Effective utilization and management of research reactors

by R. Muranaka*

The research reactor is a very versatile tool that, when used effectively, can contribute greatly to a country's scientific and technological development. In addition, it can provide many important services to many government and industrial interests. The reactor, however, represents a significant capital investment on the part of its owner institution, which must also meet recurring annual operational costs. The subject of research reactor utilization is therefore of great interest and concern to owner and operator.

The problem of utilizing a research reactor effectively is closely related to its management and therefore should not be considered separately. Too often, attention has been focused on specific techniques and methods rather than on the overall programme of utilization, with the result that skills and equipment have been acquired without any active continuing programme of applications and services.

The seminar reported here provided a forum for reactor managers, users, and operators to discuss their experience. At the invitation of the Government of Malaysia, it was held at the Asia Pacific Development Centre, Kuala Lumpur, from 7 to 11 November 1983. It was attended by about 50 participants from 19 Member States; it is hoped that a report on the seminar, including papers presented, can be published and thus reach a wider audience.

Thirty-one lectures and contributions were presented at a total of seven sessions:

- Research reactor management
- Radiation exposure and safety
- Research reactor utilization (two sessions)
- PUSPATI Research Reactor Project Development
- Core conversion to low-enriched uranium, and safeguards
- Research reactor technology.

In addition, a panel discussed the causes and resolutions of the under-utilization of research reactors.

Reactor management

Management responsibilities and influence are essential if research reactors are to be utilized effectively. It was shown that even a low-power research reactor having a maximum flux of 10^{13} n cm^{-2} s^{-1} can be used for experiments in basic research. The programme at this reactor included neutron scattering investigations of phase transition in solids and liquids, fast neutron dosimetry studies, neutron radiography, non-destructive methods of nuclear fuel burn-up assessment, activation analysis, and radioisotope production. An active research reactor programme is essential to any nuclear power programme, and reactor managers should strive to establish a close association between the reactor facility and the nuclear power programme. If the facilities or conditions required exceed the capability of the research reactor or experimenter, effective collaboration between developed and developing countries can be fostered.

Occupational exposure and safety

The organization and philosophy of research reactor safety in the United Kingdom was presented. The intention was to describe a safety organization that could be used as a guide for countries at present without a regulatory organization responsible for research reactors. Similarly, a centralized occupational radiation dose record system was described. The importance of a well-managed record system cannot be over-stated, for it is the data contained in such records that enable the radiation protection officer to show that the health and safety of workers is being protected; his efforts can then be directed to techniques of dose reduction. Another paper presented an example of occupational dose and reactor down-time reduction effected by some changes in control rod design, which reduced occupational dose due to maintenance activities, the principal source of radiation exposure. Carefully organized environmental radiation monitoring in relation to the PUSPATI facility, intended to protect the public, was also discussed.

Reactor utilization

The sessions on research reactor utilization included a case study of the development of reactor utilization in chemistry programmes following a management dictum that the mission of the organization, its structure, and its function determine the programme. Several contributions discussed neutron activation analysis programmes with emphasis on environmental studies and the analysis of soil samples.

The study of condensed matter with neutron beams perhaps constitutes the most extensive current utilization

* Mr Muranaka is a staff member in the Physics Section of the Agency's Division of Research and Laboratories.

of research reactors. It became clear during the discussions that in order to utilize research reactors effectively, automation of neutron beam experiments and data acquisition systems is a must; given rapid advances in microprocessor technology, this can be achieved at a reasonable cost.

A radioisotope production programme planned for the next five years at a centre beginning this activity was presented to illustrate the importance of long-range planning. At this centre, emphasis is being placed on medical radioisotopes. In the area of medical applications of reactors, boron neutron capture therapy for brain tumours was described. As a result of the success of this technique, it is being extended to skin cancer in the near future.

An on-line neutron radiography system and its use for industrial applications was described. The microprocessor-automated system can test many samples rapidly. Neutron radiography is an important application of research reactors, with potential for use in many industries, and it can be performed at low-power research reactors.

In the area of training and education, a paper was presented describing training programmes for professional engineers and technicians for research reactor and power reactor programmes. Details of a graduate-level reactor laboratory course in Japan, based on a low-power reactor to which ten universities send their students, were also presented. This kind of course can provide useful links between the nuclear centre and the university system and can be adapted in other countries effectively, increasing utilization of facilities.

