

# IAEA ACTIVITIES RELATED TO RESEARCH REACTOR FUEL CONVERSION AND SPENT FUEL RETURN PROGRAMS

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## ABSTRACT

The IAEA has been involved for more than twenty years in supporting international nuclear non-proliferation efforts associated with reducing the amount of highly enriched uranium (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 associated efforts to return research reactor fuel to the country where it was originally enriched. IAEA efforts have included the development and maintenance of several data bases with information related to research reactors and research reactor spent fuel inventories that have been essential in planning and managing both RERTR and spent fuel return programmes. Other IAEA regular budget programs have supported research reactor fuel conversion from HEU to low enriched uranium (LEU), and in addressing issues common to many member states with spent fuel management problems and concerns. The paper briefly describes IAEA involvement since the early 1980's in these areas, including regular budget and Technical Co-operation programme activities, and focuses on efforts in the past five years to continue to support and accelerate U.S. and Russian research reactor spent fuel return programmes.

## 1. Introduction

The IAEA has been involved for many 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 RERTR programme, as well as directly associated efforts to return spent research reactor fuel to the country of origin where it was originally enriched. IAEA efforts have included the development and maintenance of several databases with information related to research reactors and their spent fuel inventories that have been essential in planning and managing both RERTR and spent fuel return programmes. Other IAEA regular budget programs have been highly useful in supporting research reactor fuel conversion from HEU to LEU, and in addressing issues common to many member states in dealing with spent fuel management problems and concerns. This paper briefly describes IAEA involvement since the early 1980's in these areas, including regular budget and Technical Cooperation programme activities, and focuses on efforts in the

past five years to continue to support and accelerate U.S. and Russian research reactor spent fuel return programmes.

## **2. Relevant IAEA Programs and Projects**

Research reactors have played an important role in the development of nuclear science and technology. However, of the more than 650 research reactors constructed around the world in the second half of the twentieth century, at the present time only 275 are operating. About 375 research reactors have been closed, of which a bit less than half (168) have been decommissioned. Further, of the 275 operating reactors, a significant number are under-utilized and may be closed in the near future. Spent fuel management is a major consideration for many facilities.

The IAEA has sought to address the changing needs of its member states in the research reactor field, by providing assistance with strategic planning for increased utilization, refurbishment, ageing management and spent fuel management. At the same time, it has also addressed emerging non-proliferation concerns related to research reactors, such as assisting in the reduction of the use of HEU.

(See <http://www.iaea.org/NewsCenter/Features/ResearchReactors/reactors20040308.html> and <http://www.iaea.org/NewsCenter/Features/ResearchReactors/security20040308.html>)

### **2.1 Regular Program**

#### **2.1.1 Development of Activities on Research Reactor Spent Fuel Management**

The Agency's programme related to research reactors, historically oriented toward utilization issues, began to expand after 1993 with the development of activities in the Department of Nuclear Energy relevant to research reactor fuel matters. Activities included meetings on techniques for the management of failed fuels from research reactors, advice to Member States through the Irradiated Fuel Management Advisory Programme (IFMAP), and assistance to developing Member States through the IAEA's Technical Assistance and Co-operation programmes, among others.

Recognising that the degradation of materials, equipment and facilities through ageing was becoming of serious concern to many operators, the Agency organised activities in the materials science field, including Co-ordinated Research Projects (CRP) on irradiation enhanced degradation of materials in spent fuel storage facilities, and on research reactor fuel cladding (aluminium alloys) for the monitoring and control of corrosion in wet storage. These programmes were supplemented by a series of Regional Workshops organised by the IAEA to deal with all aspects of spent fuel handling, management, storage and preparation.

#### **2.1.2 IAEA-Research Reactor and Spent Fuel Data Bases**

The IAEA has developed and maintains two research reactor-related databases. The Research Reactor Data Base (RRDB) contains data on 673 research reactors, based upon responses to questionnaires sent out annually by the IAEA to owners and operators of research reactors. The Research Reactor Spent Fuel Data Base (RRSFDB) contains data provided to the Agency on spent fuel inventories at 210 research reactors. These data bases enable the Agency to analyse trends in research reactors worldwide, to plan the IAEA's regular program and budget activities, as well as technical cooperation projects, and to support RERTR and spent fuel take back programs. The IAEA is currently involved in an effort to merge the two data bases and

other Agency data bases on research reactors (e.g. research reactor decommissioning) in order to simplify queries, strengthen data consistency, and to enhance their contributions to Agency programmes.

