XA0102803

IAEA-CN-82/67

SAFETY OF RESEARCH REACTORS-A REGULATOR'S PERSPECTIVE

RAHMAN, M. S.
Pakistan Nuclear Regulatory Authority
P. O. Box No. 1912
Islamabad, PAKISTAN
Fax: +92519204112; Email: pnrb@isb.comsats.net.pk

Abstract

Due to historical reasons research reactors have received less regulatory attention in the world than nuclear power plants. This has given rise to several safety issues which, if not addressed immediately, may result in an undesirable situation. However, in Pakistan, research reactors and power reactors have received due attention from the regulatory authority. The Pakistan Research Reactor-1 has been under regulatory surveillance since 1965, the year of its commissioning. The second reactor has also undergone all the safety reviews and checks mandated by the licensing procedures. A brief description of the regulatory framework, the several safety reviews carried out have been briefly described in this paper. Significant activities of the regulatory authority have also been described in verifying the safety of research reactors in Pakistan along with the future activities. The views of the Pakistani regulatory authority on the specific issues identified by the IAEA have been presented along with specific recommendations to the IAEA. We are of the opinion that there are more Member States operating nuclear research reactors than nuclear power plants. Therefore, there should be more emphasis on the research reactor safety, which somehow has not been the case. In several recommendations made to the IAEA on the specific safety issues the emphasis has been, in general, to have a similar documentation and approach for maintaining and verifying operational safety at research reactors as is currently available for nuclear power reactors and may be planned for nuclear fuel cycle facilities.

1. INTRODUCTION

The pro-environment movements of the seventies and the accidents at Three Mile Island and Chernobyl compelled the nuclear industry, national governments and international agencies to focus their attention on nuclear power plant safety. As a consequence the research reactors received less attention than they deserved. Similarly, the nuclear fuel cycle facilities also got less attention. However, after the Tokaimura incident these facilities are now getting more attention. The nuclear industry and the IAEA should not wait for an accident in a research reactor to redefine its priorities and then look into the safety of research reactors along with the fuel cycle facilities.

In Pakistan the regulatory authority (RA), DNSRP has always accorded due importance to research reactor safety. Although it had a relatively large task of licensing of the first PWR but the research reactors had been under active regulatory surveillance all the time.

2. STATUS OF RESEARCH REACTOR SAFETY IN PAKISTAN

Pakistan has two research reactors located at the Pakistan Institute of Nuclear Science and Technology (PINSTECH) at Nilore Islamabad. The first reactor, PARR-1 was commissioned in 1965. It is a swimming pool type reactor. Originally its power was 5 MW and it used highly enriched uranium (HEU) fuel. In 1990, the HEU fuel was replaced by Low Enriched Uranium (LEU) fuel and the reactor power was raised to 9 MW. In 1985, the instrumentation and control of the reactor including its control panel were replaced due to obsolescence. In the year 2000, a formal operating license allowing the licensee to operate PARR-1 at 10 MW was issued. The second research reactor is a miniature neutron source reactor (MNSR) of 27 KW. Operation License to PARR-2 was issued in 1993. PARR-2 is mainly used for operator training and neutron activation analysis and has no significant operational safety problems.

On the other hand, in PARR-1 the issue of obsolescence of equipment and structures was faced. In the mid eighties, the licensee initiated a program for replacement of old equipment with those that provided increased operational flexibility, reliability and testability. As the philosophy of I&C was not changed, therefore a revision of FSAR was not required by DNSRP. The design of the new equipment was compared with the specifications of the previous ones. DNSRP approved the new system and also witnessed the installation and commissioning of the replaced equipment. The replacement of obsolete equipment was completed in the end of 1985.

However, the licensee continued to face problems due to ageing structures such as leakage from the reactor pool and inclusion of debris from the pool construction material in the primary coolant. These were causing operational and safety problems. The licensee also had to convert from HEU to LEU fuel according to international requirements. Accordingly, the licensee decided to convert HEU to LEU fuel and to install a stainless steel liner in the reactor coolant circuit including the pool and hold up tank. In addition, extensive repair work was carried out on the reactor containment building. An emergency core cooling system was also installed. In view of the extensive upgrading, the licensee was asked to submit a revised FSAR.

