGR fuels

In recent years, fuel cycle activities of high temperature gas-cooled reactors (HTGR) are being revived with an aim towards new nuclear fuel cycles In addition HTGRs are being considered for hydrogen generation and burning plutonium including MAs using the ‘deep-burn concept’. To enhance the capacity of the interested Member States in developing innovative nuclear fuel cycle technologies for sustainability, the IAEA is developing a handbook for use in training and education of the next generation of scientists and engineers in coated particle fuel technology. The IAEA is also cooperating with EC/ RAPHAEL (ReActor for Process heat, Hydrogen And ELectricity generation) to conduct an education and training workshop on fuel cycle aspects of coated particle fuel from 4 to 7 Dec 2007 at NRG, Petten, Netherlands. The IAEA also plans to initiate a new CRP in 2008 on coated particle fuel encompassing new fuel designs for advanced HTRs, damage mechanisms applicable to fuel constituent materials, fission product deposition and redistribution studies in international fission product loop, fission product (Pd, Ag, etc.) retention and interaction in TRISO coated fuel particles, and fuel material properties at elevated temperatures and high burnups.

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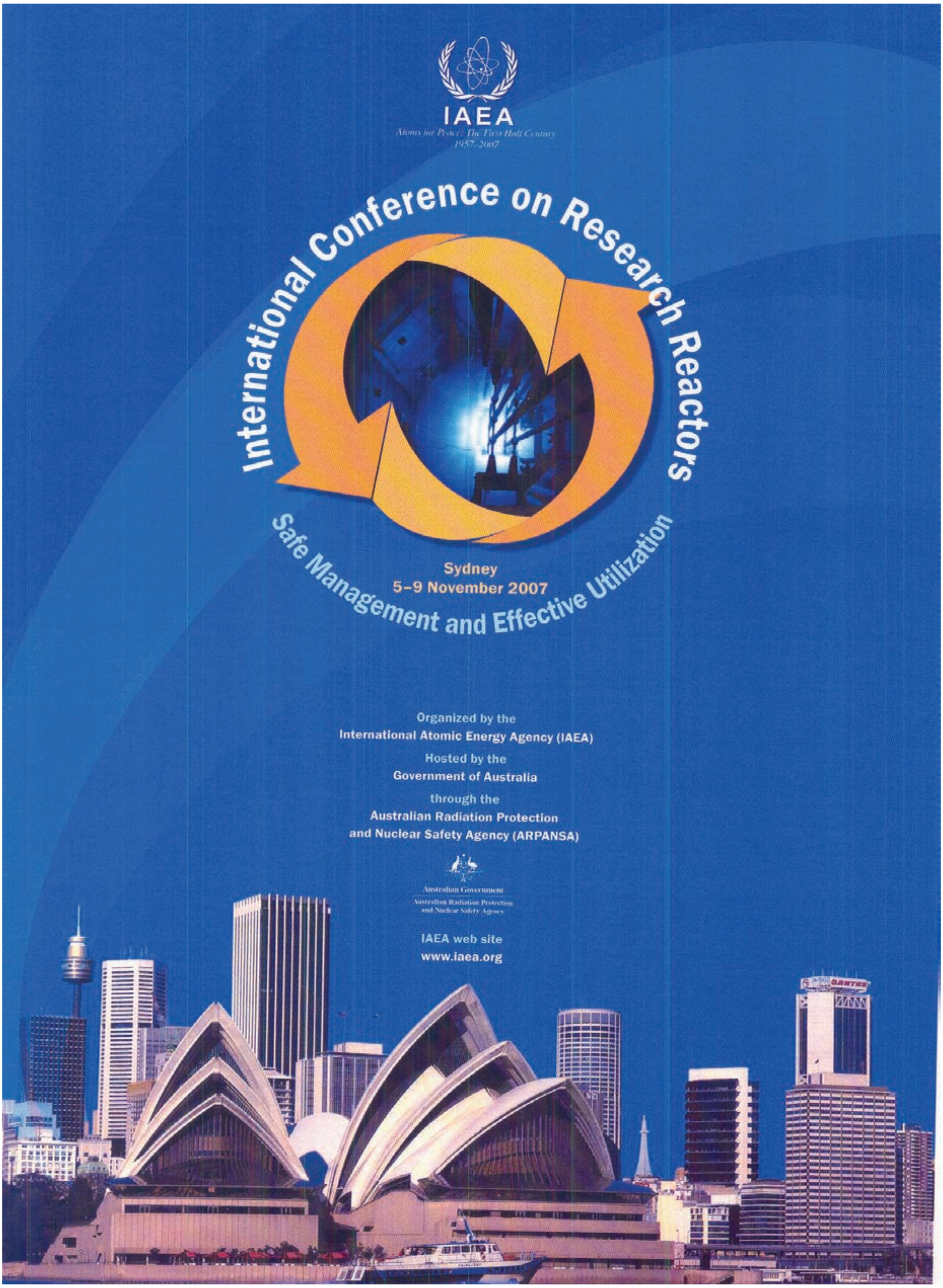
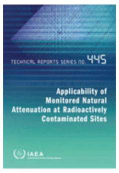


