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Fuel Cycle and Waste Newsletter

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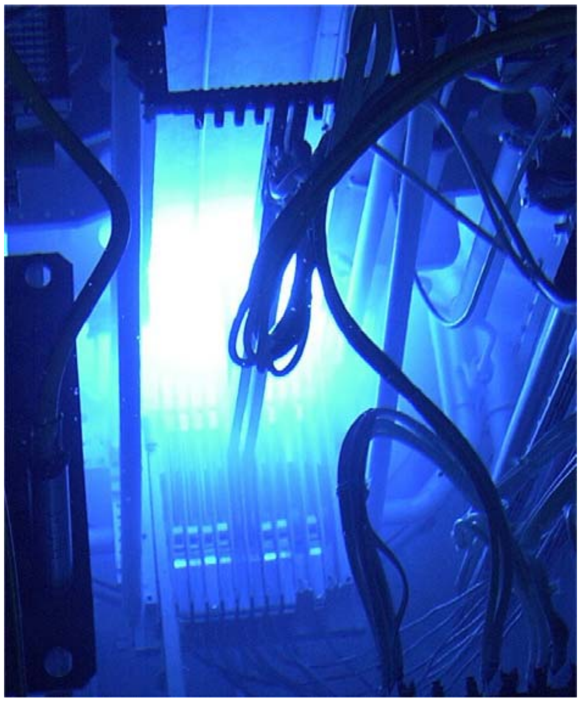
IAEA Activities to Help Ensure the Supply of Medical Isotopes

Challenges to the global supply of reactor-based medical radioisotopes could continue in coming years due to the reliance on a limited number of ageing reactors in the context of increasing worldwide demand. The issue was recently highlighted when the simultaneous outages of three medical isotope production facilities in Europe resulted in the global shortage of technetium 99m (^{99m}Tc), a radioisotope used in some 80 per cent of all diagnostic nuclear medicine procedures in the world. An unexpected outage extension of a Canadian research reactor (RR) resulted in a similar shortage in late 2007.



The High Flux Reactor in Petten, the Netherlands - one of the five major producers of medical isotopes. The other four are in Belgium, Canada, France and South Africa.

^{99m}Tc is the daughter product of molybdenum 99 (^{99}Mo); most of which is currently produced through the irradiation and chemical processing of highly enriched uranium (HEU) targets at five RRs located in Canada, Europe and South Africa. These five reactors are between 42 and 51 years old. The recently constructed OPAL reactor in Australia is expected to commence ^{99}Mo production in the near future using low enriched uranium (LEU) targets. ^{99}Mo has a relatively short half-life of 66 hours, so regular weekly production is necessary to satisfy global demand.

Several recent and ongoing activities within the Research Reactor Group (RRG) of the IAEA Division of Nuclear Fuel Cycle and Waste Technology, in close collaboration with the Division of Physical and Chemical Sciences (NAPC), will help address the above issues over the near-, medium-, and long term. These activities, which are described in some detail in the following, include improving operation and maintenance, upgrading existing facilities, considering new reactors and using LEU for isotope production. The benefits will not be limited to isotope production, but will help ensure the availability of numerous other RR goods and services as well.

Message from the Director

Dear Reader,

The top story of this Newsletter highlights a very important subject; How to ensure a secure and continuous supply of radioactive isotopes for medical use. During the last year and a half interruptions have occurred in the supply of such isotopes, not least molybdenum 99 (^{99}Mo), which is the mother nuclide for technetium 99m that is used in many different types of medical examinations and treatments. Most of the world demand of ^{99}Mo is produced in only five research reactors. When these, for different reasons, have had problems the vulnerability of the supply comes to the surface. The multifaceted actions described are thus very timely to improve the middle- to long term situation.

As usual the Newsletter also gives short reports on other activities in the Division of Nuclear Fuel Cycle and Waste Technology. I would just like to highlight two that are dedicated on new services provided by the IAEA, the Uranium Production Site Appraisal Team (UPSAT) and the Decommissioning Peer Review. To get a more complete view of our activities I recommend you to visit our website http://www.iaea.org/OurWork/ST/NE/NEFW/index.html.

During 2008 the number of countries that have expressed interest to study what is needed to introduce nuclear power has increased continuously. Although the main questions will deal with the build-up of infrastructure to be able to buy and operate the nuclear power plants themselves, it will also be important to consider the fuel cycle and waste aspects at an early stage to understand the long-term commitment. In this context also the possibilities of regional or multilateral approaches should be considered.

Finally I would like to take this opportunity to send Season’s Greetings from all of us in the Division and wish you and your families a successful 2009.

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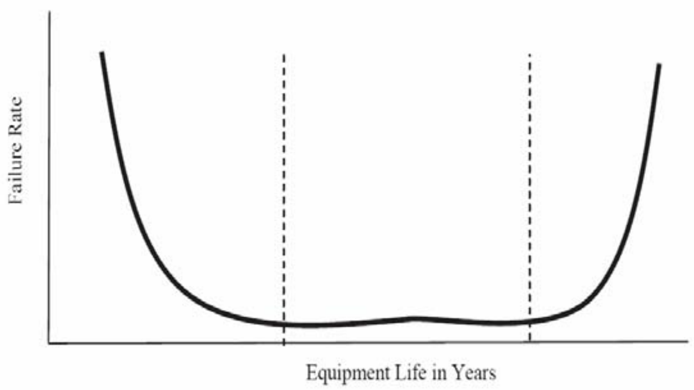
Operation and Maintenance
principal benefits in the short-term

Ensuring the reliable operation of currently available production facilities is essential to near-term supply. The IAEA has recently published Nuclear Energy Series No. NP-T-5.4, a collection of recommended practices to optimise RR availability and reliability (http://www-pub.iaea.org/MTCD/publications/PDF/Pub1338_web.pdf).



In general, these practices build on existing management practices by extending them to include the management of operational risk. The publication includes a particularly relevant discussion of the ‘bathtub curve’, a qualitative representation of increased failure rates early and later during component, system or facility design lifetimes. Such events are currently being observed among operating RRs and must be effectively managed to ensure optimal operation.

The IAEA recently initiated an activity to develop further guidance on the management of RR ageing to a greater level of detail than described in the above document. RR ageing meetings will be held in Vienna in December 2008 and March 2009.

Upgrades to Existing Facilities / New Production
principal benefits in the medium-term

Considering the age of current production facilities, efforts to improve the operational reliability of these reactors must be complimented by other work. New producers are also necessary to ensure adequate excess capacity to mitigate unanticipated supply upsets and to satisfy future demand.

Since 2005, the IAEA has been managing a Coordinated Research Project (CRP) on *Developing Techniques for Small Scale, Indigenous Molybdenum 99 Production Using Low Enriched Uranium (LEU) Fission or Neutron Activation* based on requests from many IAEA Member States. The purpose of the CRP is to promote the development of new ^{99}Mo production capabilities for local/regional nuclear medicine needs. Seven research contract and seven research agreement holders have participated in the CRP, with several members having made excellent technical progress, including developing human resources and physical infrastructure that will enable them to successfully carry out trial irradiation and processing of LEU targets, or production of gel generators using ^{99}Mo obtained by neutron activation.

