Nuclear power and safety: the IAEA's role in a changing world

by B. A. Semenov and J. U. Ahmed*

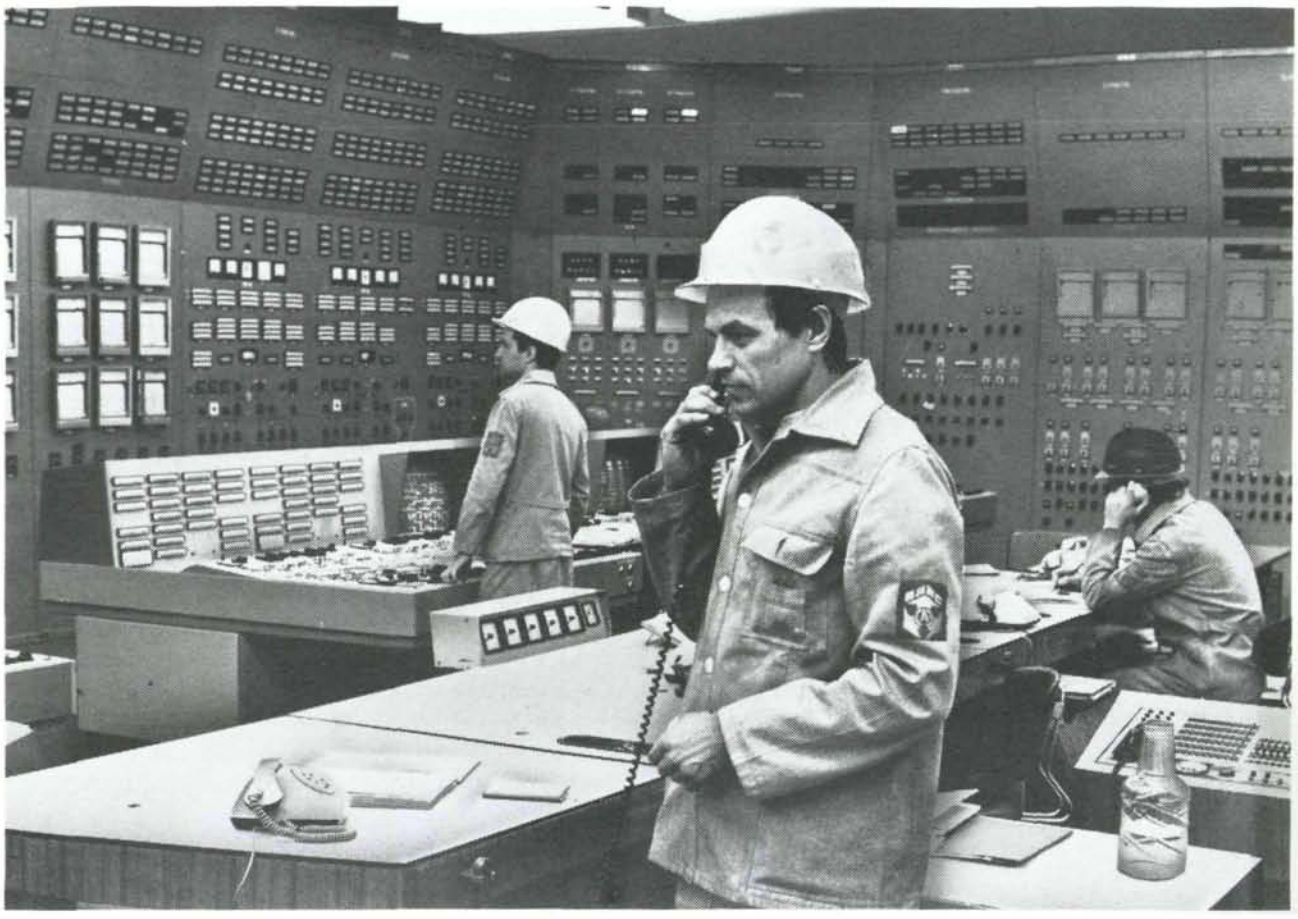
In carrying out its functions in the areas of nuclear power and of nuclear safety the Agency has followed no rigid frame of reference in assigning priorities to its programmes; rather, it has been flexible in the emphasis it placed on areas or items of activity, depending on the trends or needs of the time. During the last 25 years of its existence the Agency has responded to the requests or foreseeable needs of its Member States, particularly those of developing countries, and taken up programmes of activities that were considered to serve the interests of its Member States. New activities have been and are planned when new problems of nuclear power or related safety issues are encountered or foreseen, or when certain developments on a subject warrant special attention.

