IAEA ACTIVITIES IN OPERATION AND MAINTENANCE OF RESEARCH REACTORS

HYUNG KYOO KIM, RAM SHARMA
Research Reactor Section, Division of Nuclear Fuel Cycle and Waste Technology, Department of Nuclear Energy, International Atomic Energy Agency
1400 Vienna
Austria

Corresponding author: H.K.Kim@iaea.org

ABSTRACT

There are 246 operating research reactors globally, as of 2015, according to the International Atomic Energy Agency (IAEA) Research Reactor Database (RRDB). These reactors have a well-documented history of contributing to peaceful nuclear research and technology development, and have helped in the education and training of generations of scientists, reactor operators, and engineers. They are also used for basic research, radioisotope production, neutron radiography, neutron beam research, material characterization and testing, and other applications.
In fact, more than half of all operating research reactors are over forty years old and face concerns regarding ageing and obsolescence of equipment. The IAEA Research Reactor Section (RRS) works with Member States to optimize RR availability and reliability through shared operating experience as well as the development and implementation of operational and maintenance (O&M) plans, ageing management plans, training programs and international peer reviews. IAEA continues supporting MS, through Coordinated Research Projects and development of publications, development of research reactor ageing database (RRADB) and material property database (MPDB) to share knowledge about material ageing and available equipment and facility upgrades to sustain RR operability.
The RRS offers MS Operations and Maintenance Assessment of Research Reactors (OMARR), a peer-to-peer review to assist with improvement of operational and maintenance practices. Thus far, two facilities have used this opportunity, and another is planned for 2016. IAEA is establishing a specialized activity for conducting non-destructive examinations and in-service inspections at research reactors. Additionally, RRS is currently participating in several projects through the Technical Cooperation organization to assist individual and regional MS on specific projects.

1. Introduction

According to the Research Reactors Database [1], more than 50% of existing operating research reactors have been in operation for more than 40 years, with many of them exceeding their original design life. The majority of these reactors are challenged by ageing facilities and equipment, and obsolescence of equipment. The IAEA is leading several efforts to optimise RR availability and reliability through Coordinated Research Projects and sharing operating experience as well as the development of publication and implementation of operational and maintenance (O&M) plans, ageing management plans, training programs and international peer reviews. Additional O&M issues being addressed by MSs are fuel optimization, equipment modernization, modifications required due to security and safety requirement changes, and modifications aimed at increasing facility

reliability and availability. The Research Reactor Section (RRS) offers MSs Operations and Maintenance Assessment of Research Reactors (OMARR), a peer-to-peer review to assist with improvement of operational and maintenance practices. The IAEA is establishing a specialized activity for conducting non-destructive examination (NDE) and in-service inspection (ISI) at research reactors. Additionally, RRS is currently participating in several projects related to instrumentation upgrades, fuel upgrades, safety infrastructure support, and decommissioning planning through the Technical Cooperation organization to assist individual and regional MSs. This paper presents RRS activities to support MS with RR O&M.

2. Operation and Maintenance Assessment for RRs (OMARR) missions

OMARR stands for Operational and Maintenance Assessment of Research Reactors and its aim is to provide advice and assistance to Member States to improve their operational and maintenance (O&M) practises by peer to peer reviews thereby optimising availability, reliability and the application of human and financial resources throughout their facilities operational life cycle, from commissioning through to decommissioning.

OMARR, to be initiated in 2012, will be available to Operating Organizations in all Member States with research reactors (RRs) under construction, commissioning or in operation. Robust design, careful manufacture and sound construction are all prerequisites for RR sustainable availability and reliability. However, a high quality operational and maintenance programme ultimately depends on effective management, sound policies, procedures and practices, on comprehensive instructions, on adequate resources and on the capability of the O&M personnel. OMARR considers these aspects in assessing the effectiveness of a research reactor's O&M experience feedback programmes. The assessment considers the application of IAEA and international standards and related technical reports. Although these standards establish an essential basis for effective O&M practises, the incorporation of more detailed requirements in accordance with national or international good practices may also be necessary. Moreover, some special aspects might need to be assessed by experts on a case by case basis.