In the period after September 11, 2001, certain information in the RRDB that had been publicly available through the IAEA's web site was removed from public access due to potential security concerns.

### **2.1.3 Research Reactor Subprogramme**

Recognizing the increasing importance of activities related to the back-end of the research reactor fuel cycle, and in response to an external evaluation, the IAEA initiated subprogramme D.2, Research Reactors, in the 2002-2003 IAEA Program and Budget. Activities which had previously been fragmented in different areas of the IAEA programme were integrated into this new subprogramme, representing the first holistic approach to research reactor technical issues. The subprogramme contained projects on effective utilization of research reactors (including qualification of new, high density, low-enriched uranium fuels), supporting modernization and innovative technology development, assistance on the research reactor fuel cycle (including support to RERTR), and facilitating transfer of knowledge on decommissioning and irradiated core materials.

The external evaluation on research reactors also recommended the need for an Agency-wide policy and strategy to address in an integrated way the safe operation of research reactors, their optimum utilization, coupled with good management of the facility, the associated fuel cycle and radioactive waste, criticality safety, decommissioning and spent fuel storage and disposal. Consequently, in March 2002, the IAEA created the position of "cross-cutting co-ordinator" for research reactor activities, who is responsible for co-ordinating research reactor-related activities taking place across all IAEA departments, as well as relevant IAEA technical cooperation projects.

## **2.2 Technical Cooperation Program**

The IAEA Technical Cooperation programme carries out projects in member states that provide assistance in areas related to research reactor utilization, fuel conversion, spent fuel management and repatriation of fresh and spent HEU fuel and safety.

### **2.2.1 National and regional projects**

The IAEA has more than twenty active Technical Cooperation projects related to research reactors, regarding research reactor fuel, decommissioning and waste management, and utilization. Many of these projects involve research reactor safety issues as well. Projects in Brazil, Chile, Poland, and Romania involve assistance for the testing, qualification, or provision of low-enriched uranium fuel, which is directly supportive of the RERTR programme (see 3.1). A regional project in Latin America aims to assist and encourage the development of regional approaches to research reactor spent fuel management. An interregional project provides assistance for decommissioning of research reactors. Three projects in Serbia, funded by the non-governmental organization Nuclear Threat Initiative supports the removal of the spent fuel from the RA reactor, decommissioning, and waste management

Since 2000, there have been a total of sixteen completed TC projects related to research reactors, addressing research reactor safety, decontamination and decommissioning, utilization and fuel improvement.

## **2.2.2 Fact-finding missions (RER/9/058)**

In association with IAEA support to research reactor fuel return programs (see below), the IAEA organized a series of fact-finding missions to research reactors to assess the fresh and spent fuel situations, under TC project RER/9/058, Safety Review of Research Reactor Facilities. The initial missions took place in 17-23 June 2001 to Ukraine, Uzbekistan, and Yugoslavia. Additional missions took place February 10-21 to Romania, Czech Republic and Latvia, March 16-22, 2003 to Kazakhstan, December 9-20, 2003 to Poland, Bulgaria, and Hungary and March 3-4, 2004 in Belarus. IAEA, Russian, and other international experts have taken part in the missions, which have established the basis for spent fuel shipments from these countries.

## **3. International Initiatives involving IAEA**

### **3.1 IAEA Activities Related to the RERTR Program**

The Reduced Enrichment for Research and Test Reactors Program (RERTR) was initiated by the U.S. in 1978, with the objective of developing the technologies necessary to convert research and test reactors from the use of fuels and targets containing highly-enriched uranium (HEU) to the use of fuels and targets containing low enriched uranium (LEU). The RERTR program objective is to minimize and eventually eliminate the use of HEU in civil programs worldwide.

The IAEA has been involved with and has fully supported RERTR since its inception, initially through its Department of Research and Isotopes (now named the Department of Nuclear Sciences and Applications). This included the development of international guidelines and standards to assist the overall reduced enrichment effort as well as providing, upon request, assistance to Member States for the conversion of specific research reactors through the coordination and facilitation of interactions between Member State reactor organizations and laboratories in France, Germany, and the U.S. The IAEA also participated actively in the annual RERTR Conferences that began in 1979 and co-organized the 2004 RERTR Conference in Vienna.