Among the institutions taking part in the CRP are several research reactors and associated facilities that could become part of the international ^{99}Mo supply network, especially if assisted by the current major commercial ^{99}Mo producers, as a way of enhancing target irradiation and processing capacity. Two participants in the CRP have already embarked independently on setting up facilities for fission molybdenum production. The recently held 3rd Research Coordination Meeting (RCM) of this CRP attracted worldwide interest of several industrial isotope producers and national authorities and 20 observers attended the event held in MURR, Columbia, United States of America.

The IAEA has also collected information on the development and implementation of large scale modernization and refurbishment projects at RRs. This work contains a broad collection of project examples and lessons learned through their implementation. All information has been collected and the final draft is being compiled. The final document is expected get published in 2009. This document will be relevant to currently operating RRs considering isotope production, but requiring facility or site capital infrastructure upgrades to support that effort.

New Research Reactors
principal benefits over the longer term

In November an initiative was kicked off to capture the specific considerations and milestones in the development of a new RR. Participation included staff involved in the planning and implementation of the recently constructed OPAL reactor in Australia and the in-progress Jules-Horowitz and PALLAS reactor projects in France and the Netherlands. In addition to the three project teams, participants from reactor suppliers as well as countries looking for a first reactor contributed to the event. A Nuclear Energy Series publication is expected to capture the recommendations. The publication is anticipated to be similar to the Milestones in the Development of a National Infrastructure for Nuclear Power (http://www-pub.iaea.org/MTCD/publications/PDF/Pub1305_web.pdf) publication with unique guidance specifically applicable to RRs.

In June 2007 the IAEA held a meeting of experts to consider the application of innovative, solution reactor technologies for the production of short lived medical isotopes. Experts from China, France, the Russian Federation and the United States of America discussed uranyl-salt solution reactor technology applicability to isotope production, experiences from demonstration projects, and the potential challenges and benefits of solution reactor technology applied to isotope production. The group's findings have been documented in IAEA-TECDOC-1601 (http://www-pub.iaea.org/MTCD/publications/PDF/te_1601_web.pdf). Additionally, a CRP on LEU use in homogeneous aqueous solution reactors for the production of short lived medical isotopes is planned to commence in 2009 as recommended by these experts.

^{99}Mo from LEU
conversion from HEU to LEU

An overarching attribute of the RR Group's work includes the transition from HEU to LEU ^{99}Mo production. In general, IAEA activities support a growing global consensus that LEU is both technically and financially viable for medical isotope production. These efforts are most obvious in the CRP on *Small Scale Indigenous ^{99}Mo Production*. The IAEA has also been an active participant in other efforts directly related to ^{99}Mo.

In December 2007 DOE/NNSA (USA) and ANSTO (Australia) organised the Global Initiative for Combating Nuclear Terrorism Workshop on ^{99}Mo production in Sydney with a wide participation including representatives of the IAEA's CRP, as well as major industrial producers of ^{99}Mo. The final report called for strengthened efforts toward conversion of current ^{99}Mo production from HEU to LEU targets, and also stated that any new production should be from LEU only.

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UPSAT - Revival of an IAEA Service to Support Member States with Uranium Production Activities

As previously recorded in this newsletter the uranium mining industry is currently in the throes of a strong revival. This has been brought about by a combination of events. These include increasing shortfall of current production against existing demand and the likely increase in development of nuclear power plants. In 1996 the IAEA launched a programme known as UPSAT (Uranium Production Safety Assessment Team). However, at this time the global uranium production industry was sadly in a state of declining activity and the programme never really caught on; consequently not one mission was undertaken.

In view of the upsurge in uranium production activity the decision was made to re-launch UPSAT at the 2008 IAEA General Conference. Retaining the original acronym the revised programme is now called Uranium Production Site Appraisal Team (UPSAT). The UPSAT programme is expected to facilitate the exchange of knowledge and experience between team members and industry personnel. It is intended to enhance overall safety and efficiency in uranium production wherever such activities take place or are planned to be developed. An UPSAT review will be conducted only at the request of the relevant Member.

An UPSAT mission is a peer review of one or more phases of a uranium production cycle by a team of selected international experts having direct experience in the technical areas specific to that operation. Judgements of the performance are made on the basis of the collective expertise of the review team. The review is a technical exchange of experience and work practices aimed at strengthening the programmes and procedures and their implementation at the subject facility. The benefit of such a review for the requesting Member State or organization is to obtain independent, international expert opinion and advice on: (a) proposed or ongoing resource development programmes and their implementation; (b) upgrading present and future safety programmes; and (c) regulatory matters. An UPSAT mission may also be useful in improving public acceptability.

Each UPSAT team will be specifically recruited by the IAEA and will comprise experts from countries other than the country in which the review is performed. The team members will be selected on the basis of their expertise and special skills in the areas of the review. After a period of desk study using data provided by the host Member State and the specific facility the UPSAT team carries out a review on site of up to two weeks duration. A summary of the review findings is submitted to the facility management at the exit meeting. The IAEA then prepares the final report to the requesting Member State within six weeks of the end of the fieldwork. Such a report is the property of the requesting Member State and of the reviewed organization, and will be kept confidential.

A number of already producing and potentially new uranium producing Member States have expressed interest in the programme. At a recent IAEA Technical Meeting on Best *Practice in the Uranium Mining Industry*, attended by representatives of both regulators and operators in major and emerging uranium producing countries, the programme was recognised as having the potential to assist in the expansion of best practice throughout the global uranium production cycle.

For further information on UPSAT contact Jan Slezak or Peter Waggitt or look at http://www.iaea.org/OurWork/ST/NE/NEFW/nfcms_rawmaterials.html

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Spent Fuel Reprocessing Options

Spent fuel treatment/reprocessing options have evolved significantly since the beginnings of nuclear energy. 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 still at the pilot scale, laboratory scale or conceptual stage of development. Innovative reprocessing methods would have to be developed for the treatment of fuel types that may be utilized in the future; these fuels may differ substantially from the UO2 or MOX ceramics used in current light water reactors.

IAEA-TECDOC-1587 on spent fuel reprocessing options has recently been published and addresses these important issues. In brief, general reprocessing benefits are improved use of fissile materials resources by up to 25%, reduced volume of conditioned/packaged high level and long lived waste to be disposed of, and decreased long term radiotoxicity of the waste.

The design of advanced reprocessing methods must deal in a comprehensive manner with (1) safety, (2) the control and minimization of plant effluents, (3) minimization of the waste generation, (4) the production of stable and durable waste forms, and (5) economic competitiveness. International collaboration on the development of advanced reprocessing methods, considering the magnitude of the challenges, is essential to facilitate the future deployment of these technologies.

Major obstacles to be overcome include reduction of proliferation risk (see separate article) and public acceptance of advanced fuel strategies. The objectives of the emerging strategies and their respective merits can be summarized as follows:

- Co-management of U and Pu to improve the proliferation resistance of spent fuel treatment.
- Selective separation and heterogeneous recycling of minor actinides to further reduce decay heat of the

waste to be disposed of in a geologic formation. Heat load of the repository can already be significantly reduced with Pu removal, since this is the major source of decay heat and long term radiotoxicity of spent fuel.