The licensee prepared a revised FSAR and presented a case for allowing operation at a maximum power of 9 MW. DNSRP reviewed the FSAR and witnessed the installation of the liner, other safety related equipment and fabrication of LEU fuel in China. In addition, DNSRP had several control (hold) points in the commissioning process such as approach to criticality and during ascension of power in steps. DNSRP allowed progression from one stage to the next only when it was satisfied. After completion of the commissioning the licensee was permitted to operate PARR-1 at a maximum power of 9 MW. Recently, the licensee applied for permission to raise the power to 10 MW. A revised FSAR was submitted by the licensee, which was reviewed and approved by DNSRP. A formal operation license was issued to the licensee to operate PARR-1 at a maximum power of 10 MW. As a result of the above, the licensee has been able to significantly improve the safety level of PARR-1.

A regulatory framework and oversight has existed for research reactors since PARR-1 was commissioned in 1965. The nuclear regulatory authority has been evolving since then and various regulatory bodies of the time have maintained a regulatory surveillance and have licensed the supervisors and operators responsible to manipulate the controls of research reactors. With the passage of time this frame work and oversight has become more formal and documented. Procedures for the licensing of research reactors and operating personnel have been in place and rigorously followed and enforced. DNSRP as part of its surveillance program conducts regulatory inspections at specified intervals and also when an unusual event occurs. Both the research reactors are in use and there is apparently no immediate need for preparing procedures defining safety precautions and preservation measures to be taken during long shutdowns. However, DNSRP would be asking the licensee to start work on such procedures to cater for a remote possibility.

3. SPECIFIC SAFETY ISSUES

In the ensuing sections comments are presented on safety issues identified by IAEA.

3.1. Systematic (periodic) reassessment of safety

A single safety review, no matter how thorough, cannot detect all the safety deficiencies. Moreover, with time additional safety deficiencies tend to creep in. This happens in spite of the fact that during the operational phase all modifications in technical specifications and plant hardware are reviewed and approved by the regulatory authority. A comprehensive safety review has its own advantages; for example, in such reviews the plant is analysed as a whole and not as a single modification.

In case of PARR-1, as already described above, there have been several systematic assessments, though not at regular intervals. In the future we intend to have regular periodic safety reviews for research reactors with an interval on the order of 10 to 15 years. Necessary steps for rulemaking in this regard are being taken. Since PARR-1 has been recently reviewed, PARR-2 will be subjected to a periodic review in the near future. Later, DNSRP will specify the documents to be submitted along with the time frame, their format and contents, etc. and in parallel it will try to develop a standard review plan for reviewing these documents.

3.2. Obsolescence of equipment and lack of maintenance

RA should refrain from defining the obsolescence acceptable to it. Instead it should verify that the plant safety systems are available as required by technical specifications (TS). In case a channel/train or system is not available due to unavailability of equipment due to obsolescence, the licensee should be asked to invoke the limiting condition (LCO) of operation and complete repairs in the stipulated time or go in the specified mode of operation. The licensee should be guided in such cases by the requirements of TS, maintenance policy, etc. and should weigh his losses due to shutdowns. Consequently, the forces of economics may require implementation of a replacement program in the early phases of obsolescence. RA may allow the licensee to have a continuous upgrading program. In addition, it may include a comprehensive safety review of all the upgrades in the periodic safety reviews.

3.3. Loss of expertise and corporate memory

A reasonable turn over of manpower is good but if it affects the plant functioning then preventive measures should be taken. If incentives, including financial, are provided, experts can be retained and new experts can be attracted. Regarding loss of corporate memory, it can be stated that written record is the corporate memory. All the events significant or insignificant should be reported reviewed and documented. When there are changes in corporate management there should be over lapping periods and extensive exchange of information during the handing over and taking over. A two man approach may also be followed in which the main person keeps another person informed of the salient events in his work so that he can act as a back up in his absence. New owner should retain the old operating team for a while. This can provide some sort of continuity and preserve the corporate memory.