Beginning in 1979, the IAEA convened meetings, which produced a series of IAEA Technical Documents (TECDOCS) directly relevant to the RERTR, as guides for the conversion of research reactors.

After 1993, the IAEA Department of Nuclear Energy, Nuclear Fuel Cycle and Waste Management Division extended the scope of its spent fuel management programme to include programmes which focused specifically on spent fuels from research and test reactors. These activities cover the collection, analysis and dissemination of information on storage, management and related experience with spent fuels, formulation of norms and provision of technical assistance to developing Member States.

This corresponded with the rising awareness that many research reactors were in or rapidly approaching a crisis situation and in every case, due to spent fuel storage and management problems and the constraints of national laws. It was clear that the capacity for spent fuel storage had been reached or was close to the limit at many research reactors and there were concerns from a materials' science point of view about ageing materials in ageing storage facilities. Consequently, the IAEA's activities in this area were formulated to address these concerns and proved to be helpful to the RERTR program and to related efforts in the mid-1990's to repatriate spent research reactor fuel to the country of origin.

## **3.2 Research Reactor Fuel Take Back Programs**

The IAEA has been an active supporter of the effort(s) to return research reactor fuel to the country of origin.

### **3.2.1 U.S. Take Back Program**

In 1986, to further encourage foreign research reactor operators to convert to LEU fuel, the U.S. Department of Energy DOE "Off-Site Fuels Policy" was extended to include the acceptance of foreign spent nuclear fuel containing uranium enriched in the United States. The U.S. accepted foreign research reactor spent nuclear fuel until the program expired (in 1988 for HEU fuels and 1992 for LEU fuels). A number of urgent "relief" shipments of spent fuel of U.S. origin did continue to take place, however.

During the period following the expiration of the U.S. Off Site Fuels program (which coincided with the creation of the research reactor fuels program in the IAEA Department of Nuclear Energy), the IAEA was involved as an observer in many of the meetings of the "ad hoc" group of research reactor operators, known as the Edlow/Egan Group. Beginning in January 1992 this Group kept up pressure on the U.S. DOE to accept US-origin spent fuel from foreign research reactors

Toward the same end, the Director General of the IAEA, Dr. Hans Blix, wrote letters to Secretary O'Leary of the US DOE (1 July 1993) and Mr. Victor Michailov, Minister of Atomic Energy of the Russian Federation, (2 February 1995) suggesting that these major partners in RERTR could facilitate the non-proliferation goal of RERTR by taking back foreign research reactor fuel.

A Record of Decision was published by DOE on May 13, 1996 to re-start the U.S. Foreign Research Reactor Spent Nuclear Fuel (FRR SNF) Acceptance Program with a deadline of May 13, 2006 for eligible fuel to be discharged from reactors and a deadline of May 13, 2009 for fuel to be received in the U.S.

With the re-initiation of the U.S. take-back program, the IAEA began a number of activities to assist member states eligible to ship spent research reactor fuels back to the U.S. The IAEA convened experts to develop guidance for Member States in this regard, which produced a Guidelines Document on Preparatory Work Prior to Return of Spent Fuel of US-Origin from Foreign Research Reactors", Draft IAEA-TECDOC (June 1996). (Note: These documents and lectures from the training courses, below, are available on the ANL/RERTR website at <http://www.td.anl.gov/Programs/RERTR/RERTR.html>).

In response to a request from the US Government the IAEA organized two interregional training courses on the "Technical and Administrative Preparations Required for Shipment of Research Reactor Spent Fuel to its Country of Origin," in cooperation with the Government of the United States through Argonne National Laboratory. The first course was held at Argonne in January 1997 and the second in May 1999, also at Argonne. These courses included participants from Russian research reactors.

The purpose of the courses was to provide participants with the technical, organizational and administrative information needed to prepare irradiated research reactor fuel for shipment to its country of origin, in this case, the United States.

The aforementioned guidelines were later revised and expanded in scope into a "Guidelines document on Technical and Administrative Preparations Required for Shipment of Research Reactor Spent Fuel to Its Country of Origin, Draft IAEA-TECDOC (March 1999).

The U.S. announced in April 2004 that the U.S. take-back program would be consolidated with DOE support for the Russian research reactor spent fuel return program.