- Ultimately, achieving the more challenging goal of group extraction and homogeneous recycling of actinides in an integrated fuel treatment and re-fabrication facility to further minimize the proliferation risk, and the heat load of the repository for the waste.

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 and/or fast spectrum reactors. The physical design of these plants must incorporate effective means for materials accountancy, safeguards and physical protection.

The deployment of multinational fuel cycle centres, operating under an international framework, can serve to ensure a sustained supply of nuclear fuel and related services under conditions in which the risk of proliferation of technologies that could be used in nuclear weapon production is minimized. Reprocessing of spent fuel could be an important function of these centres.

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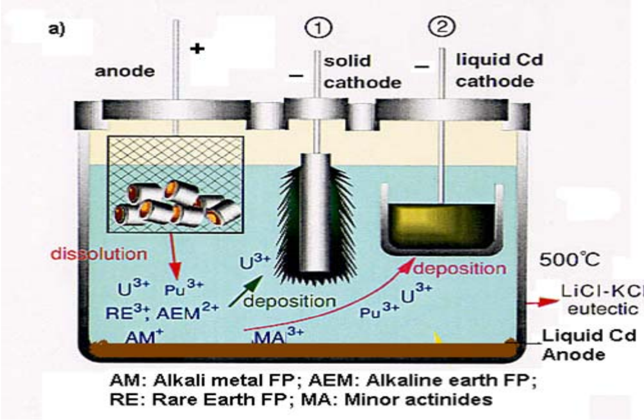
Role of Advanced Partitioning Methods in Enhancing Proliferation Resistance

Closed fuel cycle with nuclear fuel reprocessing is re-emerging as the key strategy for the sustainable development of nuclear energy for the future. The PUREX (plutonium-uranium extraction) process was established as commercial reprocessing of spent nuclear fuel. The process is in active use on a large scale in France, Japan, India, Russian Federation, and the United Kingdom. Although the PUREX process has significantly improved in terms of reduced waste generation, it has some major drawbacks: i) it produces separated plutonium (which is a proliferation concern); ii) concerns regarding high level waste owing to the presence of minor actinides (MAs) and long lived fission products in the waste.

Proliferation of nuclear materials is described as the attribute of a system that assist the diversion or undeclared production of nuclear material, or misuse of technology, by States' intentions to acquiring nuclear weapons. In response to the concerns associated with the



Schematic drawing of an electro-refining cell for pyro-chemical

conventional reprocessing technologies, several advanced partitioning methods are being developed that could co-recover actinide mixtures e.g., plutonium with MAs instead of recovering pure individual actinides. The co-recovered actinides mixture could be utilized as the fuel for dedicated transmutation reactors i.e., fast reactors and accelerator driven systems which are also under development. It also provides sufficient material barriers (viz., isotopic, chemical, radiation, and detectability barriers) and technical barriers (e.g., requirement of additional processing facilities) as impediments for any potential proliferation of nuclear materials. In addition to enhancing proliferation resistance for the closed fuel cycles, the reuse of Pu and MAs reduces radiotoxic inventories in the final waste that is destined for disposal. In the aqueous partitioning processes two different lines of approach are followed: (i) co-recovery of different components from the high level liquid waste (HLLW) that is obtained in the PUREX process, and (ii) alternate advanced processes to PUREX by changing the chemistry in the first separation step so that only U is separated, while keeping Pu, MAs and fission products in the waste solution for later processing.

In a longer time perspective, pyro-processing technologies are being developed, which could provide additional benefits in terms of size and radiation resistance. Semi-industrial scale level reprocessing technologies based on pyro-process has been developed in the United States of America (see Fig.) and in the Russian Federation. The main challenges of the pyro-processes are the oxygen and moisture free plant environment and development of materials that would not only withstand high radiation level but have excellent resistance to high temperature corrosion in molten metals and molten halide salts.

Proliferation resistance attributes of partitioning processes has been reviewed in the coordinated research project on partitioning and transmutation (2003-2008).

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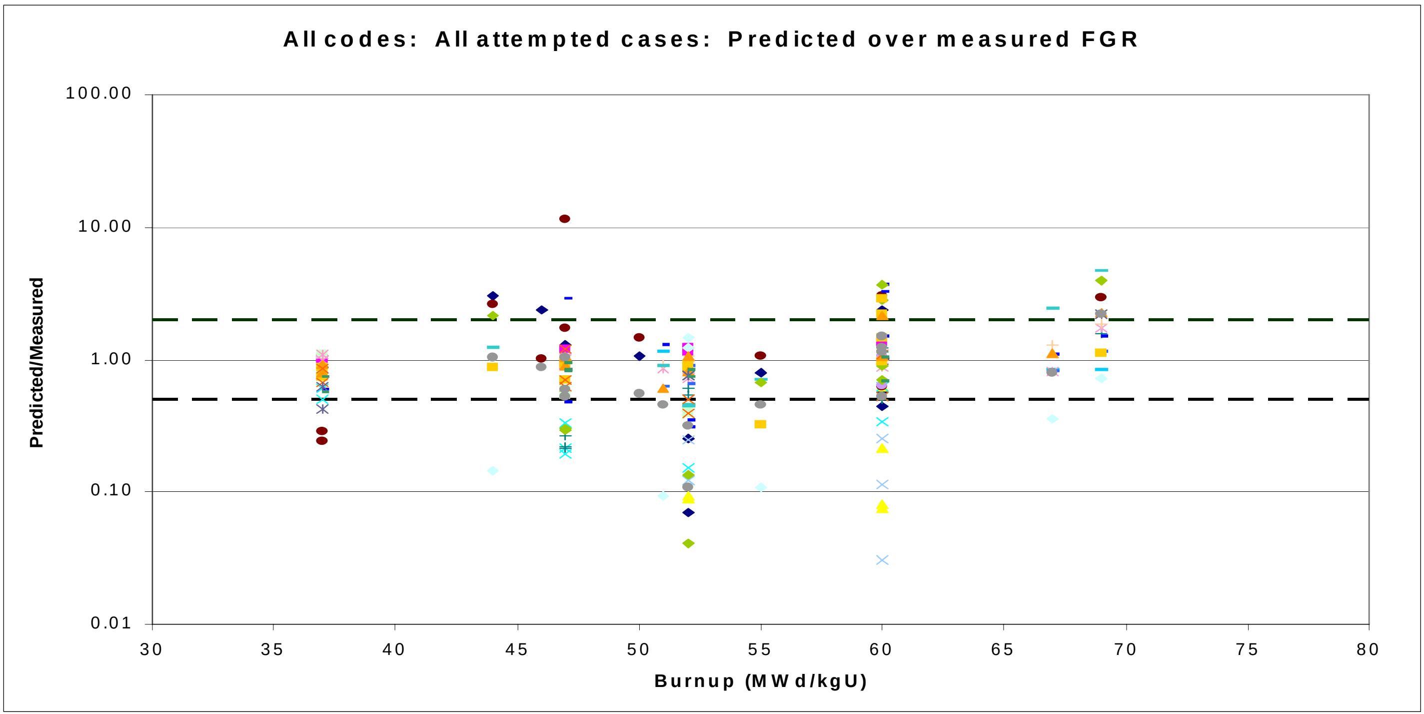

Figure 1: All results for the fission gas release predictions from the codes compared with the measurements

FUMEX-II
Fuel Modelling at Extended Burnup

The IAEA sponsored a Coordinated Research Project on Fuel Modelling at Extended Burnup (FUMEX-II) between 2003 and 2007. Eighteen fuel modelling groups participated with the intention of improving their capabilities to understand and predict the behaviour of water reactor fuel at high burnups. The exercise was carried out in coordination with the OECD/NEA and the Halden Reactor Project.

