

IAEA's SUBPROGRAMME ON RESEARCH REACTORS: TECHNOLOGY AND NON-PROLIFERATION

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ABSTRACT

For nuclear research and technology development to continue to advance, research reactors (RRs) must be safely and reliably operated, adequately utilized, refurbished when necessary, provided with adequate proliferation-resistant fuel cycle services and safely decommissioned at the end of life.

The IAEA has established its competence in the area of RRs with a long history of assistance to Member States in improving their utilization, by taking the lead in the development of norms and codes of good practice for all aspects of the nuclear fuel cycle and in the planning and implementation of decommissioning. The IAEA Subprogramme on RRs is formulated to cover a broad range of RR issues and to promote the continued development of scientific research and technological development using RRs. Member States look to the IAEA for coordination of the worldwide effort in this area and for help in solving specific problems.

In this paper a description of the ongoing and planned activities under the IAEA's Subprogramme on RRs for the years 2007-2009 is presented. Special emphasis is put on new international collaborative undertakings, like the new IAEA's Technical Working Group on RRs.

1. Introduction

The IAEA coordinates and implements an array of activities that together provide broad support for RRs. As with other aspects of nuclear technology, RR activities within the IAEA are spread through diverse groups in different Departments. To ensure a common approach a Cross-Cutting Coordination Group on Research Reactors (CCCGR) has been established, with representatives from all departments actively supporting RR activities.

Utilization and application activities are generally lead from within the Department of Nuclear Applications (NA). With respect to RRs, NA is primarily carrying out IAEA activities to assist and advise Member States in assessing their needs for research and development in the nuclear sciences, as well in supporting their activities in specific fields.

Safety and Security aspects of RRs operation and decommissioning are handled by the Department of Nuclear Safety and Security (NS).

The technological, fuel cycle and operational aspects of RR management are supported by the Department of Nuclear Energy (NE). NE is primarily working to support RR organizations in their pursuit of often diverse strategic objectives within the context of modern RR operational constraints. Today RR operating organizations must overcome challenges such as the ongoing management of

ageing facilities, pressures for increase vigilance with respect to non proliferation, and shrinking resources (financial as well as human) while fulfilling an expanding role in support of nuclear technology development within an evolving “nuclear renaissance”.

In addition, the Department of Nuclear Safeguards is responsible for the control of the fissile material for RR and the Department of Technical Cooperation (TC) supports RR activities for the principal benefit of RRs in developing countries. TC is subsequently supported by NA, NS, and NE who assist in the development and implementation of relevant TC projects within their specific fields of expertise.

The Subprogramme on RRs is under IAEA’s Programme D on Nuclear Science. Implementation of the IAEA Subprogramme on RRs (IAEA code D.2) is shared between NE and NA while separate subprogrammes, managed by NS, deal with RR safety and security. In this paper, only the activities managed by NE and NA under the subprogramme on RRs are presented, including a complete description of the ongoing and planned activities for the years 2007-2009. Special emphasis is put on new international collaborative undertakings, like the IAEA’s Technical Working Group on RRs. The IAEA organization chart is presented in Fig. 1, the Subprogramme on RRs is implemented by the RRs Unit in the Division of Nuclear Fuel Cycle and Waste Technology and the Physics Section in the Division of Physical and Chemical Sciences.

