IAEA SUB-PROGRAMME ON RESEARCH REACTOR SAFETY AND STRATEGY FOR ITS IMPLEMENTATION

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Abstract

The IAEA has greatly contributed through its programmes and activities to the records of safe operation of research reactors worldwide. Since 2006, the activities of the IAEA sub-programme on research reactor safety have been mainly focusing on supporting Member States (MSs) to enhance the safety of their research reactors mainly through the application of the Code of Conduct on the Safety of Research Reactors for the management of the safety of these facilities. In doing so, the key part of the implementation strategy of the activities included the development of Safety Standards and supporting documents. At present, the corpus of Safety Standards for research reactors has reached maturity. Safety review services, based on the IAEA Safety Standards, were provided, in the field, through the implementation of Integrated Safety Assessment (INSARR) missions and other safety review and expert missions. Since 2006, about one hundred missions were conducted to research reactors worldwide. Fact finding missions were also implemented by the IAEA in MSs establishing their first research reactors in order to identify gaps and define actions to assist them building the necessary technical and safety infrastructures. An important part of the implementation strategy for the IAEA safety enhancement plan included the fostering of regional and international cooperation to enhance operational safety and regulatory supervision of research reactors, and support for the establishment and functioning of regional advisory safety committees and nuclear safety networks. International exchange of information and sharing of operating experience feedback are essential contributors for enhancing safety and have been promoted through the IAEA web-based incident reporting system for research reactors IRSRR which ensures the collection of data and information on events and the dissemination of lessons learned from their analysis. Existing inconsistencies in the safety demonstrations for research reactors worldwide were addressed by two Coordinated Research Projects to promote the use of research results in safety assessment and the harmonization of approaches and data used in safety analysis of research reactors. The implementation of the above mentioned activities has resulted in a substantial progress in enhancing the safety of research reactors worldwide. This paper presents a brief summary of recent progress and achievements for improving research reactor safety, outlines the Agency's strategy for further improvement and discusses the approach for implementation of the strategy.

1. INTRODUCTION

Research reactors (RRs) have supported development and application of nuclear science and technology and education and training of nuclear scientists and engineers since the first controlled chain reaction. The benefits of RRs extend to applications of nuclear technology in many fields, including the production of medical radioisotopes. Safety and utilization of RRs are complementary; sustainable or increased utilization of RRs depends upon safe operation. Continued safe operation of RRs is essential to their future and the future of the nuclear sector. For Member States (MSs) that are embarking on a new nuclear power programme, the RR should be an important resource in building the national nuclear safety infrastructure needed for nuclear power. The RR organization and the associated regulatory body are likely the home of much of the nuclear expertise in the country, and the RR should be the centrepiece of the country's nuclear research, education and training activity.

In the past five years, several sources of information including feedback from safety review missions, insights form the MSs self-assessments and feedback from incidents which occurred in RRs and other nuclear installations, have been used by the Agency in order to identify common safety issues for RRs worldwide. The main identified safety issues are the following:

— The safety documentation (SAR, OLCs and emergency plans) are out of date or incomplete for many RRs;
— The regulatory supervision needs further improvements, in particular concerning the review of safety submittals and inspection programmes;
— The operational radiation protection programmes for many RRs are not adequate concerning the radiological zoning, the contamination monitoring and the operating procedures;
— The role and responsibilities of the safety committees need to be enhanced in many operating organizations;
— Aging management programmes are not effectively implemented and decommissioning plans are not established for many RRs;
— Important disparities exist in the safety demonstrations for similar RRs, related mainly to the selection of the design basis accidents, to the safety analysis methodologies and to the data used for the evaluation of radiological consequences of the accidents;
— Inadequate safety and regulatory infrastructures in some MSs acquiring their first RR.