The participants used a mixture of data derived from actual irradiation histories of high burnup experimental fuel and commercial irradiations where post-irradiation examination measurements are available, combined with idealised power histories intended to represent possible future extended commercial irradiations and test code capabilities at high burnup. All participants were asked to model nine priority cases out of some 27 cases made available to them for the exercise, mainly from the IAEA/ OECD International Fuel Performance Experiments Database. The high priority cases were designed to test fuel modelling codes in the specific areas of:

- Thermal performance;
- Fission gas release;
- Pellet to clad interaction (PCI) at extended burnup above 50 MW•d/kgU.

Calculations carried out by the participants, particularly for the idealised cases, have shown how varying modelling assumptions affect the high burnup predictions, and have led to an understanding of the requirements of future high burnup experimental data to help discriminate between modelling assumptions. This understanding is important in trying to model transient and fault behaviour at high burnup. Two examples of the code comparisons are shown.

Figure 1 gives the results of an overall comparison of the code predictions of fission gas release and the experimental measurements. These results include all the reported code predictions for the end of base irradiations and release from ramp tests where appropriate. The results are shown as a ratio of predicted to measured fission gas release as a function of burnup. It shows that, although there is a wide spread in the results there is no trend with burnup.

Figure 2 gives the calculated results for a very high burnup PWR fuel rod with an idealised power history, based on actual lead test assembly data with indicative

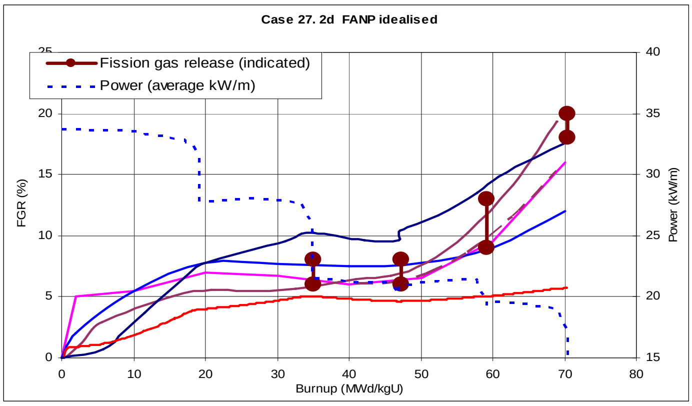

Figure 2: Fission gas release predictions from five codes for an idealised operational history to 70 MWd/kgU (provided by FANP). Indicated FGR measurements and rod average power are shown.

fission gas release values. It shows that fuel modelling codes are capable of predicting the behaviour of such fuel with reasonable accuracy throughout the irradiation.

The general conclusions of the CRP are:

- The modelling results show good agreement with fuel centre temperature measurements for both normal operation and during power ramps, up to burnups of around 60 MW•d/kgU. Temperature predictions have been much improved since the previous FUMEX-1 CRP;
- The codes consistently predict the effect of grain size on fission gas release;
- The codes show good agreement for fission gas release at burnups close to current commercial limits (around 55 MW•d/kgU);
- However, the standard models do not account for an increase in fission gas release rates observed at high burnups.

To deal with the last point, the teams have developed their codes to account for this phenomenon. Three distinct modelling approaches have been tried:

- Allowing fission gas release directly from the rim structure seen at the periphery of pellets at high burnup.
- Allowing release of additional gas from saturated regions of the fuel, where the saturation is temperature dependent and the additional release comes from the pellet interior.
- Allowing an additional burnup dependence on the diffusion and resolution parameters used in standard models.

These different approaches lead to different predicted high burnup release behaviour. With the limited amount of very high burnup data available, all three model developments are able to represent the data fairly well, but there is a need to improve modelling in this area to ensure accurate predictions of fuel behaviour for alternative power histories and for high burnup transient behaviour.

However, mechanical interaction between pellet and clad is not well developed and many codes have very limited capability in this area. Further work in this area is about to commence in the FUMEX-III CRP, where this time over 30 fuel modelling teams will be comparing their predictions of experimental data to help develop and validate their codes.

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Source Inventory Operation in Nigeria

In April of this year, by invitation of the Nigerian Nuclear Regulatory Authority (NNRA), a radiation source recovery expert from the United States Department of Energy (USDOE) visited the Ajaokuta Steel Company Limited (ASCL) site and found a large number of radioactive sources at two locations, totalling more than 240 sources. Most of these sources were industrial gauges supplied by the former Soviet Union in the mid-eighties for a steel factory. All items seemed to be new and almost all were stored in the original wooden crates or steel drums. Following this mission, the Source Recovery Group (SRG) of the Waste Technology Section (WTS) was asked to arrange a fact finding mission to ASCL to check the sources and establish a complete source inventory. Because of the large number of sources and the complexity of the problem, the mission team included two Russian experts from the company IZOTOP Moscow, an American source expert from the Los Alamos National Laboratory, a certified radiation protection officer from Necsa, South Africa and the SRG technical officer.

Opening, labelling and re-packing of the gauges

Due to the security conditions in the country, the team used special field mission vehicles rented from the Nigerian UNDP Office in Abuja and was protected by the Nigerian Police as well as the State Security Office of Nigeria.

The sources were located in a huge hangar made of steel plates erected during the construction of the steel factory. Many technical items, machines, and raw materials were left there when the plant was completed in 1987. The site was extremely dusty but clean and safe from radiological point of view.

Following a radiological survey, the team checked the original wooden cases and crates containing the sources. Most of them were in good shape, but some were damaged. The team systematically checked all the radioactive items found in the storage building. Full support was provided by the ASCL staff during the mission, including local workers to handle the heavy items during the work.

Identified and labelled gauge housing a CS-137 source

With some exceptions, all of the radioactive gauges and containers were found to have the original shipping documents including source and package certificates. The majority of the sources were Cs-137, with the rest comprised mainly of Co-60 and some neutron sources. After inspection each item was labelled with a new label in English, showing the new inventory number. The items were returned into their original packages and placed into two empty 20-ft ISO steel containers in the building.

The stand-alone building of the site called ‘Isotope Laboratory’ was also investigated. The building was built for non-destructive testing, but had never been used. However, it was found to be an ideal facility for future source handling. All technical systems and infrastructure are in place to manipulate and store sealed radioactive sources. The building has a large storage room provided with proper shelves and huge underground vaults.