At its inception, the IAEA started a programme on reactors. The Agency created a Division of Reactors to implement this programme by providing advice and assistance to Member States in their reactor programmes; by technically evaluating applications from Member States for reactor projects; and by collecting and disseminating information on reactor design and technology. Since at that time the development of different reactor types in the advanced countries was at an experimental phase, the main task of the Division of Reactors was to keep Member States informed of all developments in the reactor field. This prompted the publication of a three-volume *Directory of Nuclear Reactors* in 1959 and 1960 to deal with design, cost, and operating characteristics of power, research, experimental, and test reactors. The book was updated and expanded subsequently.

At birth of the Agency in 1957, only three nuclear power plants with a total capacity of 105 MWe were operating in two Member States (UK and USSR). The Second United Nations Conference on Peaceful Uses of Atomic Energy in 1958, and the fourth regular session of the IAEA General Conference held in 1960 revealed the growing interest in, and trend towards nuclear power. This led to the inclusion of power reactor applications, reactor engineering, reactor physics and reactor safety as the main activities of the Division or Reactors. Nuclear power studies were carried out by the Agency for a number of its developing Member States. This programme, particularly of power surveys and reactor safety, expanded rapidly, and by 1963 the Division of Reactors was renamed the Division of Nuclear Power and Reactors to reflect the increased emphasis on nuclear power.

The studies carried out in the early 1960s included economics of nuclear power; methodology for costing; and, with a view to the needs of the developing Member States, the technology and economics of medium-sized power reactors. Where results were positive, and definite projects developed, the Agency assisted in project planning, site selection, choice of reactor system, preparation of specifications, evaluation of bids, and advice on construction. But by 1965, only a few pilot or demonstration power plants, with a total capacity of 5 GWe, were in operation in a few developed Member States. Optimism about commercial nuclear power surged from the mid-1960s to the mid-1970s; as recently as 1974, the IAEA's forecasts for nuclear power capacity in 1990 and 2000 (based on national forecasts) were some three times those of today. Also, in this optimistic period, Member States like Canada, Israel, Mexico, Tunisia, UK and the USA showed an interest in combined power and desalination plants. To cope with such trends, the Division of Nuclear Power and Reactors studied advanced applications, including large-scale, multipurpose application of nuclear power for electricity, desalination, and for agro-industrial complexes. Advisory services to developing Member States tended to take the same direction, with desalination studies for arid regions (Israel, Egypt, Tunisia etc.). After the Third Geneva Conference on the Peaceful Uses of Atomic Energy in 1964, there was a turn to the technical problems associated with the design, construction, and operation of large nuclear power plants. The Agency's information exchange activities became directed to more specific technical areas, for example, integration of power plants into small grids, problems of pressure vessels or control instrumentation. During this period the exchange of information through the IAEA's smaller symposia essentially took over the function of the big Geneva conferences: the Agency became the biggest publisher of literature for nuclear energy and nuclear techniques.

* Mr Semenov is Deputy Director General of the Agency's Department of Nuclear Energy and Safety. Mr Ahmed is a staff member in the Radiological Safety Section of the Agency's Division of Nuclear Safety.