The IAEA sub-programme on RR safety and its implementation strategy were updated to reflect the insights into the status of RR safety and the common safety issues above mentioned. This sub-programme and its implementation strategy, outlined in this paper, were dedicated to reach the objectives of the Agency's Medium Term Strategy for 2006-2011, which are related to continued strengthening of international nuclear safety and security instruments and promotion of global acceptance of international safety standards, and the IAEA Fundamental Safety Principles [1], in particular, those related to the role of government, leadership and management for safety, radiation protection, prevention of accidents and emergency preparedness and response. Accordingly, the top-level element of the strategy is to work with the governments, regulatory bodies and operating organizations in MSs to enhance the research reactor safety, to ensure widespread and effective application of the Code of Conduct and the IAEA Safety Standards relevant to RRs [2-14].

2. PROGRESS IN ENHANCEMENT OF RESEARCH REACTOR SAFETY

2.1. The Code of Conduct on the Safety of Research Reactors

The Code of Conduct is the principal international legal instrument applying to RR safety. It sets forth the desirable attributes for management of RR safety and provides comprehensive guidance for the State, the regulatory body and the operating organization for the actions needed to achieve a high level of RR safety. The Board of Governors adopted the Code of Conduct in March 2004. Subsequent General Conference resolutions have continued to support the Code and its application by MSs. The Code of Conduct is now widely known and accepted as a principal source of guidance for management of RR safety.

Four regional workshops on application of the Code of Conduct were conducted in 2006 and 2007 in preparation for the first periodic International Meeting on this subject (Vienna, October 2008). At each of these meetings, a tutorial on the Code and the supporting Safety Standards was provided, a self-assessment of the status of its application was presented and discussed by the participants in working groups and priority needs for assistance were identified. At the 2008 International Meeting, the thirty-two participating MSs made presentations based on a self-assessment of the status of implementation of the Code in their countries. Most MSs reported that they were in compliance with most of the recommendations of the Code. However, several areas were identified as needing improvement, including: regulatory supervision; periodic safety review; the safety analysis report; financial resources and qualified human resources; safety culture and human factors;

quality assurance; emergency preparedness; criteria for extended shutdown; and decommissioning. The delegates recommended that additional international or regional meetings be arranged with a focus on particular issues identified in this meeting and others as the need appears.

Following this recommendation, the IAEA organized during 2008-2010 fifteen regional meetings addressing common safety issues and specific issues for RRs operating in the different regions of the world. These meetings resulted in improved awareness of the operators and regulators on different safety topics, including safety culture, periodic safety review, ageing management and operational radiation protection, and helped the participating MSs define action plans for improving the safety of their facilities.

The Second International meeting on Application of the Code of Conduct was held in Vienna in May 2011 and attended by delegates from thirty-one MSs. The presentations made during this meeting and the associated discussions showed that globally the situation with respect to application of the Code of Conduct appears to be much the same as was reported at the previous meeting, although there has been progress in some areas. Even though the Code is a non-binding document, a commitment on the part of the MSs to apply it is needed. Such commitment could be included in the MSs' national statement at the General Conference of the IAEA.

2.2. Research Reactor Safety Standards

The Code of Conduct does not provide detailed technical guidance. To provide such guidance, the Agency has developed (and is developing) Safety Standards and other safety documents that provide comprehensive and consistent requirements that shall be met and guidance on the means of meeting them to ensure RR safety. There are numerous Safety Standards that cover general topics that are applicable to RRs. Among these are the Safety Standards for Legal and Governmental Infrastructure, Management Systems, Site Evaluation and Emergency Preparedness. The corpus of specific Safety Standards for RRs is now mature and nearing completion[1]. Safety Requirements, NS-R-4, *Safety of Research Reactors,* and seven Safety Guides [4-10] are now published; three additional Safety Guides [11-13] are in publication and one Safety Guide is in preparation [14]. Several Safety Reports and TECDOCs providing more detailed technical information are also available on the IAEA web site.

2.3. Safety Review Missions and sharing of operating experience

The Safety Standards define criteria upon which the IAEA and MSs may assess the safety of RRs. Since 2006, there were about one hundred safety review missions to RRs, including those under Project and Supply Agreements (PSAs)[2] with the Agency. These missions have provided essential insights into the status of safety at the reactors involved and provided recommendations which resulted in safety improvements.