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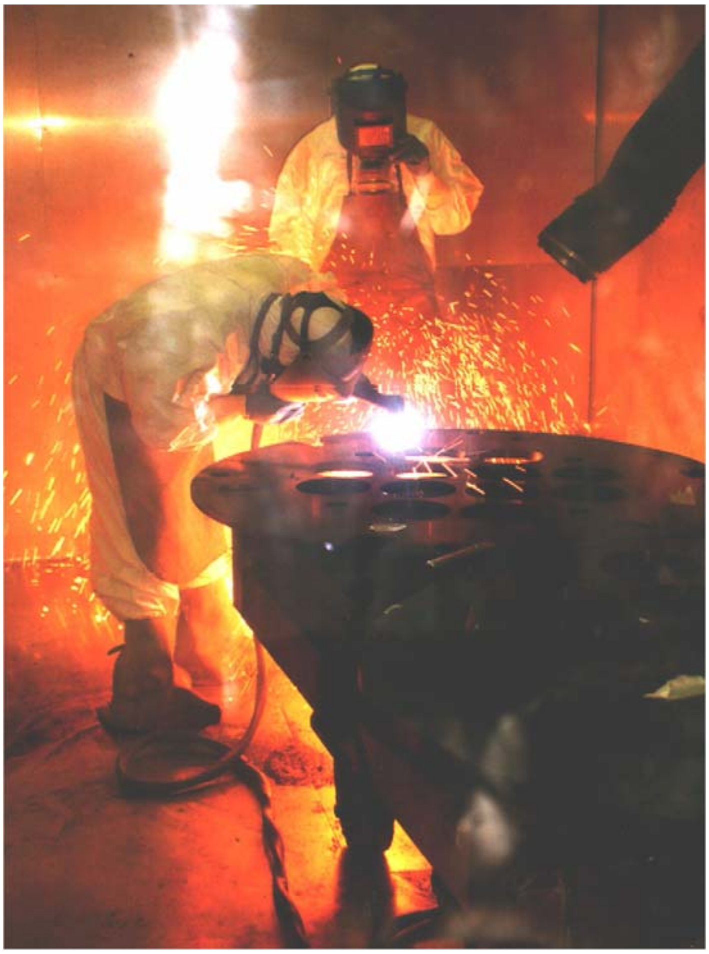
IDN Workshops in Belgium and Spain: Breaking the Mould of Traditional Training

October was a month of accomplishments for the International Decommissioning Network (IDN) with events being hosted by national organizations in Belgium and Spain, cost-free for the IAEA. Two teams of enthusiastic professionals, many of them young practitioners, enhanced the engagement of participants and provided a ‘living’ link to the decommissioning work being performed in the facilities. Participants were impressed with how they were able to combine the presentations with advice and demonstrations in the field in a seamless manner. We have seen from this that the combination of presentation, discussion, video (of professional implementation on active components) followed by hands-on work using actual tools and measuring equipment provides a highly effective learning experience, in line with the needs of developing Member States trying to implement decommissioning projects. The generosity of CEN/SCK and ENRESA in openly sharing such valuable experience in support of the IDN objectives illustrates our growing vision for Centres of Excellence in cooperation with the IAEA.

Group Scientific Visit on Size Reduction of Components for Decommissioning of Nuclear Facilities – A Visual and Hands-on Experience

8-10 October, CEN/SCK Mol, Belgium

During the three days of the workshop, participants received lecturers on state-of-the art dismantlement technologies and toured the Mol facilities to observe actual work in progress. These tours included an escorted visit to the in-containment site of robotic cutting of the BR3 neutron-shield tank, the actual cutting of reactor internals, close-up views of diamond-saw concrete cuts, operation of specialized radiation monitoring

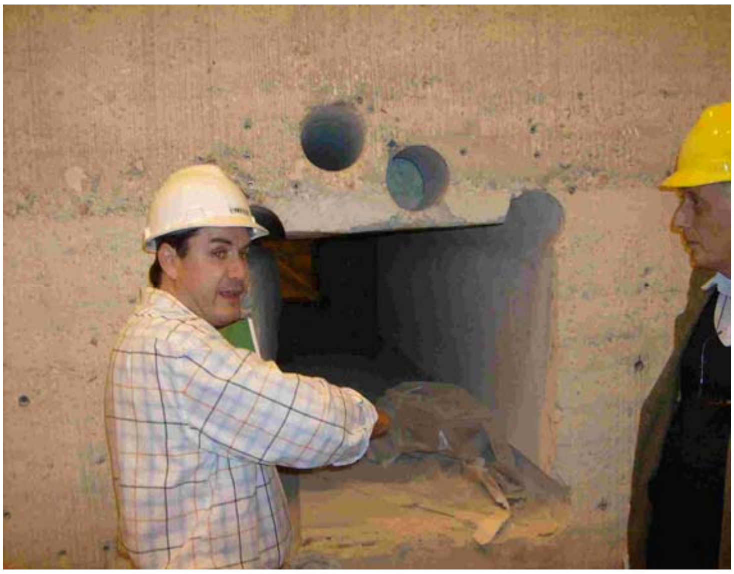


Reactor cutting demonstration by CEN/SCK equipment for clearance of waste and structures, and the waste-clearance and decontamination of a disused hot-cell. Participants were able to engage in detailed discussions with the lecturers and with the technical staff engaged in dismantlement and come to a detailed understanding of the strengths and limits of the techniques and equipment being demonstrated. The lecturers made effective use of video segments shot of work being performed in high radiation environments which could not be directly accessed. In addition to being able to get close to the work-face, participants were introduced to important decommissioning software tools developed in SCK-CEN for waste-tracking and dose-planning.

Workshop on Materials Management and Clearance - Strategic Considerations and Hands-on Experience

13-17 October, ENRESA Vandellós and Madrid, Spain

Combining hands-on efforts of a similar nature on more than one facility serves effectively to re-enforce lessons learned on the first, as the instructors, methods and applications are sufficiently different for participants to observe and analyze the significance of the differences. The diversity of skills, interests, and experience-levels created an ideal networking environment. The workshop provided a unique opportunity for participants to understand how waste segregation and clearance approaches developed and applied by ENRESA could be adapted to their own specific decommissioning needs. All participants also benefited from an understanding of the effective management model developed by ENRESA for projects on decommissioning sites.



Diamond saw cutting demonstration by ENRESA

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Developments and Trends in Environmental Remediation

Traditionally environmental remediation has been considered after the contamination of the environment took place, i.e., after the termination of what used to be called in the past a *practice*.

This approach has proven not to be the most effective in terms of environmental logic and economics. As a result the concept of remediating contaminated sites only after the cessation of operations is being gradually replaced by the concept of environmental remediation (ER) under a life-cycle perspective that ultimately is integrated in the overall environmental management system (EMS) of the operations. In addition to this, concurrent engineering is being applied from initial planning to the post-closure phase as an input to the remediation plan.

This new approach demands the identification and prioritisation of environmental aspects and help in resolving the relevant situations by applying new technologies or even good house-keeping practices rather than dealing with an end-of-life or legacy problem.