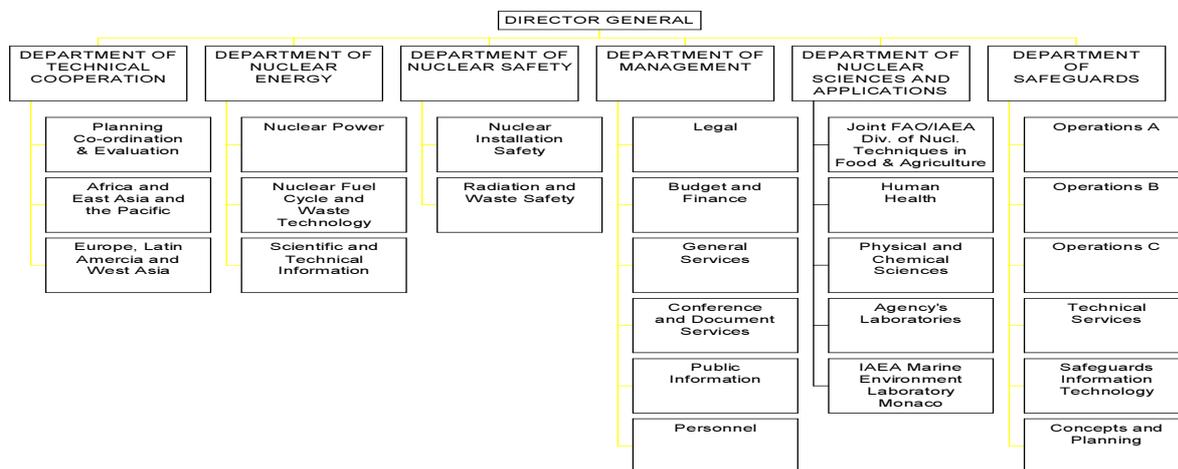


Fig. 1. IAEA organization chart

2. Subprogramme on RRs

For nuclear research and technology development to continue to advance, RRs must be safely and reliably operated, adequately utilized, refurbished when necessary, provided with adequate proliferation resistant fuel cycle services and safely decommissioned at the end of life. Moreover, since about 60% of the operating RRs in the world are over 30 years old, ageing core materials and the technology of ageing management are priority issues in the majority of Member States with aged RRs.

The IAEA has established its competence in the area of RRs with a long history of assistance to Member States in improving their utilization, by taking the lead in the development of norms and codes of good practice for all aspects of the nuclear fuel cycle and in the planning and implementation of decommissioning. This Subprogramme is formulated to cover a broad range of RR issues and to promote the continued development of scientific research and technological development using RRs. Member States look to the IAEA for coordination of the worldwide effort in this area and for help in solving specific problems.

From the traditional support of fundamental research and training, the focus of the Subprogramme has recently moved to helping facilities with strategic planning to increase use in more sustainable areas

such as isotope production and materials modification, in refurbishment and replacement of ageing equipment, in the management of increasing spent fuel inventories and in planning decommissioning. The Subprogramme supports regional and interregional thematic collaborations, networking and centres of excellence for enhanced utilization of RRs.

To contribute to non-proliferation efforts worldwide, support of RERTR and the programmes of returning of RR fuel to the country of origin has been strengthened. To address RR support needed for the evolutionary and innovative nuclear power reactors and fuel cycles, the subprogramme promotes international collaboration to assess projected needs, with a long term time horizon, for RRs on a global and regional basis.

Funding reductions and limited succession planning have strained available resources of a number of RRs, pressurising many facilities to pursue commercial activities to remain in operation. It is in this context that modern RRs are to be used to conduct advanced research in support of innovative nuclear development (in most cases to very aggressive schedules) and training. To support the scientific, educational and commercial demands being placed in present times on RRs, a new project addressing RR Operation, Maintenance, Availability and Reliability has been initiated in 2007.

The main objectives of the RRs Subprogramme are:

- To increase the capabilities of interested Member States to safely and reliably carry out scientific research and technology development at RRs, conduct ageing management, decommissioning, refurbishment and modernization; and
- To enhance the potential of interested Member States to plan new facilities when needed, to cope with RR fuel cycle issues and reduce proliferation risks by conversion from Highly Enriched Uranium (HEU) to Low Enriched Uranium (LEU) of RRs cores and targets used for radioisotope production, and to repatriate fuel to the country of origin.

3. Projects under the Subprogramme on RRs

Organization of the Subprogramme on RRs in projects is shown in Fig. 2.