### 3.2.2 Russian Take-Back Program

At the IAEA General Conference in September 1999, U.S. Energy Secretary Bill Richardson announced that the U.S. was prepared to work with Russia and the IAEA to manage and dispose of Russian-origin HEU research reactor fuel remaining in a number of countries.

On 14-15 December 1999 the IAEA convened the first Ad Hoc Tripartite Meeting on the possible management and disposition of Russian origin fuel currently at foreign research reactors. The meeting reviewed the situation regarding fresh and spent Russian origin research reactor fuel in various locations around the world, Russian experience in regard to spent fuel transport, legal, policy and safeguards issues, criteria for prioritising sites; scenarios for a demonstration shipment and action plan, as well as financial issues.

The Second Tripartite Meeting was held 27-29 March 2000 in Vienna, which included a presentation of the data and information collected by the IAEA, discussions of the IAEA role in the program as well as applicable Russian laws, regulations, and policies. It was decided that the IAEA should send a letter to targeted member states to assess their interest in participating in a fuel return program. It was also decided that the site for a first demonstration shipment would be decided based on the responses to the letter, and the U.S. would provide funding for the shipment.

IAEA Director General Mohamed ElBaradei sent a letter on 29 September 2000 to sixteen countries with inventories of Russian research reactor fuel (Belarus, Bulgaria, China, Czech Republic, Egypt, Germany, Hungary, Kazakhstan, Latvia, Libya, Poland, Romania, Ukraine, Uzbekistan, Vietnam, and Yugoslavia). There were thirteen responses, all positive (one with reservations) and three did not reply (one of these, Libya, later shipped fresh fuel to Russia in 2004, see below).

The third and fourth Tripartite Meeting were held in April and September 2001, which requested and reviewed fact-finding missions to Ukraine, Uzbekistan, and Yugoslavia to begin detailed planning for eventual spent fuel shipments. Additional Tripartite meetings were held in November 2001, July 2002, and January 2003, the last of which included a report on the Vinca fresh fuel shipment which had taken place the previous August (though not a Tripartite shipment), progress on a possible fuel shipment from Uzbekistan, as well as for additional fact-finding missions to Latvia, Czech Republic, Romania, and Kazakhstan.

The first shipment of the Tripartite Initiative took place on September 21, 2003 (see <http://www.iaea.org/NewsCenter/News/2003/weapons20030922.html>), fresh HEU fuel was returned from the Magurele research reactor in Romania to Russia (14 kg uranium total, 10 kg U-235). The U.S. provided the funding for the shipment, which was carried out by the IAEA, under IAEA TC project RER/9/058. In association with the shipment, the U.S. provided approximately \$4 million to IAEA Technical Cooperation project ROM/4/024 for the full-core conversion of the Triga research reactor at Pitesti, and committed to pay for the eventual repatriation of the Russian-origin spent fuel at Magurele (the U.S.-origin spent fuel at the Triga reactor in Pitesti is eligible for repatriation under the U.S. return program.).

On November 7, 2003, U.S. Energy Secretary Abraham and Russian Minister of Atomic Energy Rumyantsev issued a joint statement concerning the Russian return program, stating that a government-to-government agreement to provide the legal framework for the implementation of the Tripartite Initiative would be ready for signature. The joint statement also committed to the development by the end of 2003 of a schedule of shipments of fuel.

The Eighth Tripartite Meeting was held 3-4 December 2003 in Vienna. The fresh fuel shipment from Romania in September was noted, as was an upcoming shipment from Bulgaria. The U.S. announced that it had already contacted Ukraine, Kazakhstan, and Vietnam regarding future shipments including incentive packages. Agreement was reached

on a suggested schedule of both fresh and spent fuel shipments. Discussions also took place on the subject of a programmatic ecological expertise for the spent fuel shipments, as well as the potential spent fuel shipment from Vinca. A feasibility study using large scale transport and/or other casks was requested.

The second tripartite shipment took place in mid-December 2003 (see <http://www.iaea.org/NewsCenter/News/2003/bulgaria20031224.html>), with approximately 17 kg of 36% HEU removed from the IRT research reactor in Sofia. Once again, the fuel removal was funded by the U.S. under TC Project RER/9/058, and the U.S. committed to assist Bulgaria with an LEU fuel core for a planned research reactor as well as to eventually ship the existing spent research reactor fuel to Russia.