These attempts are also connected to the concept of *cleaner production*, which is governed by five elements: product modification, input substitution, technology modification, good-house-keeping, and (on site) recycling and reuse.

As different studies have already demonstrated that more than 90% of the total impact of nuclear power generation systems is caused by mining/milling, it is obvious that this sector is a natural candidate for rapid implementation of the principles discussed above. The current boom in demand for mineral resources that has increased the pressures on the rate of development, or more precisely to *exploit resources before prices drop*, is another factor to be taken into account.

It is clear that many large mining companies are already committed – obviously to different degrees – to these principles. However, so-called ‘junior companies’ may find it hard to implement good-practices due to a lack of available funds. One needs to remember that these companies represent small operations with limited resources and no regular sources of income. Economic constraints are not the only issues to prevent the adoption of good practices by the mining sector. In addition, there are technologic problems and even legislative barriers to overcome.

However, one should not forget to include the social dimension in the overall process. Over time, identification of stakeholders has broadened to include those whose voices may be strong (NGO’s), and those whose voices may be weak, such those directly affected who have little power over decision-making. Under the capitalist logic, land and the concept of place have to do with exclusive proprietorship. This ownership is understood as the right to do with the land as one pleases within the law of the day. In other words, it is a commodity, and could therefore be bought, sold, dug-up, and generally capitalised on. In short, the value of place for capitalist enterprises like mining companies is commercial, whereas for native/indigenous people, the value may be both economic and cultural, and frequently is mainly the latter. The appropriate management of this type of conflict may lead to time consuming approval processes, negotiations with traditional owners and community engagement activities, all these sitting uneasily within time-squeezed schedules. Moreover, it will affect to a large extent decisions regarding environmental remediation and leading to high and unjustified expenditures of cleanup projects.

This new situation puts new challenges on the IAEA to produce technical material that shows how environmental remediation should be done, and why and when a particular option may be seen as the best option. It must produce guidance material that reflects good existing practices keeping in mind the feasibility of the incorporation of these elements by small and medium size companies. The social dimension should also be duly introduced recognizing that issues related to stakeholder involvement in the decision making process will be more and more a decisive element in the development of these operations. It is important that ongoing discussions worldwide are reflected to ensure up-to-date approaches. This will be achieved through partnerships and networking. In the end, however, the success of environmental remediation will depend on the local human capacity, which makes capacity building for technical staff, regulators and operators, from emerging economies a priority for the IAEA.

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BEFORE: Remediation of an acid-drainage-generating waste-rock dump at the mining site of Pocos de Caldas - Brazil

News on Decommissioning Funding

Decommissioning of facilities is inseparable from the issue of radioactive waste management. In accordance with the ethical principle of intergenerational fairness, these management costs need to be borne by the generations that had the benefit from the primary, producing activity. Therefore, it is important to set aside sufficient funds so that, when the moment comes, the financial resources needed to decommission facilities, remediate sites and manage the wastes are available. A liability on future generations would exist if these funds were proven to be insufficient. Such liability can have several originating causes, such as:

- Underestimation of the actual costs by the operator or owner of the facility, or by the holder or owner of the radioactive material,
- Transfer of ownership of the installation or site without transfer of the corresponding provisions,
- A reduction in the operating time (reducing the time available to collect funds),
- Owner/operator financial problems, and
- Ignorance or negligence.

Liabilities identification concerns all the facts that would enable governments, institutions, or others to determine whether every operator or owner of a facility or radioactive material have provided, or are providing, the requisite financial resources in time to cover the future costs of decommissioning, remediation and waste management. Liabilities management is to assure that appropriate frameworks exist for funds to accrue, to be managed, and to be disbursed at the appropriate time. [Source: International Atomic Energy Agency, Financial Aspects of Decommissioning, IAEA-TECDOC-1476, IAEA, Vienna, 2005].

Some recent developments can provide reflections on the challenges and difficulties encountered in establishing appropriate decommissioning funding.

- The plans by Energy Solutions to acquire and dismantle the Zion’s nuclear power plant, which closed 10 years ago, as a total contract have been delayed due to uncertainties in the remaining value of the decommissioning fund because of the declining economy.
- A petition to the United States Nuclear Regulatory Commission (NRC) to use funds from licensees’

AFTER: Remediation completed

decommissioning trust funds to cover the cost of disposal of some 'major radioactive components' (MRC) that were removed from reactors before the permanent cessation of operations were turned down.

- A report by the UK House of Common's Business and Enterprise Committee questions the sustainability of the funding of the activities of the UK Nuclear Decommissioning Authority (NDA) and suggests that a new system of funding was needed. At present NDA funding comes from a combination of government funds and income from commercial operations, including reprocessing and sales of electricity from the Magnox stations that remain in operation. Earlier this year the UK's National Audit Office warned that decommissioning work on some sites was hampered by changes to funding which had been introduced at short notice and that the costs of the work were rising rapidly.
- The UK government has appointed a special board (the Nuclear Liabilities Financing Assurance Board - NLFAB) to oversee the decommissioning and waste disposal funding arrangements of new nuclear power stations. As part of any application to build a new nuclear power station, operators will have to submit plans for decommissioning and waste management that will include arrangements for financing those plans.
- Several of the sites in the UK presently under decommissioning also include land that would be useful for new nuclear power production as they have the necessary infrastructure. The sale of land adjacent to three of the NDA's Magnox sites has been announced. This could be a means of generating income also for other decommissioning projects.

Michele Laraia (m.laraia@iaea.org)

Bradwell Decommissioning Peer Review: A Pilot Project

Scope

In mid-2007 UK's Magnox Electric contacted the IAEA to discuss the organization of a peer review of the decommissioning their Bradwell reactors. Magnox had had good experience with peer reviews for operating stations through WANO, but noting similar exists for defuelled reactors and decommissioning sites. A key factor for asking the IAEA was that IAEA has much more involvement with decommissioning world wide, underpinned by Safety Standards, Recommendations and Technical Reports. Magnox expressed a desire for the review to be high level experience-based rather than 'compliance-based', but it was agreed that review of alignment with IAEA standards and expectations can be a useful initial element of such a review.

The objective of the proposed international decommissioning peer review service mission was to provide an independent review of activities associated with the planning and implementation of decommissioning. It aimed to assist the host organization – the operator [Magnox Electric Ltd] — to identify opportunities for improvement to their decommissioning project planning and execution based on the international safety standards, good international practice and other relevant recommendations in this field. The review was also to facilitate the sharing of good practices identified in the review and inform the development of the international standards and recommendations

Bradwell NPP site was chosen as it is midway on the Magnox NPP sites' decommissioning timeline having ceased generation in 2002 and completed defuelling.

For the success of the review two issues are crucial, a well defined scope and well chosen external experts. The decommissioning review is a flexible service, and was tailored according to the requests of the host organization. Upon request of Magnox, the peer review was intended to cover the following tasks: (i) peer review of decommissioning strategy and policy for the facility; (ii) peer review of the decommissioning plan for this facility and relevant supporting documents; (iii) peer review of the implementation of decommissioning plan, including related operational activities. The review addressed all areas of importance for decommissioning and in particular five major focus areas:

- Decommissioning Strategy;
- Radiological characterisations;
- Decommissioning approach, technologies and techniques;

- Materials management during decommissioning;
- Surveillance and maintenance.

