

# Nuclear Science

## Objective

*To increase Member State capabilities in the development and application of nuclear science as a tool for their economic development.*

## Atomic and Nuclear Data

The Agency maintains an extensive collection of nuclear, atomic and molecular databases that are available to all Member States through both on-line and traditional services. In this connection, four new CRPs were initiated in 2007. The first one is on establishing a recommended numerical database for processes important for modelling heavy elements in nuclear fusion reactor plasmas. The second one focuses on generating data relevant to erosion processes in fusion devices, with the goal of understanding how plasma constituents interact with the solid wall materials of fusion devices, leading to erosion and re-deposition of these materials. Such understanding and control are crucial for achieving fusion energy. The third CRP has the goal of assembling and evaluating neutron cross-section data for important minor actinides. These data are of great value for innovative reactor design. The fourth CRP is on improving the quality of heavy charged particle interaction data for patient dose delivery calculations in radiotherapy.

The Agency's Reference Input Parameter Library (RIPL), which has become a standard source of input data for nuclear reaction modelling, was extended in 2007 to encompass energy and non-energy applications. The methodology of this library has been adopted by the US nuclear application library (ENDF/B-VII), and RIPL technical documents are being frequently cited by users worldwide. The Agency convened a workshop on the medical applications of nuclear data for science and technology, which helped scientists and engineers obtain extensive training in the use of nuclear data in therapy and diagnostics. This will enable the 40 participants, including 35 from developing countries, to work with greater understanding and confidence in medical uses of radiation and radioisotopes.

## Research Reactors

The Agency promotes regional collaboration to improve the utilization of small and medium size

research reactors. In 2007, the Agency organized a workshop on strategic planning for research reactor utilization in the Mediterranean region and a technical meeting on the utilization of small and medium size research reactors. The presentations and discussion at both meetings reflected increasing networking and collaboration among the participants, one of the Agency's goals for this activity.

A new initiative was launched by the Agency to promote research reactor coalitions to serve as international user centres that would enable countries that do not have research reactors, or that are considering closing an old reactor, to use nearby facilities with modern technical capabilities. Efforts in 2007 created a number of potential research reactor coalitions. The need for such coalitions was strongly supported in the final report of the Agency's international conference on 'Research Reactors: Safe Management and Effective Utilization', held in Sydney.

The Agency promotes materials studies for the energy sector using research reactors. The use of research reactors and complementary techniques, such as positron annihilation, for such studies is summarized in a new publication, *Characterization and Testing of Materials for Nuclear Reactors* (IAEA-TECDOC-1545).

## Innovation and research reactor operation

Rising expectations for nuclear power have increased interest in research on new generation fuels and materials that pose challenges for existing research reactors. Limited government funding and the increased importance of revenue from, for example, commercial isotope production add further management challenges for sustainability. To facilitate the exchange of ideas and experience in this more competitive environment for selecting, designing and operating various devices in research reactors, the Agency published in 2007 a *Compendium on Utilization Related Design Features of Research Reactors* (Technical Reports Series No. 455), which collected worldwide experience in these areas.

The Agency started an assessment of the use of aqueous homogeneous reactors (AHRs) for radioisotope production. A group of experts reviewed the state of the art of AHRs, including

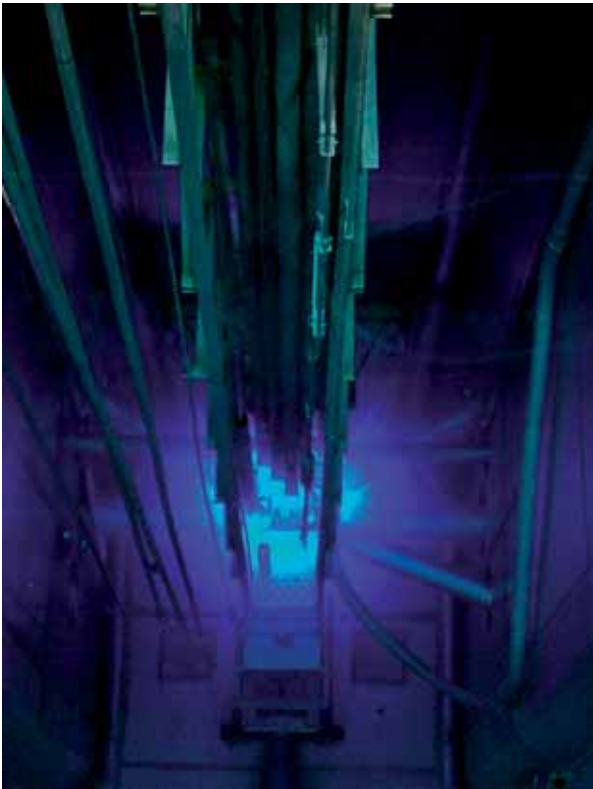


FIG. 1. New LEU core in operation at the Portuguese RPI reactor.

historical and ongoing activities in China, France, the Russian Federation and the USA, and identified specific opportunities and challenges with respect to the recovery of different isotopes of importance for medical use. The Agency also organized a training course in Ljubljana, Slovenia, on good practices in water quality management for research reactors and research reactor spent fuel storage facilities.