The Agency has operated the Incident Reporting System for Research Reactors (IRSRR) for several years. Since 2004, the number of MSs participating in the system has increased from 35 to 53. The number of reported incidents in the last five years has increased by about 50 %. The IRSRR database structure was revised in 2009 and established on a common computer platform with the nuclear power plant and fuel cycle facility reporting systems. The reports offer useful insights into the causes of incidents, the majority of which

[1] For current information on Safety Standards, see the document *Long Term Structure of the IAEA Safety Standards and Current Status* available on the IAEA Web site.
[2] At present, there are 35 RRs in 28 MSs under PSAs.

are the result of aging of the facilities or human errors. Regular meetings are organized by the IAEA for exchange of operating experience and lessons learned from events.

3. STRATEGY FOR ENHANCING RESEARCH REACTOR SAFETY

Ensuring effective application of the Code of Conduct and IAEA Safety Standards is the overarching element of the Agency's strategy for strengthening RR safety. For States that are Contracting Parties of the Convention on Nuclear Safety (CNS), effective application of the Code of Conduct will provide an important step towards compliance with their obligations under the CNS, since the operative provisions of the CNS and the Code are very similar in content.

Ensuring that all MSs having an existing RR and those planning to build their first one have an effective safety infrastructure, including an independent and competent regulatory body with the necessary financial and human resources, is required to satisfy one of the fundamental safety principles and is a major element of the Agency's strategy. The objective is to ensure that appropriate laws and regulations are in place so that the regulatory body is independent of organizations having responsibility for development or promotion of nuclear technology and that the regulatory body has adequate authority and resources to fulfil its mandate.

A related element of the Agency's strategy is to build the capability of the regulatory body in all of its functions. Strengthening the technical capability and attitudes of the regulatory staff are key objectives, which will involve education and training activities and fostering regional collaboration in regulatory activities.

While RR safety is the sovereign responsibility of each MS, through its operating organization and regulatory body, monitoring of both the operational and regulatory aspects of RR safety will continue to be a major component of the Agency's strategy. The importance of safety review missions to observe and assess RR safety in the field cannot be over-emphasized. Field work is necessary to validate MSs' self-assessments of application of the Code of Conduct and Safety Standards, to provide an independent assessment of RR safety and help them to resolve safety issues. It is also an efficient tool to get feedback for improving the IAEA Safety Standards and to adapt the activities of the Agency to the needs of MSs.

Promoting improved networking and more efficient exchange of operating experience and good practices for RRs is another element of the Agency's strategy. The objective is to ensure the exchange of operating experience, incidents, lessons learned and good practices from all nuclear installations, including nuclear power plants and fuel cycle facilities, in addition to research reactors.

Security of RRs is becoming an increasingly important matter and Agency activities in this area are increasing. Maintaining a balance between safety and security is an important consideration in the RR safety strategy. It is necessary that a synergy between security and safety interests be maintained, and that safety be taken into account as early as possible in security-related projects. Agency activities covering safety and security aspects will continue to help MSs achieve this goal.

4. IMPLEMENTATION OF THE STRATEGY

4.1. Approach to implementation

Implementation of the strategy for enhancing RR safety will continue to include working at the national level with both the operating organizations and regulatory bodies in the MSs. However, it will emphasize improving the legal infrastructure and developing the capabilities of the regulatory body, with the intent that a more capable and effective regulatory body can drive improvement of the safety performance of the operating

organization. In most cases, improvement of the knowledge, skills and attitudes of the regulatory staff is needed to improve regulatory effectiveness. Emphasis will be placed on 'coaching' missions focused on building capabilities, as well as support through education and training activities. In addition, field services such as INSARR[3] and other safety review and assistance missions will continue to be provided to MSs. However, a guiding principle will be that the MS must provide a self-assessment prior to a safety review mission. Similarly, the MS must demonstrate effort towards solving problems for which assistance is requested.