It further covered funding, decommissioning plan, management issues, hazard management and lessons learned.

In preparation of the peer review Magnox provided all relevant documentation, e.g. national legislation, national strategies and Magnox strategy documents, as well as Bradwell site specific documentation. The IAEA provided a questionnaire for self assessment based on the Safety Requirements WS-R-5 *Decommissioning of Facilities Using Radioactive Materials*, complemented by questions on good practices measured against IAEA Safety Reports, Technical Reports, and IAEA-TECDOCs; and hands-on experience provided by the members of the review team.

Bradwell NPP site

Review Mission

The review team consisted of 6 experienced decommissioning experts from USA, Canada, France, Germany, Switzerland and Spain and two coordinators from the IAEA. Consistent with Magnox request, the team was mostly selected on the basis of their in-field experience/expertise rather than knowledge of IAEA Standards.

The mission was carried out through review of written documents provided by the Host Organization, presentations by the Host Organization (e.g. in response to issues raised following review of the questionnaire responses), visits to facilities, and discussions with the Host Organization. On the Magnox side, the site staff was mostly involved in the interviewing, with some seconded from Magnox Headquarters. During the review, the team visited appropriate site/facility areas and met with local experts to exchange views and experience on specific issues related to the review. The Bradwell onsite visit and review took place 30th June- 7th July 2008.

The preliminary conclusions of the mission were presented to the Host Organization at the end of the mission. Limited time was available for IAEA team and Magnox to discuss and solve issues as they came up during the first week. Some clarification was given afterwards. At a follow-up meeting between IAEA, the review team leader and Magnox, held 11-12 September, a number of issues were clarified in detail.

On 6th November 2008, a Topical Meeting was organized by the IAEA on the outcomes of the Magnox Peer Review and was open to the international decommissioning community. This meeting offered Magnox, the review team (as represented by the Team Leader) and the IAEA the opportunity of discussing all aspects of the Review in an open and transparent manner, and to collect the opinions of a number of attendees in order to identify the lessons learned on how to improve the next peer review.

The final report of the peer review is under preparation providing detailed results. Here only some highlights can be given.

The Magnox Station Decommissioning Project continues to perform within the International Safety Standards (WS-R-5 and WS-G-2.1), the Stations License Conditions and Safety Cases. The IAEA team was impressed by the competence and professionalism of their counterparts. The Bradwell Site staff strives for the best possible use of the resources at their disposal. However, the Bradwell Project is presently experiencing a significant level of changes in policy, strategy and boundary conditions, which makes it difficult to establish a consolidated and stable multi-year program. In particular, the Project has received, and is expected to continue to receive, reduced and limited funding; and there are limited, or no waste options for disposal of some of the waste generated during decommissioning. This also makes it difficult to optimize the level and composition of human resources.

The review could not avoid to address also plans and activities not entirely within the reach of the reviewed organization. In the nuclear decommissioning context of the UK, other organizations than Magnox play a significant role as policy makers, regulators and funding bodies. In this way, the responsibilities of Magnox in the planning and management of Bradwell decommissioning are limited by overarching players, which it might have been useful to include in the review.

Future Peer Reviews

It is hoped that the Magnox Peer Review will stimulate interest by other organizations in charge of decommissioning projects. International co-operation has been very successful in the decommissioning area. Co-operation of this nature has many benefits and is practical for several reasons. First, it makes good economic sense to share and learn from each other‘s experiences and compare future strategies. The resulting benefit is that it prevents duplication of efforts. A second point worth mentioning is that projects initiated by any or all of the international organizations tend to be considered more credible and therefore generate more support. Third, joint projects create a support network and a system of formal and informal peer reviews. This external review process enhances and adds technical credibility and validity to national approaches and methodologies. And finally, co-operation and exchange of information are required and used by countries as a means of checking their own progress - a means of calibration.

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Staff Members who Joined the Division in 2008

Ms Ksenija Ajvazi provides secretarial support to the Nuclear Fuel Cycle and Materials Section.

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Mr Oleg Goroshko works as Executive Secretary of the Contact Expert Group on matters related to international cooperation in safe and secure management of spent nuclear fuel and nuclear waste, mainly from nuclear submarines.

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Mr Stephen Melnick is providing support and development services for the next version of the IAEA’s Radioactive Waste Management Database (NEWMDB).

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Mr Antonio Morales Leon works on matters related to predisposal management of radioactive wastes and network on waste characterization.

a.morales-leon@iaea.org

Mr Susanta Kumar Samanta works on activities dealing with technologies for handling, treatment, conditioning and storage of radioactive waste from nuclear power plants, nuclear fuel cycle facilities and nuclear applications.

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Mr Peter Waggitt works as a consultant on matters in the uranium production cycle, particularly on Technical Cooperation projects.

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Mr Ruediger Zettel works on matters related to options for assurance of supply of nuclear fuel and issues like the multilateralization of nuclear fuel cycle.

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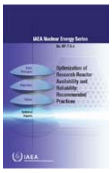
Mr Xuxin Zou works on activities related to spent fuel management like spent fuel storage, transportation, testing and systems management.

x.zou@iaea.org

Recent Publications

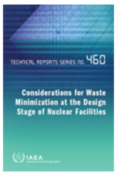
http://www-pub.iaea.org/MTCD/publications/publications.asp



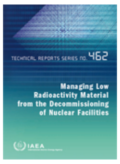
Nuclear Energy Series No. NP-T-5.4
Optimization of Research Reactor Availability & Reliability: Recommended Practices (2008)

Technical Reports Series No. 455
Utilization Related Design Features of Research Reactors: A Compendium (2008)

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

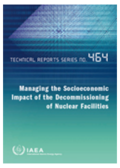


Technical Reports Series No. 460
Considerations of Waste Minimization at a Design Stage of Nuclear Facilities (2008)

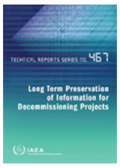


Technical Reports Series No. 462
Managing Low Radioactivity from the Decommissioning of Nuclear Facilities (2008)

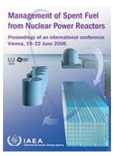
Technical Reports Series No. 463
Decommissioning of Research Reactors and Other Small Facilities by Making Optimal Use of Available Resources (2008)



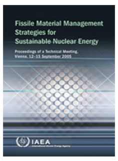
Technical Reports Series No. 464
Managing the Socioeconomic Impact of the Decommissioning of Nuclear Facilities (2008)



Technical Reports Series No. 467
Long Term Preservation of Information for Decommissioning Projects (2008)



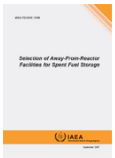
STI/PUB/1295
Proceedings of June 2006 International Conference on Management of Spent Fuel from Nuclear Power Reactors (2007)



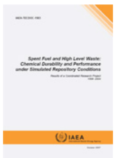
STI/PUB/1288
Proceedings of Sept. 2005 Technical Meeting on Fissile Material Management Strategies for Sustainable Nuclear Energy (2007)