Research reactor development

This session was devoted to the development of the PUSPATI research reactor project. Its purpose was to illustrate the procedures and activities necessary to plan and commission a research reactor, as well as to provide guidance on administrative and organizational matters. Papers covering the essential steps included: design and development; construction, installation and commissioning; organization and administrative procedures; recruitment and training; neutron flux measurement; first year of operation; and present and possible utilization. The session was useful in that it preceded a visit to the PUSPATI site.

Core conversion and LEU fuels

Nearly all research reactor owners and operators with highly enriched uranium (HEU) fuel will have to convert their reactors to low-enriched uranium (LEU) fuels. The International Nuclear Fuel Cycle Evaluation report in 1980 identified more than 150 research reactors in more than 35 countries, operating at powers between 10 kW and 250 MW and using HEU fuel. To this end, programmes have been in progress for several years in a number of countries with the aim of developing high uranium density fuel materials, demonstrating their suitability for commercial fabrication and qualifying a range of practical fuel element types by extensive irradiation testing. The Agency has co-ordinated detailed studies of the performance of converted reactors and of safety and licensing issues which are of concern in relation to reduction of research reactor core enrichment. The status of highly loaded uranium-zirconium hydride LEU fuel and the fabrication of plate-type LEU fuel were also discusssed.

The Agency applies safeguards to almost 150 facilities classified as research reactors. The effort spent by the Agency at any given facility depends on the thermal power of the reactor and on the quality and type of nuclear materials present. The conversion of such reactors therefore influences this effort. A paper reviewed the safeguards activities performed by the State and by the Agency in relation to large (greater than or equal to 50 MW) and small (less than or equal to 1 MW) reactors in accordance with the most common type of Agency/State agreement.

Research reactor technology

A developing country starting now in the nuclear field would approach the question of which type of research reactor to use differently from industrial countries in the past. Whereas in many industrial countries during the past 25 years a multitude of nuclear research plants were installed to cover different aspects of the nuclear field, a developing country will be considering a single multi-purpose facility capable of all the typical tasks of a research reactor. Such a multi-purpose reactor was described; it has in-core and reflector irradiation positions, a large central hole for fuel and material testing by the use of loops, beam tubes with flux optimized by the use of beryllium blocks, and a neutron radiography facility. The design of this reactor was clearly dictated by the planned utilization programme. This reactor is presently being constructed in south-east Asia.

A summary of the characteristics and utilization experience of four installations at Mol, in Belgium, was presented and analysed in relation to various objectives: personnel training, isotope production, analysis of materials, and irradiation of reactor components. The four plants include a zero-power, a low-flux, a high-flux, and a prototype power reactor. Their efficient utilization requires a technology group specialized in design and fabrication of irradiation devices, a dosimetry group, and a hot cell group to handle radioactive materials and post-irradiation examinations.

Panel discussion

The causes and resolution of the under-utilization of research reactors were discussed by a panel comprising A. Tajuddin (Malaysia, chairman), V. Dimic (Yugoslavia), E. Bautista (Philippines), R. Chidambaram (India),

K. Kanda (Japan), and J.P. Genthon (France). The discussion showed that lack of supporting policy or direction from higher authorities is manifested in (a) inadequate funding for operations; (b) inadequate staff; and (c) lack of appropriate equipment. In some cases, the lack of sufficient fuel reserves limits the power and operating times to levels at which research activities or radioisotope production are severely limited. Insufficient trained manpower as a result of high attrition was cited as another major factor. Industry, governments, utilities, and so on also seem insufficiently aware of the possible benefit of research reactors and nuclear techniques. Related to this is the tendency for workers to use known and familiar techniques, such as wet chemistry, to do chemical analysis, and not adapt to newer, more efficient nuclear techniques. Finally, an over-emphasis on safety can have a negative effect on research reactor utilization and operation.

Recommendations from the panel included the following:

1. Education – there is a need to educate scientists, the public, and other sectors early and continuously on the possible uses and advantages of research reactor techniques.
2. The training of specialists abroad, at institutions very different from their home institutions with respect to interests and facilities, tends to increase staff attrition. Scientists should be trained at institutions most similar to their own whenever possible.
3. Greater emphasis should be placed on building and assembling experimental facilities locally. This contributes toward development of in-house capability and specialty groups.
4. To alleviate boredom on the part of reactor operators, their duties should include involvement in experiment and service activities. Automated data logging was cited as a means of relieving operators from tedious tasks.
5. A research centre should select and specialize in narrow fields consistent with staff interests and equipment, and not try to emulate the activities of large research centres in industrialized countries. Well-performed research, published in major journals, will have a fertilizing effect on universities and research centres.