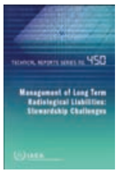
Recent Publications

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)

Technical Reports Series No. 456
Retrieval and Conditioning of Solid Radioactive Waste from Old Facilities (2007)

IAEA-TECDOC-1519
Data Requirements and Maintenance of Records for Spent Fuel Management: A Review (2006)

IAEA-TECDOC-1521
Characterization, Treatment and Conditioning of Radioactive Graphite from Decommissioning of Nuclear Reactors (2006)

IAEA-TECDOC-1523
Optimization Strategies for Cask Design and Container Loading in Long Term Spent Fuel Storage (2006)

IAEA-TECDOC-1527
Application of Thermal Technologies for Processing of Radioactive Waste (2006)

IAEA-TECDOC-1529
Management of Reprocessed Uranium – Current Status and Future Prospects (2007)

IAEA-TECDOC-1532
Operation and Maintenance of Spent Fuel Storage and Transportation Casks/Containers (2007)

IAEA-TECDOC-1534
Radioactive Sodium Waste Treatment and Conditioning: Review of Main Aspects (2007)

IAEA-TECDOC-1535
Nuclear Fuel Cycle Simulation System (VISTA) (2007)

IAEA-TECDOC-1537
Strategy and Methodology for Radioactive Waste Characterization (2007)

IAEA-TECDOC-1538
Categorizing Operational Radioactive Waste (2007)

IAEA-TECDOC-1547
Advances in Applications of Burnup Credit to Enhance Spent Fuel Transportation, Storage, Reprocessing and Disposition (2007)

IAEA-TECDOC-1548
Retrieval, Restoration and Maintenance of Old Radioactive Waste Inventory Records (2007)

IAEA-TECDOC-1553
Low and Intermediate Level Waste Repositories: Socioeconomic Aspects and Public Involvement (2007)

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)

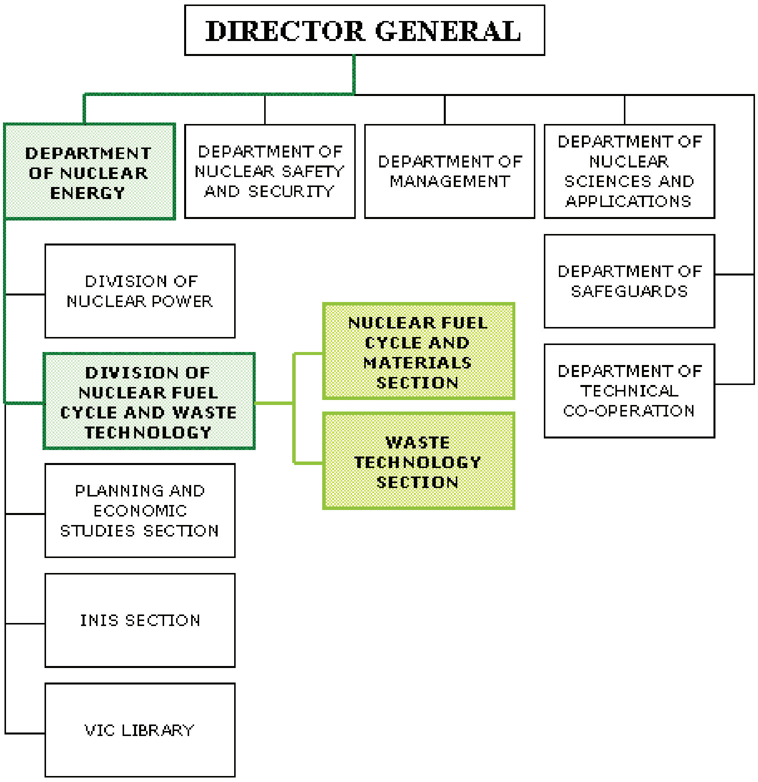
STI/PUB/1259
Uranium Production and Raw Materials for the Nuclear Fuel Cycle - Supply and Demand, Economics, the Environment and Energy Security (2006)