Improved international and regional networking to ensure feedback of operating experience, lessons learned and good practices will be implemented by continuation of international conferences, meetings on application of the Code of Conduct, regional meetings and training events addressing specific safety issues of regional importance. Regional networking will also be used to improve the capabilities of regulatory bodies, and to provide regional expert advisory groups, such as a regional safety committee, to augment national resources. Networking resources such as the Research Reactor Information Network (RRIN) and the IRSRR will enhance sharing of knowledge and experience within the RR community, and to reduce the isolation of small operating organizations and regulatory authorities

All MSs eligible for Technical Cooperation (TC) having existing RRs or planning new ones will be encouraged to establish a suitable TC project focused on development of the safety infrastructure and enhancing RR safety through safety missions and regional education and training activities.

4.2. Ensuring effective application of the Code of Conduct and IAEA Safety Standards

While the Code of Conduct is now widely known and accepted as a principal source of guidance for management of RRs, there remains a need for continued assistance to MSs to ensure effective application of the Code. A continuing series of regional meetings and workshops will be organized to examine progress, exchange experience and address particular areas of difficulty. The emphasis in these meetings will be on building regional capability and cooperation. There are many general and specific Safety Standards that are applicable to RRs. A continuing effort to review and revise as necessary the existing Standards and to produce new Standards is required to ensure that these documents reflect current international best practices and address the topics needed to enhance RR safety.

Many MSs that are also Contracting Parties to the CNS have voluntarily reported on RRs in their national reports to the triennial review meetings. Several MSs that have only RRs and no nuclear power plants have become Contracting Parties. The Agency will encourage all MSs having RRs to do so. Participation in the review processes of the CNS will help MSs to view research reactor safety in a broader context and open up new opportunities for exchange of experience and information, especially with States having large nuclear programmes. Becoming a Contracting Party to the CNS is especially important for MSs considering embarking on a new nuclear power programme.

4.3. Monitoring and enhancing research reactor safety

The INSARR safety review service, provided at the request of a MS, will continue to provide a comprehensive peer review and assessment of safety at a RR. Self-assessments, both within the operating organizations and the regulatory authorities, developing effective corrective actions and developing strategies to improve operational safety performance will be key points. The INSARR database will be updated to improve sharing of information and experiences. Analysis of data from INSARR missions, which is intended to identify generic

[3] INSARR: Integrated Safety Assessment of Research Reactors.

safety issues and trends and to communicate best practices, will be conducted on a periodic basis. This information will be made available internationally.

The Agency has a special mandate with respect to RRs under PSA, which generally require that a MS receiving assistance to acquire and/or operate a RR or its fuel apply the Agency's health and safety standards and measures as specified in the agreement. While many 'agreement reactors' have received safety review missions regularly, scheduled missions to ensure that operators are fully implementing the health and safety measures specified in the agreements should become the norm. In addition, the Agency will continue to conduct periodic meetings of 'agreement reactor' operators. These meetings provide a forum to discuss and share operational experience and safety insights and formulate suggestions for more effective mutual assistance and Agency support.

4.4. Building international and regional cooperation in safety

Regional cooperation among MSs can be an effective means of dealing with the challenges facing the RR community. Regional and international cooperation can have direct safety implications through maximizing the availability of financial resources, helping to maintain the professionalism and qualification of operating personnel, and promoting development of more effective regulatory bodies. Regional cooperation in particular allows identification of common safety issues and optimization of resources which could be facilitated by geographic and cultural proximity. Development of regional and international cooperation will continue to be a major goal of future activities.

Establishment of regional networks of experts to provide advice on safety issues will be encouraged and facilitated. Such expert networks can provide a technical resource to the operating organizations and their safety committees or to the regulatory bodies (with due attention to avoiding conflicts-of-interest) and help compensate for limitations of technical expertise available in a MS. The IAEA facilitated the establishment of regional advisory safety committees with clear mandates in Africa, Eastern Europe and Latin America regions, and initiated the creation of a regional advisory committee for RRs in Asia.

Sharing experience, reporting incidents and operational events, following-up to assure that events are properly analysed and that the lessons learned are disseminated throughout the nuclear community are essential to improving safety. The principal mechanisms for sharing experience are periodic regional and international meetings, networks organized for information exchange and databases of mission results. To improve and broaden sharing of experience, MSs will be encouraged to network with appropriate existing international organizations, such as the International Standards Organization (ISO), regional associations of regulators, such as the Western European Nuclear Regulators Association (WENRA) and regional safety information networks, such as the Asian Nuclear Safety Network (ANSN).