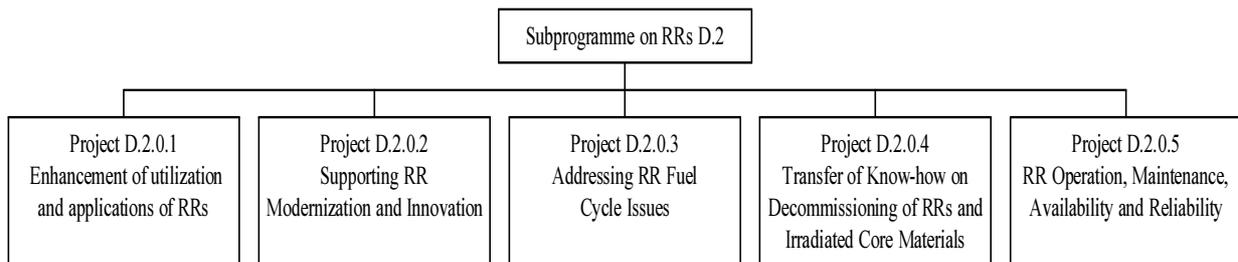


Fig. 2 Projects under the Subprogramme on RRs

A brief description of each one of the projects is given in the following paragraphs.

3.1. Project D.2.0.1: Enhancement of utilization and applications of RRs

RRs have played and continue to play a key role in the development of the peaceful uses of atomic energy. Their contribution to the education and training of scientists and engineers for the whole nuclear community is well documented. In addition they have played an important role in development of science and technology, in the production of isotopes for medicine and industry, in non-destructive testing of materials, in analytical studies, in the modification of materials, in research in various areas of science and in support of nuclear power programmes.

Existing RRs, especially in developing countries, should be supported on an individual level for example in radioisotope production, beam line applications, and analytical services as well as in regional or collaborative efforts in education and training. The sharing of resources will increase the utilization on the one hand and on the other hand pave the way for the decommissioning of under-utilized ageing reactors, without depleting knowledge base and human resources.

We give here an overview of this project formulated to cover the broad range of possible applications and to promote the continued development of scientific research and technological development using RRs.

The main objectives of this project are:

- To enhance RR utilization in Member States for many practical applications, such as isotope production, neutron radiography, neutron beam research and material characterization and testing consistent with RR features; and
- To increase cooperation between different RR centres.

Some of the activities proposed to be carried out under this project are:

- Develop a RR assessment methodology on strategic networking;
- Update RR Database (RRDB). Incorporate user need modification/changes;
- Organize a Technical Meeting (TM) on RR application for materials under high neutron fluence and particle flux in energy sector;
- Coordinate a Coordinated Research Project (CRP) on “Development, characterization and testing of materials using neutrons and complementary techniques” and “Development and application of the techniques of residual stress measurements in materials”;
- Organize a technical meeting on strategic planning and regional networking for sustainability;
- Provide technical support for the IAEA-TC projects involving utilization and applications of RRs;
- Support and participate in meetings pertinent to RRs and neutron based techniques;
- Prepare report on data acquisition and analysis for neutron beam line experiments; and
- Prepare a report on specific application of RRs.

In addition, publication of technical documents based on the output of CRPs and TMs will help in disseminating knowledge and capacity building for RR operators and users.

3.2. Project D.2.0.2: Supporting RR Modernization and Innovation

Member States, especially developing Member States, involved in planning or carrying out refurbishment and modernization of RRs often look to the IAEA for advice and assistance and to exchange information and ideas. Similarly, IAEA assistance is requested when new RRs or major innovative systems, such as in-core loops or cold sources, are being planned or constructed. Regional and interregional thematic collaborations, networking and centres of excellence are being increasingly considered worldwide as an appropriate way to enhance utilization of RRs. This project is designed to fulfil these needs by collecting and sharing relevant information, including best practices and lessons learned.

The main objective of this project is:

- To increase the competence of interested Member States to plan and implement large scale refurbishment and modernization of RRs, and to plan and implement construction of new RRs or major RR systems.

Some of the activities proposed to be carried out under this project are:

- Develop regional RR networks and centres of excellence;

- Provide advice and assistance as requested to RR planning, modernization or refurbishment;
- Hold international workshops on modernization and refurbishment of RRs;
- Coordinate a CRP on innovative methods in RR analysis (2008–2011); and
- Support TC projects on modernization and innovation.