The IAEA Code of Conduct on the Safety of Research Reactors and the Optimization of Research Reactor Availability and Reliability Recommended Practices, IAEA Nuclear Energy Series, No. NP-T-5.4 document [2], cover the baseline for good practises in RR O&M. The OMARR guidelines, based on these two documents, provide overall guidance for the experts to ensure the consistency, and comprehensiveness of the assessment. This could also be used by the facility to prepare a self-assessment report on the effectiveness of its O&M experience feedback processes. It recommends the required expertise of the OMARR team members themselves and forms the bases of the assessment.

OMARR missions are performance oriented in that they accept different approaches to O&M management that represent good practices and may contribute to ensuring a good operational availability and reliability on the part of the operating organization. Recommendations and potential solutions are made on items of direct relevance to O&M with a principal aim to improve performance. While suggestions made could also enhance plant safety, these are considered a secondary, although positive outcome, more directly related to the objective of INSARR Missions. The OMARR service, focusing on O&M improvements, is one of a suite of complementary services offered by the IAEA for the research reactor community. The OMARR will consist of up to three missions: pre-OMARR Mission, main mission and follow up mission if requested by the facility.

It was decided to have two pathfinder missions to kick off the OMARR program, one on a

larger power RR and the second on a smaller facility. Two pathfinder OMARR missions have been completed and the process is now available for member states to take full advantage of this peer to peer assessment. NIST was the first to respond and is a 20MW reactor; LENA 250kW, was the first small facility to express a desire for an OMARR mission.

3. Building Capacity in conducting Non-destructive Examination and In-service at Research Reactors

In-service inspection (ISI), which is performed using non-destructive examination (NDE), is an important measure for assurance of equipment integrity and the avoidance of failure and thus a key tool in the management of research reactor safety and lifetime. The IAEA has consistently supported the operation and maintenance programmes of research reactors, particularly in the formulation and implementation of ageing management and surveillance programmes, which include the regular examination of structures, systems and components of reactor facilities for potential degradation to verify reactor safety and maintain optimal availability.

A Coordinated Research Project “Application of Non-Destructive Testing and In-Service Inspection to Research Reactors” was organized and successfully completed during 1995–2001 and eponymous guideline (TECDOC-1263) for NDE/ISI as part of an ageing management and surveillance programme of research reactors was released in 2001 [3]:

- NDE methodology for use in ISI of research reactor of various types;
- Guidance for the preparation of appropriate programmes/plans/schedule, including documentation, of such ISI and for their implementation;
- Appropriate methods and procedures to be used in ISI of research reactors of various types;
- Guidance on the requirements for qualification and certification of NDE personnel involved in ISI of research reactors.

The IAEA has been preparing to establish and promote a specialized activity for conducting NDE/ISI at applicant reactors. The necessary equipment had been procured to assist member states in the performance of NDE/ISI. The IAEA can assist by providing experts to train local staff, promulgate best practices and improve ageing management and surveillance programmes using procured equipment.

4. Coordinated Research Project (CRP)

4.1. CRP T34003: Condition Monitoring and Incipient Failure Detection of Rotating Equipment in Research Reactors

Online Monitoring (OLM) technologies have been successfully implemented in power reactors for a number of applications such as condition based calibration, performance monitoring of process instrumentation systems, detection of process anomalies, and distinguishing between process problems/effects and instrumentation/sensor issues. In spite of great advances in OLM technologies for power reactors, research reactors are yet to benefit from all that OLM can offer. The experience from these implementations has stimulated an interest in the research reactor community to use OLM for improved maintenance regimes, safety and reliability of research reactors, and to contribute to their life extension and aging management objectives.

This CRP T34003 is the second in a series involving on-line monitoring techniques. The first

was CRP T34001 “Improved Instrumentation and Control (I&C) Maintenance Techniques for Research Reactors using the Plant Computer” implemented 2012 to 2015. As research reactors continue to operate, there is increasing pressure for improved asset management programs that involve advanced predictive maintenance technologies to manage equipment degradation and aging. For example, advanced technologies are now available for predictive maintenance of motors, compressors, fans, and turbines and also for on-line condition monitoring of plant instrumentation. These methods have been used successfully for numerous applications in industrial processes such as equipment health and condition monitoring, reliability assessment, aging management, life extension, troubleshooting, safety improvement, and process optimization. Although some research reactors have taken advantage of these developments, significant improvements are still needed toward a systematic implementation of these technologies at research reactors.

The overall objectives of this CRP are to avoid lengthy and costly shutdowns, and to promote safe and reliable operation and lifetime extension through monitoring the health of key rotating components.