An international conference entitled 'Research Reactors: Safe Management and Effective Utilization', held in Sydney in November, was the latest in a series of Agency conferences on these subjects. It recommended continued support for: international coalitions and shared regional facilities; feasibility studies for future research reactors; applying the Code of Conduct on the Safety of Research Reactors; periodic safety reviews of research reactors; and efforts to reduce proliferation risk, including minimizing the use of HEU.

### Research reactor fuel

Through the technical cooperation programme, the Agency worked with the Government of Portugal

to convert the Portuguese RPI reactor from the use of HEU to LEU (Fig. 1). To support an ongoing CRP on the conversion of miniature neutron source research reactors from the use of HEU to LEU, a workshop organized by the Agency reviewed core conversion calculations and experimental data and agreed on the path forward to select a single candidate LEU fuel.

The Agency continued to support Member States participating in international programmes to return research reactor fuel to the country of origin. As part of the Russian Research Reactor Fuel Return Programme (RRRFR), two shipments of fresh HEU fuel were sent from Poland and Vietnam to the Russian Federation under contracts arranged by the Agency. The Agency also assisted in the shipment of irradiated Russian origin research reactor fuel from the Řež Nuclear Research Institute in the Czech Republic. This was the first research reactor spent fuel shipment for which the high capacity casks purchased by the Agency for the RRRFR in 2006 were used (Fig. 2).

The Agency's technical cooperation project to help remove irradiated Russian research reactor spent fuel from the Vinča Institute in Serbia completed prerequisite work within the spent fuel pools. The preliminary safety analysis and transport safety reports were also completed and submitted to the Serbian regulatory authority for review.

## Utilization of Accelerators and Nuclear Instrumentation

In 2007, the Agency organized a worldwide proficiency test for X ray fluorescence (XRF) laboratories

that confirmed the high level of analytical reliability of environmental material analyses in most of these laboratories. A portable XRF

spectrometer that was developed at the Agency's Laboratories, Seibersdorf, was used extensively in 2007 to study and characterize precious cultural heritage objects and biological materials in museum collections in Vienna. It is available to all interested Member States for similar investigations.

Three workshops were held in cooperation with the Abdus Salam ICTP in Trieste to strengthen the use of nuclear methods using accelerators and X rays in Member States. Also, the Agency, together with the American Nuclear Society, organized an international conference in Pocatello, USA, on

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FIG. 2. High capacity cask used in the shipment of spent fuel from Řež, Czech Republic.

the application and use of accelerators. Through the workshops and conference, a broad range of international experts and researchers from developing countries enhanced their technical knowledge of accelerator based techniques and their potential applications in their countries.

Two CRPs were concluded in 2007. One, on the development of new techniques and applications of accelerator mass spectrometry (AMS), looked at previously inaccessible research areas opened up by the ultra-trace sensitivity of AMS (as low as  $10^{-15}$ ) and at possible new applications in environmental monitoring and nuclear security. The CRP both improved existing methods and developed new procedures that are easily adapted in developing countries without access to modern dedicated accelerator facilities. The second CRP, on ion beam modification of insulators, helped to develop a new type of doped silicon carbide, a very promising material surpassed only by diamond in its performance in high power microelectronic devices. Ion beam synthesis of a new carbide is hence of great value in microelectronics.

Through its technical cooperation programme, the Agency conducted 13 training courses at both the Agency's Laboratories, Seibersdorf, and in developing Member States on the methods and applications of X ray emission techniques. Training focused on the study and protection of cultural heritage objects, air pollution monitoring, training and teaching materials based on information and communication technology, and quality control and quality assurance in nuclear analytical

techniques and nuclear instrumentation. These training modules are available to all Member State laboratories.

## Nuclear Fusion Research

On 24 October, a milestone in nuclear fusion research was achieved with the entry into force of the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the International Thermonuclear Experimental Reactor (ITER) Project. In his capacity as the Depositary of that Agreement, the Director General convened the first session of the ITER Council in Cadarache, France, in November 2007.

The main emphasis of the Agency's fusion programme is on increasing international cooperation and support for science and technology for fusion power. Nine technical meetings were held in 2007 on fusion power plant reliability and topics of relevance to the operation of ITER. In connection with the challenges and application of plasmas that meet the requirements of a real power plant, a specialist meeting involving both fission and fusion experts was convened to discuss materials research using neutrons.

To encourage the exchange of expertise between Member States, the Agency co-organized an experiment in the tokamak in Lisbon and a plasma school at the Abdus Salam ICTP in Trieste, both of which exposed participants to mainstream fusion research.

In conjunction with the 'Fifth Inertial Fusion Sciences and Applications' conference, organized by Osaka University and held in Kobe, the Agency conducted a technical meeting on the physics and technology of inertial fusion energy targets and chambers to enhance international cooperation

in developing alternative fusion concepts. The convening of these meetings in Kobe helped to strengthen collaboration between scientists from emerging economies and the major groups in fusion research, and enhanced the prospects of developing human resources for fusion research.