Meetings in 2007

Date	Title	Place	Contact
29-31 August	Technical Meeting on Re-use Options of Reprocessed Uranium	Vienna, Austria	H.Nawada@iaea.org
3-5 September	Technical Meeting on Fuel Rod Instrumentation and In-pile Measurement Techniques	Halden, Norway	J.Killeen@iaea.org
17-19 September	Technical Meeting on International Experience in the Determination and Use of Scaling Factors in Waste Characterization	Vienna, Austria	Z.Drace@iaea.org
1-5 October	Technical Meeting on Remediation Strategies for Managing Environmental Liabilities under Constrained Resources	Vienna, Austria	H.Monken-Fernandes@iaea.org
1-5 October	Technical Meeting on Uranium Exploration, Mining, Processing, Mine and Mill Remediation and Environmental Issues	Swakopmund, Namibia	J.Slezak@iaea.org
9-11 October	Technical Meeting on Nuclear Fuel Cycle Options and Spent Fuel Management	Vienna, Austria	W.Danker@iaea.org
22-25 October	Technical Meeting on Thorium-based Fuels and Fuel Cycle Options for PHWR, LWR and HTGR	Istanbul, Turkey	C.Ganguly@iaea.org
29-31 October	Technical Meeting on the Establishment of an International Decommissioning Network	Vienna, Austria	M.Laraia@iaea.org
29-31 October	41th Joint OECD/NEA-IAEA Uranium Group Meeting	Vienna, Austria	J.Slezak@iaea.org
1-2 November	Technical Meeting on Recent Developments in Exploration Resources Production and Demand	Vienna, Austria	J.Slezak@iaea.org
5-9 November	International Conference on Research Reactor: Safe Management and Effective Utilization	Sydney, Australia	P.Adelfang@iaea.org
12-15 November	Workshop to Update Waste Management Information in the Net-Enabled Waste Management Database	Vienna, Austria	J.Kinker@iaea.org
12-16 November	Technical Meeting on Lessons Learned by Member States in Using the Catalogue of Sealed Radioactive Sources	Vienna, Austria	A.Kahraman@iaea.org
19-22 November	Technical Meeting on LEU Fuel Utilization in Accelerator Driven Sub-critical Systems	Rome, Italy	P.Adelfang@iaea.org
26-30 November	Technical Meeting on Technical Conditions for Radioactive Waste Long Term Storage	Vienna, Austria	Z.Drace@iaea.org
3-7 December	Technical Meeting on Benchmarking of Liquid and Solid Waste generated by WWER	Vienna, Austria	Z.Drace@iaea.org
10-12 December	Technical Meeting on Development Needs for Deployment of Advanced Fuel Cycles	Vienna, Austria	H.Nawada@iaea.org
10-14 December	Training Course on Water Quality Management for Research Reactors and Research Reactor Spent Fuel Storage Facilities	Ljubljana, Slovenia	P.Adelfang@iaea.org
17-19 December	Conventional and Innovative Fuels for Fast Reactors	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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