3.4. Lack of quality assurance programs

Generally activities affecting safety in all research reactors should be subject to a quality assurance program. However, an ANS standard on QA programs for research reactors does not require a QA program for research reactors below 10 MW power. Such relaxation should be withdrawn. All activities affecting safety including those of siting, design, construction, operation and decommissioning should be controlled by a QA program for research reactors of all power levels and types. The QA program should however be commensurate with the power (flux) level of the reactor. Reference documents for preparing such QA programs are available in plenty for nuclear power plants but are scarce for research reactors.

3.5. Lack of clear utilization programs and consequent lack of financial support

The nuclear industry as a whole should look in to this issue. The number of research reactors should be decreased and several universities and organization may share a research reactor. Neighbouring countries can share a reactor and its expenses. To enhance reactor utilization, programs can be started for training and retraining of operators and regulators. While attempts should be made to reduce the operating costs, a fraction of these can be borne by the governments. Licence fee and other regulatory expenses may also be reduced commensurate with the utilization of the reactor. Licensees may seek Agency's support in drawing up new utilization programs.

3.6. Financing of safety measures (safety assessment, safety upgrading, dismantling and decommissioning)

All safety measures and regulatory activities cost money. This burden is necessary to ensure the public that the reactors are being operated safely. These costs are a very small percentage of the total cost. As the licensee has to bear these costs he should be informed of the regulatory requirements at an early stage of planning. Cost of safety measures should be included in the financial feasibility calculations with a reasonable margin for future regulatory requirements. The RA should also carefully evaluate the cost and benefit of a regulatory requirement before imposing it and try to reduce paper work. However, there are certain activities for which the burden is to be borne by the licensee alone; for instance; decommissioning costs. A mechanism for ensuring sufficient funds at the end of life or whenever decommissioning is expected should be in place before operation license is granted. The regulator should frequently verify this capability. For cutting costs, national or international contractors may be hired for jobs that are rarely performed.

3.7. Ownership of shutdown reactors

Research reactors should not be in the shutdown mode for long periods. If a long shut down is anticipated, proper safety precautions and preservative measures should be taken according to written procedures. In case of even longer duration of shutdown, consideration should be given to de-fuelling and blanketing of safety significant equipment in an inert atmosphere. Adequate monitoring of parameters such as chemistry and reactivity should be continued. Critical parameters such as water level in the pool should be alarmed. Physical protection of the facility should be ensured. While transferring the ownership of the reactor it should be noted that the operation license is non-transferable. The RA should satisfy itself that the new owner meets its criteria and then allow transfer of the operation license.

3.8. Safety assessment of different modes of utilization including experiments

The RA should not assess different modes of utilization including experiments. Rather, it should place limits on power, flux, differential temperature across the core, clad temperature, radioactivity in the coolant, etc. The licensee should assess experiments and reactor utilization according to written policy/procedures preferably with the advice of an in-house committee. The RA may verify in its periodic surveillance that the applicable procedures are being followed.

3.9. Emergency preparedness

It has been a general experience that in research reactors the level of emergency preparedness is more than what is required. This has resulted due to use of criteria and safety assessment tools developed for nuclear power plants. As a result, the licensee has to implement emergency preparedness measures generally prescribed for power or large research reactors. If a rational approach is adopted in this area the cost of operation can be reduced. In turn it will also decrease the regulatory cost. More emphasis should be placed, in the future, on the on-site measures rather on off-site measures.

3.10. Training and qualification of operators and regulators

Training of operators should be arranged when obsolete equipment and structures are repaired or replaced, new utilization plans are drawn, new experiments are planned, new fuel is used, new regulatory requirements are introduced, ownership is changed with an accompanied change in operation policy, long shutdowns are terminated, etc. The training should be such that an operation engineer can also work in maintenance and engineering. This can help in reducing costs and keep personnel gainfully employed. There should be several stages in licensing so that the interest of the operators is maintained. Compulsory periodic retraining should be a part of licensing requirements. The operators should be trained on event and symptom (or a combination of the two) emergency procedures.