3.3. Project D.2.0.3: Addressing RR Fuel Cycle Issues

The IAEA has been involved for more than twenty years in supporting international nuclear non-proliferation efforts associated with reducing the amount of HEU in international commerce. IAEA projects and activities have directly supported the RERTR programme, as well as directly associated efforts to return RR 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 RRs and RR spent fuel inventories that have been essential in planning and managing both RERTR and spent fuel return programmes. After the announcement of the Global Threat Reduction Initiative (GTRI) by United States Secretary of Energy Spencer Abraham on May 2004 at the IAEA headquarters in Vienna and following recommendations of the 2004 RERTR meeting, held in Vienna in November 2004, IAEA support of RERTR and the programmes of repatriation of RR fuel to the country of origin have been strengthened and a comprehensive number of new activities have been initiated in 2005 and 2006.

At the back end of the fuel cycle, hundreds of RRs worldwide, both operational and shut down but not yet decommissioned, are storing spent fuel on site. In many cases, this RR spent nuclear fuel (RRSNF) is old (more than 30 years) and physically degraded. Therefore the continued safe, reliable and economic handling, management and storage of RRSNF of all types, standard, failed and experimental, is a serious issue for almost all Member States with RRs. In particular, most RRSNF is aluminium clad which is particularly vulnerable to corrosion. Many Member States, especially those having RRs but no power reactors, are expressing concerns about final disposition of RR spent nuclear fuel. Non-proliferation and environmental concerns associated with RRSNF have become just as important, if not more so, as the above mentioned technical concerns. This project is designed to address these issues.

The main objective of this project is:

- To strengthen the capability of interested Member States having RRs to deal with all fuel cycle issues including fuel development, fabrication and qualification, mitigation of identified health, and environmental vulnerabilities associated with spent fuel management; and to promote conversion from HEU to LEU, repatriation of spent fuel to its country of origin, and regional solutions to the back end of the fuel cycle.

Some of the activities proposed to be carried out under this project are:

- Maintain a database on spent fuel from research and test reactors, publish summary statistics periodically;
- Provide advice and assistance as requested to RRs with corroded or otherwise degraded spent fuel;
- Support spent fuel assessment teams for the preparation for shipment of RR spent fuel;
- Update the RR core conversion guidebook to include conversion to high density U-Mo fuels;
- Prepare a technical document on good practices for the management and storage of RR spent fuel;
- Update the guidelines documents on the technical and administrative procedures required for the shipment of spent fuel;
- Support national projects on RR fuel and fuel cladding;
- Prepare a technical document on the economic aspects of the RR nuclear fuel cycle;
- Support activities related to RR conversion and return of RR spent fuel to the country of origin;

- Prepare a technical document on the use of LEU in accelerator driven subcritical assemblies;
- Coordinate an International Technical Working Group on RRs;
- Coordinate a CRP on small-scale, indigenous production of Mo-99 using LEU or neutron activation;
- Coordinate a CRP on conversion of miniature neutron source RRs (MNSR) to low enriched uranium (LEU);
- Evaluate RR support needed for the innovative nuclear power reactors and fuel cycles; and
- Prepare a technical document on good practices for water quality management at RRs.

3.4. Project D.2.0.4: Facilitating Transfer of Know-How on Decommissioning of Research Reactors and Irradiated Core Materials

A large number of RRs are approaching the end of their useful lifetime and become likely candidates for decommissioning. Within the broader range of nuclear facilities, the decommissioning of RRs presents some unique features including experimental devices, unusual materials, and often proximity to populated areas. A lot of RRs are situated in Member States not having adequate resources for the decommissioning of their reactors. Decommissioning is the inevitable legacy of operation of RRs and needs timely and effective management. This includes management of the materials that result from the decommissioning project. To this end, accurate assessments of the material arising from all sources are required and methods/technologies should be available for Member States to minimize arisings and any environmental impact from the wastes. In many instances the radiation damage mechanisms of core materials, especially after high fluences are poorly understood. With many RRs now beginning to decommission or undergoing extensive refurbishment, it has been pointed out that an opportunity to take samples from the core materials and to study their microstructures is being squandered. Besides providing valuable information for decommissioning waste management, the life extension of RRs and input for improved materials for new reactors, the promotion of information exchange and effective coordinated research effort in this area has the potential to increase the understanding of fundamental ageing mechanisms of reactor structural materials.