The third Tripartite shipment took place in early March 2004 (see [http://www.iaea.org/NewsCenter/News/2004/libya\\_uranium0803.html](http://www.iaea.org/NewsCenter/News/2004/libya_uranium0803.html)) from the Tajoura Nuclear Research Centre near Tripoli. Libya, consisting of 80% HEU in the form of fresh fuel, in fuel assemblies containing about 13 kg of fissile U-235 as well as about 3 kg of uranium. The \$700,000 fuel removal project was funded by the U.S. under TC Project RER/9/058, following Libya's announcement in December 2003 that it was ceasing all activities related to development of nuclear, chemical, and biological weapons. This fuel removal was accompanied by a U.S. commitment to fund, under an IAEA TC project, the full core conversion for the Tajoura reactor, as well as a U.S. pledge to pay for the eventual return of the Russian-origin spent fuel at Tajoura.

The fourth tripartite shipment took place on September 2004 (see <http://www.iaea.org/NewsCenter/News/2004/uzbekistan.html>), with about 10 kg of fresh reactor fuel transported by truck and air from the Institute of Nuclear Physics of the Academy of Sciences of Uzbekistan, near the country's capital, Tashkent to the Russian Federation. Once again, the fuel removal was funded by the U.S. under TC Project RER/9/058. and the U.S. committed to assist Uzbekistan to eventually ship the existing spent research reactor fuel to Russia.

The IAEA has considered organizing training courses in Russian for countries with Russian-origin spent research reactor fuel in order to assist countries to prepare for spent fuel shipments. However, as no shipment of spent fuel has yet taken place, many of the procedures and required documentation are still to be developed. The Agency stands ready to assist Member States when the relevant information is available.

The U.S. and Russia signed the bilateral agreement concerning the repatriation of Russian-origin HEU research reactor fuel to Russia on May 27, 2004, under which more than a dozen countries are eligible to receive financial and technical assistance from the U.S. under the Tripartite Initiative.

### **3.2.3 Global Threat Reduction Initiative (GTRI)**

The Global Threat Reduction Initiative (GTRI) was announced by U.S. Secretary of Energy Spencer Abraham at a speech at the IAEA on May 26, 2004.

The stated goal of the program is to substantially expand existing national and international efforts in order to secure and remove high-risk nuclear and radiological materials that continue to pose a threat to the United States and the international community. GTRI is to be carried out in cooperation with the IAEA and other international partners, building upon existing efforts such as the RERTR programme, and the U.S. and Russian research reactor spent fuel return programs. IAEA Director General ElBaradei has expressed his support and the Agency's willingness to work together to achieve the goals of the GTRI. There have been several discussions between IAEA and U.S. officials to clarify cooperative activities, and a GTRI Partners Conference was held in Vienna on September 18-19, 2004, which adopted

conference findings supportive of the goal of accelerating and expanding relevant programs such as RERTR and the spent fuel take back programs.

#### **4. Future Activities and Prospects**

The 2006-2007 IAEA programme and budget, is currently in the final stages of development before presentation to and review by member states. It will continue to address the fact that 60% of research reactors around the world are over 30 years old.

Thus, the focus of the subprogramme will continue the transition from traditional support of fundamental research and training to helping facilities with strategic planning to increase utilization in more commercial areas, to refurbish and replace ageing equipment, in managing spent fuel inventories and supporting decommissioning. In particular, the subprogramme will support regional and interregional thematic collaborations for enhance utilization and to promote solutions to the back-end of the research reactor fuel cycle.

In addition, to contribute to non-proliferation efforts, support of RERTR and the programmes of repatriation of research reactor fuel to the country of origin are being strengthened. The IAEA will provide technical support for the development and qualification of high-density fuels that will facilitate the conversion of a number of research reactor facilities which cannot use the existing LEU silicide fuel. A Coordinated Research Project (CRP) on <sup>99</sup>Mo production using LEU targets is being planned to begin in 2006 but may be able to be initiated earlier if funds are made available.

New or extended TC projects in Bulgaria and Libya are expected to involve the design or conversion of research reactors with low enriched uranium cores.

Additional fresh HEU shipments from several countries in the former Soviet Union and Asia are currently being planned, which will probably be carried out with IAEA assistance, with a goal of having all fresh HEU repatriated by the end of 2005.

It is hoped that an initial shipment of spent Russian research reactor fuel (from either Uzbekistan, or the Vinca Institute in Serbia), will take place as soon as possible.