Condition monitoring techniques can provide various types of information that can be used to better plan and schedule maintenance activities. Planned activities can be carried out in a much more efficient, and safe manner than activities carried out in response to an unknown failure event. Unforeseen failures and their unscheduled repair place significant stress on plant staff and have the potential to adversely affect related plant equipment and plant safety. Knowledge of poor equipment condition may be used to reduce the load on that equipment such that the risk of further damage is minimized until the next maintenance opportunity, and the consequent maintenance time, and direct costs are reduced. Condition monitoring techniques are equally important to identify normal conditions. Indications of the proper equipment condition can be combined with other information to plan maintenance activities only when they are necessary.

4.2. CRP T34002: Establishment of a Material Properties Database for Irradiated Core Structural Components

The CRP will provide a forum for the establishment of a material properties database for irradiated core structural components. A structured database is required to understand the material behaviour in core components of research reactors for their continued safe operation and lifetime extension of ageing research reactors. The database can be used by research reactor operators and regulators to help predict ageing related degradation. This would be useful to minimize unpredicted failures of core components and to mitigate lengthy and costly shutdowns.

The database will be a compilation of data on material degradation from research reactors operator input, comprehensive literature reviews and experimental data from research reactor. Moreover, the CRP will specify further activities needed to address the identified gaps of the database for potential follow-on activities required by Member States. The database will be provided by IAEA to interested end-users Member States with controlled access.

Continued safe and efficient operation depends amongst others on the predictability of structural materials behaviour of major components such as reactor vessel and core support structures, many of which are difficult to replace. Management of the ageing process requires predictions of the behaviour of materials subjected to irradiation. Ageing management of research reactors includes a comprehensive effort of engineering, operation and maintenance strategy to ensure reliability and availability of structures, systems and components (SSC) important to safety. Age-related degradation mechanisms can result in unplanned outages as well as lengthy shutdowns and the need for additional regulatory activity, which can be

prevented by utilising available data and implementation of appropriate maintenance and surveillance programmes. In many instances data for the radiation-induced changes of research reactor core materials resulting from exposure to very high neutron fluences are not generally available because the materials and operating conditions are diverse and specific. Therefore, effective sharing of experimental results related to the core-structural materials is needed in order to evaluate the reliability of ageing reactor core components. Moreover, safe operation, reliability, and availability of the RR irradiation services has to be assured as older, heavily utilized facilities may be required to extend their operation to provide these services. Consequently, the uncertainties in the core structural materials behaviour need to be reduced for timely action for improvements and/or replacement of components. Furthermore, predicting the lifetime of irreplaceable components will contribute considerably to the managerial process of decision making on operation schedules.

The overall objective of the CRP is to collect, review and assess existing data of the relevant materials properties and operating experience with research reactors worldwide for inclusion in a Research Reactor Components and Material Properties Database that can be used by research reactor operators to help predict ageing related degradation in order to avoid lengthy and costly shutdowns, and to promote safe and reliable operation and lifetime extension.

5. Conclusions

The activities outlined in this paper represent the current body of work for Operational and Maintenance issues in the Research Reactor Section. In addition to the above there are IAEA organised workshops and technical meetings on a variety of O&M issues such as aging management, continued work on the aging database and support for RR safety work in O&M areas (with the Nuclear Safety Research Reactor Safety Section).

In practice, an ageing management programme is accomplished by coordinating existing programmes, including maintenance, periodic testing and inspection and periodic safety reviews, as well as applying good operational practices, and incorporating lessons learned from operating experience.

The IAEA has consistently supported the operation and maintenance programmes of research reactors, particularly in the formulation and implementation of ageing management and surveillance programmes, which include the regular examination of structures, systems and components of reactor facilities for potential degradation to verify reactor safety and maintain optimal availability.

6. References

[1] International Atomic Energy Agency, Research Reactor Database: https://nucleus.iaea.org/RRDB/RR/ReactorSearch.asp

[2] International Atomic Energy Agency, Optimization of Research Reactor Availability and Reliability: Recommended Practices, Nuclear Energy Series NP-T-5.4, IAEA, 2008

[3] International Atomic Energy Agency, Application of Non-destructive Testing and In-service Inspection to Research Reactors, TECDOC-1262, IAEA, 2001