The main objectives of this project are:

- To increase the capability in interested Member States with RRs to plan and implement decommissioning; and
- To improve understanding of the ageing of irradiated materials and advanced materials for reactor core applications.

Some of the activities proposed to be carried out under this project are:

- Prepare a technical report on decommissioning of RRs and other small nuclear facilities under constrained resources;
- Prepare a technical document on how to make use of samples from the cores of decommissioning or refurbishing reactors to improve understanding of ageing irradiated core materials;
- Prepare a technical document on cost estimates for decommissioning of RRs;
- Prepare a technical report on pool side inspection of RR fuel; and
- Coordinate a CRP on ageing of irradiated reactor core materials.

3.5. Project D.2.0.5: Research reactor operation, maintenance, availability and reliability

Since the mid 1980's, investment in nuclear RR facilities and infrastructure has decreased significantly compared with earlier decades. Many older facilities have been decommissioned, permanently shutdown, or are faced with probable shutdown in the very near future. Funding reductions and limited succession planning have strained available resources, pressuring many facilities to pursue commercial activities to remain in operation. It is in this context that modern RRs are being tasked to conduct advanced research in support of innovative nuclear development (in most cases to very aggressive schedules) and training. To support the scientific, educational and commercial demands being placed

in present times on RRs, many are looking to optimize operations and maintenance activities to ensure the most cost effective completion of their assigned missions. Many Member States look to the IAEA for advice, ideas and information exchange on these topics. This project aims to fulfil these requests by documenting good practices and lessons learnt as an element for strengthening the operational management.

The main objective of this project is:

- To increase the competence of interested Member States to develop operations and/or maintenance plans and implement these plans to optimize facility availability and reliability.

Some of the activities proposed to be carried out under this project are:

- Prepare a technical document on RR availability and reliability;
- Prepare a technical report on RR quality management system development;
- Coordinate a CRP on on-line monitoring systems for RRs; and
- Support TC projects involving operation, maintenance, availability and reliability improvements.

4. Technical Working Group on Research Reactors (TWGRR)

The TWGRR, a new international collaborative undertaking under IAEA's Subprogramme D.2, will consist in a group of experts to provide advice and support programme implementation, reflecting a global network of excellence and expertise in the area of RRs.

4.1. Scope

The TWGRR will focus its work on activities related to all types of RRs, including critical assemblies, subcritical assemblies and pulsed reactors. Also included in the scope are facilities for: RR fuel fabrication, RR fuel development, RR fuel post irradiation and RR spent fuel storage. All managerial areas involved in the operation of the above listed types of facilities are included in the scope of the TWGRR. The TWGRR will give the necessary attention to all of its relevant aspects, including operation, utilization, nuclear fuel cycle, maintenance, refurbishment, modernization, quality assurance, new designs and decommissioning. The TWGRR will especially address the projected needs for RRs on a global and regional basis with a long-term time horizon. The scope of the TWGRR cuts across all IAEA organizational structures dealing with RRs.