The training and qualification of regulators is equally important. It should be noted that there are several industry standards and IAEA documents available for training and qualification of operators but guidelines for the training and qualifications of regulators are rarely available.

Training of regulators and operators should be such that rigidity of approach (trained incapacity) is avoided. It prepares them to adjust to changing circumstances while still achieving their goals of verifying safety.

3.11. Safety implications of new fuels

The safety implications of new fuels should be very carefully considered before allowing their use in the core. While converting from HEU to LEU we did not encounter any difficulty in the thermal hydraulic behaviour of the fuel but the new fuel had a feature that required careful handling during fuelling. The operators had to be trained in this aspect before first fuelling of the core. We also paid attention to the QA of the fuel during fabrication and our inspectors witnessed the qualification tests. The IAEA may collect performance-related data on different type of fuels fabricated by various vendors and make it available to Member States. This will be helpful to both RA and licensee.

3.12. Lack of regulatory framework

It can be generally said that there is a lack of industrial standards for research reactors. For example compare the regulatory guides issued by USNRC under its Division 1 with those issued under Division 2. An examination of the list of regulatory documents issued by other leading RA or a review of the catalogue of ANS standards will give a similar picture. As a consequence the standards written primarily for nuclear power plants are being used for research reactors as well. Similarly, computer codes written for nuclear power plants along with very conservative assumptions are being used in safety assessments of research reactors. This has resulted in over conservative results requiring unwarranted safety measures causing difficulties for the RA and the licensee. On the basis of NUSS documents, the Agency may prepare a version applicable to research reactors. Similarly, other documents and programmes initiated for power reactors may be amended and applied to research reactors as well. For example; PROSPER, INES, IRS, OSART, etc. may be extended to research reactors. The definition of nuclear installation should also include research reactors.

3.13. Insufficient independent peer reviews for research reactors

It is felt that there should be more international and national peer reviews, as is the practice in nuclear power plants. The licensee should invite more INSARR missions through IAEA or through any other similar forum. The research reactor operators may form such associations or under the sister organization framework share their experience of research reactor operation. The research reactor suppliers can also form an organization similar to COG (CANDU Operator Group) and collect and disseminate safety and operational experience on the reactors supplied by them. If such peer reviews are conducted, then RA may adjust their surveillance programs to reduce the regulatory burden of the licensee.

3.14. Lack of an International Convention on Research Reactor Safety

The idea of including research reactors in the present convention or having another safety convention is a good one and should be considered by the stakeholders in the Member States namely; the governments, RA and the licensees.

4. RECOMMENDATIONS TO IAEA

In view of the above, the following recommendations are made to the IAEA:

- revise NUSS documents and prepare a research reactor version of these;
- establish a list of documents required to be prepared by the licensee for submission to the regulatory authority and specify their format and contents and prepare a document on the lines of the US Standard Review Plan (NUREG 0800) for use by the RA;
- collect data on the performance of various types fuels supplied by various vendors being used in the current research reactors and publish it annually;
- act as a catalyst to establish organizations for research reactors similar to WANO and COG;
- assist Member States to form regional groups of countries for increasing reactor utilization and financial support to research reactor owners;
- include research reactors in the definition of nuclear installations so that IAEA programs such as IRS, PROSPER, INES, OSART, IRRT, etc cover research reactors also;
- offer more INSARR missions to Member States;
- prepare technical report series documents for QA of research reactors;

- commission studies for extension of life of operating research reactors;
- establish various task groups to discuss and prepare TECDOCs on each specific safety issue.

5. CONCLUSIONS

It is concluded that in Pakistan and other Member States the research reactors are operating safely. However, the nuclear industry is going through a transition and the stake holders in the safety of research reactors will have to act in unison and take concerted initiatives now to address these multi-dimensional problems as outlined in the above paragraphs. In this regard, a proactive approach should be preferred over a reactive approach. The dividends accrued from this approach will surpass the financial and other inputs that will have to be made in this context. The respective governments of the Member States, the regulators and operators of research reactors and the IAEA should liberally provide these inputs, share their experience and mutually help each other in attaining the goal of safer research reactors.