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-TECDOC-1558
Selection of Away from Reactor Facilities for Spent Fuel Storage (2007)

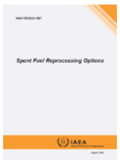


IAEA-TECDOC-1563
Spent Fuel and High Level Waste: Chemical Durability and Performance under Simulated Repository Conditions (2007)

IAEA-TECDOC-1566
Factors Affecting Public and Political Acceptance for the Implementation of Geological Disposal (2007)

IAEA-TECDOC-1572
Disposal Aspects of Low and Intermediate Level Decommissioning Waste (2008)

IAEA-TECDOC-1579
New Developments and Improvements in Processing of 'Problematic' Radioactive Waste (2008)



IAEA-TECDOC-1587
Spent Fuel Reprocessing Options (2008) **NEW!**

IAEA-TECDOC-1593
Return of Research Reactor Spent Fuel to the Country of Origin: National Experiences and Requirements for Technical and Administrative Preparations (2008) **NEW!**

IAEA-TECDOC-1601
Homogeneous Aqueous Solution Nuclear Reactors for the Production of Mo-99 and Other Short Lived Radioisotopes (2008) **NEW!**

Soon available

IAEA-TECDOC-1602
Innovative and Adaptive Technologies in Decommissioning of Nuclear Facilities (final report of a CRP 2004-2008) (2008) **NEW!**

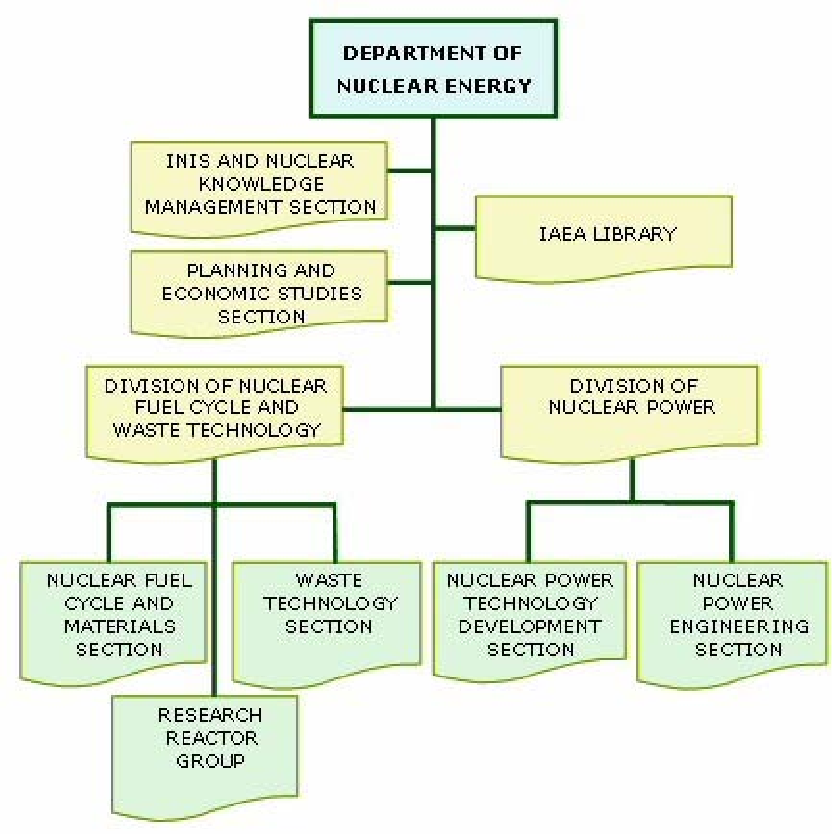
Radioactive Waste Management Profiles No. 8
A Compilation of Data from the Net Enabled Waste Management Database (NEWMDB) (2007)

Upcoming Meetings in First Half of 2009

Date	Title	Place	Contact
12-16 January	International Workshop on Sustainable Management of Disused Sealed Radioactive Sources (DSRS) - Working Toward Disposal	Chiang Mai Thailand	r.heard@iaea.org
9-11 February	International Working Group Meeting of Research Reactors	Vienna Austria	p.adelfang@iaea.org
23-27 February	Technical Meeting on High Level Waste Processing and Spent Nuclear Fuel (SNF) Encapsulation	Vienna Austria	s.samanta@iaea.org
16-20 March	Technical Meeting on Organization, Principles and Technical Options for Waste Minimization	Vienna Austria	z.drace@iaea.org
16-20 March	Technical Meeting on the Development and Implementation of Research Reactor Ageing Management Systems	Vienna Austria	e.bradley@iaea.org
31 Mar. - 3 April	Annual WATEC Meeting	Vienna Austria	j.m.potier@iaea.org
20-24 April	Workshop on Development of Radiation Resistant Materials	ICTP Italy	v.inozemtsev@iaea.org
20-24 April	Technical Meeting on Mobile Processing Technologies and Systems for Radioactive Waste Management	Vienna Austria	s.samanta@iaea.org
21-24 April	Technical Meeting on Advances in Applications of Burnup Credit for Spent Fuel Storage, Transport Reprocessing, and Disposition	Madrid Spain	z.lovasic@iaea.org
22-24 April	Technical Meeting on Training in and Demonstration of Waste Disposal Technologies in Underground Research Facilities—An IAEA Network of Centres of Excellence	Montpellier France	s.hossain@iaea.org
27-29 April	Technical Meeting on Planning and Design of Geological Repositories	Vienna Austria	b.neerdael@iaea.org
27-30 April	Annual IWGFPT Meeting	Vienna Austria	v.inozemtsev@iaea.org
4-7 May	Technical Meeting on Systems Integration Considerations in Spent Fuel Management	Vienna Austria	z.lovasic@iaea.org
11-15 May	Technical Meeting on Mixed Waste Management: Concepts, Characterization and Strategies	Vienna Austria	z.drace@iaea.org
18-22 May	**International Conference on Remediation of Land Contaminated by Radioactive Material Residues**	**Astana Kazakhstan**	**h.monken-fernandes@iaea.org**
25-29 May	Technical Meeting to Develop a Layperson's Guide to Environmental Remediation	Vienna Austria	h.monken-fernandes@iaea.org
17-19 June	43rd Joint IAEA-OECD/NEA Uranium Group Meeting	Vienna Austria	j.slezak@iaea.org
22-26 June	**International Symposium on Uranium Raw Material for Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM-2009)**	**Vienna Austria**	**c.ganguly@iaea.org**

Division of Nuclear Fuel Cycle and Waste Technology (NEFW) WebSite Links

Division Introduction - NEFW Home: http://www.iaea.org/OurWork/ST/NE/



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
- Databases (NEWMDB)
  http://www.iaea.org/OurWork/ST/NE/NEFW/wts_information.html

Research Reactor Group (RRG)

- Main activities
  http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_home.html
- Technical Working Group on Research Reactors (TWGRR)
  http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_twgrr.html
- Research Reactor Database
  http://www.iaea.org/OurWork/ST/NE/NEFW/rrg_RRDB.html

IAEA International Atomic Energy Agency

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