4.2. Functions

The functions of the TWGRR are:

- To provide advice and guidance, and to marshal support in their countries for implementation of the IAEA's programmatic activities in the areas of RR operation, utilization, nuclear fuel cycle, maintenance, refurbishment, modernization, quality assurance, new designs and decommissioning;
- To provide a forum for information and knowledge sharing on national and international programmes development in the area of RR operation, utilization, nuclear fuel cycle, maintenance, refurbishment, modernization, quality assurance, new designs and decommissioning;
- To act as a link between the IAEA's activities in specific area and national scientific communities, delivering information from and to national communities;
- To provide advice on preparatory actions in Member States and the IAEA's activities in planning and implementing coordinated research projects, collaborative assessments and other activities as well as the review of the results on RR activities within their scope;
- To develop and/or review selected documents from the Nuclear Energy Series, assess existing gaps and advise on preparation of new ones, in the scope of their field of activity;

- To identify important topics for discussion at the Standing Advisory Group for Nuclear Energy (SAGNE) and contribute to status reports, technical meetings and topical conferences in the field of RRs;
- To provide guidance to member states in order to improve and optimize the utilization of RRs, in national, regional and extra regional contexts. When considered appropriated, to provide guidance in order to define actions for reactors that have been placed in shutdown condition;
- To identify relevant issues and topics which might increase cooperation among different RR centres, particularly in various regions of the world;
- To encourage and facilitate regional and international collaborative programmes in the construction and utilization of RRs, and to be a forum for discussion of issues related to impediments and challenges that can be faced by the concept of a regional RR park;
- To propose the realization of events that will work as a forum for the exchange of information among the participants in all areas indicated in 4.1. Such events include, technical meetings, workshops, international symposiums and conferences;
- To address the projected needs for RRs on a global and regional basis with a long-term time horizon; and
- To encourage participation of young professionals, as appropriate, in IAEA activities.

4.3. Membership

Members of the TWG on RRs shall be appointed by the Deputy Director General, for Nuclear Energy, following consultation with the respective national authorities or organizations.

Members of the TWG on RRs:

- Shall be recognized experts that worked with RRs having extensive links with national technical communities. There shall be appropriate representation on the Group from RR operators, fuel cycle, materials specialists, designers of RRs, researchers and users of RRs;
- Are to serve for a standard length of four years;
- Shall participate in the Group in their personal capacity and shall provide as appropriate views on national policies and strategies in the technical field; and
- May as appropriate bring experts to provide additional information and share experience in the meetings of the TWG.

The Deputy Director General of the Department of Nuclear Energy may from time to time also co-opt additional members and/or invite observers from other Member States and international or regional organizations on an ad-hoc or continuing basis.

4.4. Methods of Work and Deliverables

The TWG on RRs will determine its own methods of work, including preparation of its Agenda, establishment of special groups, keeping of records and other procedures, and report on its findings to SAGNE. The activity of the TWG on RRs between periodic meetings shall be coordinated by a Scientific Secretary taking into due consideration the relevant recommendations of the TWG and SAGNE. Following each meeting the TWG on RRs shall provide the Deputy Director General with a report on its achievements and recommendations. The report shall be also published on the WEB in a format and content agreeable to all members. The Chairman of the TWG shall communicate to SAGNE recommendations for strategic development or other important topics to be discussed at SAGNE meetings.

4.5. Meetings

The TWG on RRs will meet at regular intervals but no more than once in a year with each meeting lasting up to five working days. Extraordinary meetings may be called when required.

5. Conclusions

The IAEA subprogramme on RRs maintains the focus on the different facets of RRs for their effective utilization and management. In order to address increasingly important non-proliferation concerns, emphasis is put on the support of Member States' work in the framework of the GTRI on RR core conversion from HEU to LEU, conversion from HEU to LEU of targets used for radioisotope production, the repatriation of RR fuels to the country of origin, and the global clean out of RR fissile material, including experimental or exotic fuels and sources. To help achieving an enhanced utilization of RRs, the subprogramme supports the establishment of regional and interregional thematic collaborations, networking and centres of excellence. To address the issue of RR support for evolutionary and innovative nuclear power reactors and fuel cycles, the subprogramme promotes international collaboration to assess projected needs over the long term for RRs on a global and regional basis. To support the scientific, educational and commercial demands being placed at present on RRs, a new project on RR operation, maintenance, availability and reliability has been initiated in 2007.

The new TWGRR will provide a unique forum for information and knowledge sharing on national and international programmes in all technical areas of RR and will provide advice and guidance for implementation of the IAEA's programmatic activities in those areas.

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