The IRSRR will continue to be an important mechanism for MSs to effectively and efficiently share operating experience and lessons learned. Establishment of national systems for reporting, analysing and disseminating lessons learned will be promoted at regional meetings, and during the biennial meetings of IRSRR national coordinators.

Monitoring and enhancement of RR safety requires engagement of competent technical experts familiar with the IAEA Safety Standards, especially in the field of design, operation, experiments, safety analysis and regulation. Very often the availability of such qualified experts cannot be ensured. In addition there is often a need to improve their knowledge of the Fundamental Safety Principles and Safety Standards. Thus, there is a need for continued involvement of the Agency to effectively and timely implement the strategy outlined above, and to effectively promote the application of the Safety Standards.

TC projects facilitate funding of safety review missions for the benefit of MSs. Establishment of safety-related TC projects will be encouraged and support of these projects will be enhanced.

5. IMPLEMENTATION OF ACTIVITIES ON RRS SAFETY ISSUES

The IAEA activities were adapted progressively to address the identified common safety issues for RRs. Since 2006, the work done in relation to these issues included eighteen technical meetings and thirty one regional and interregional training workshops with a focus on:

— Regulatory supervision and inspection programmes;
— Safety analysis and validation of computer codes;
— Safety of experiments;
— Safety of reactor core conversion from HEU to LEU;
— Safety culture, human factors;
— Integrated management system;
— Preparation, review and assessment of safety documents;
— Aging management and periodic safety reviews;
— Operational radiation protection programmes;
— Training and qualification of operating personnel;
— Emergency planning;
— Synergy between safety and security;
— Decommissioning plans and transitions between operation and decommissioning;
— Establishment of a new research reactor.

In addition, the IAEA implemented the following Coordinated Research Projects (CRPs):

— Safety significance of Postulated Initiating Events for different research reactor types and assessment of analytical tools (completed in 2007);
— Modelling and analysis of radio nuclides transport and source term evaluation within containment/confinement and release to the environment, for research reactors (completed in 2010).

A third CRP is ongoing on benchmark of neutronic and thermal-hydraulic computational methods and tools for safety analysis of research reactors.

6. SUMMARY AND CONCLUSIONS

The analysis of the data and information derived from various IAEA activities has resulted in identification of main safety issues and trends common to RRs and to the definition of activities more relevant to MSs' needs.

Substantial progress has been made in enhancing the safety of RRs. The Code of Conduct on the Safety of Research Reactors is now widely known and accepted as a principal source of guidance for the management of RR safety. Most MSs reported that they are in substantial compliance with the recommendations in the Code of Conduct, and the areas of difficulty have been identified. The corpus of Safety Standards for RRs has reached maturity. Going forward, the Agency's strategy for continued enhancement of RR safety includes these principal elements:

— Complete and maintain the Code of Conduct and Safety Standards, promote their application and provide assistance to MSs in their application, for example by means of "coaching missions", focussed on helping MSs to solve specific safety problems;
— Continue the programme of regional meetings and triennial International Meetings on application of the Code of Conduct, with emphasis on exchange of experience and assistance in addressing difficulties in applying the Code;
— Continue and enhance field monitoring of RR safety, including working with both operating organizations and regulatory bodies, through INSARR safety reviews and other safety missions, with the objective of improving the RR operational safety and their regulatory oversight at the national and regional levels;
— Assist MSs in establishing the technical and safety infrastructures needed for building and operating their first RR;
— Promote international and regional cooperation in all aspects of RR safety and related safety infrastructure, including consolidation of facilities, formation of regional expert groups to provide advice on safety matters, and networking with regional and international bodies;
— Continue to provide mechanisms and forums, such as the INSARR database, IRSRR, and various meetings for sharing of experience; and
— Ensure synergy between security and safety to ensure that safety is taken into account in security-related projects.

These measures should lead to continued and accelerated progress in enhancing RR safety by addressing the safety challenges facing the research reactor community.

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