The USSR was one of the two Member States operating nuclear power plants at the inception of the Agency; its nuclear programme has since developed and prospered. This photograph shows a control room at the Beloyarsk nuclear power station: as new reactors are brought on line, the output of this station should double by 1985. [Photo TASS]

This last decade from 1972, has been marked by an increasing awareness of the complexities and demands of nuclear power, and by rapidly increasing costs and completion times for nuclear power plants. At the same time, rising energy prices began to slow the rate of growth of energy demand. The Agency's assistance and advice to Member States emphasized the need for objectivity in planning of nuclear power, and in particular the pre-conditions, requirements, and constraints on introducing nuclear power. Such requirements and constraints include grid size and structure, economics and financing, manpower, organization and industrial infrastructure, and safety and quality assurance. These differ from country to country, and the Agency helped Member States define their own requirements.

To help developing Member States especially, the Agency produced tools to estimate how much energy, electricity and nuclear power was needed to fulfill plans for economic development. The tools developed include *WASP*, Wien (Vienna) Automatic System Planning, a computer program for optimizing costs of alternative long-term patterns of electric system expansion. In 1980 WASP III was completed, the latest in a line of successive improvements from the original program developed in 1973. The WASP model has been widely used by the IAEA and has been requested by 40 Member States and 5 international organizations. Up to mid-1981, 20 Member States reported using WASP in 53 planning studies, and another 30 or more studies using the technique are intended.

The Division also developed an Energy and Economic Data Bank, which contains basic data on energy and economics required for the analytical studies. A Power Reactors Information System was established to help analyse operating experience of nuclear power plants. The Power Reactor Information System showed that load factors were in general well below the 80% which had been used in most economic studies. This finding has prompted efforts to achieve higher reliability by exchanging information on particular design and operating problems.

Over the years the IAEA has held training courses in this field, which have evolved from general courses on nuclear power project planning and implementation to more specific courses covering subjects of importance to the nuclear programmes of developing Member States: such as electric system expansion planning;

the role of nuclear energy within a national energy plan; man-power development; quality assurance; safety and reliability in operation, etc. The Division of Nuclear Power has prepared guidebooks on some of these subjects and on others including: the introduction of nuclear power; interaction of grid characteristics with design and performance of nuclear power plants; nuclear power plant instrumentation and control; nuclear power project management, and bid specifications; and the Division has co-operated in the preparation of NUSS safety codes and guides on all aspects of QA.

Since the beginning of the Agency, many missions have been sent to developing countries to advise and assist them on the need for, and the role of, nuclear power, and on specific essential activities in a nuclear power programme. The earliest missions provided advice primarily on the feasibility of nuclear power, but increasingly they have focused on special needs of individual Member States and on transferring know-how and training. Important to the success of future such missions and technical co-operation are: IAEA co-operation with Member States in planning and formulating longer-term projects; training and participation of local experts in country studies and other IAEA projects; and, where possible, follow-up and evaluation.

The growth of nuclear power slowed in the late 1970s. However, the recession, aggravated by the Three Mile Island accident, did not dampen the IAEA's activities, rather more seriousness was attached to activities such as planning, design, siting, operation, quality assurance, and safety. This is demonstrated by the big conference on nuclear power held by the Agency in Salzburg in 1977 and one planned for September 1982.

Radiological and nuclear safety

Throughout the 25 years of the IAEA's existence, radiological and nuclear safety has been a primary concern. Thus, when the Agency was organized, a division was established to deal with this mandate; in 1963 the division was renamed the Division of Health, Safety and Waste Management to indicate broader coverage of activity in the area of radioactive wastes.

At first, as Member States began to use radiation and radioisotopes in medicine, agriculture and industry, occupational radiation protection was the focus of interest. As an initial step, it was considered important to provide users of radioactive sources with a manual of practice for the safe handling of these substances. Such a document was completed in 1958 and represented the first of the *Safety Series* publications of the Agency. Soon after, work began on other safety standards, guides, codes of practice, and manuals. By 1960 the internationally recognized regulations for the safe transport of radioactive materials were approved by the Board of Governors and published as Safety Series No.6. In 1963 Basic Safety Standards for Radiation Protection were released as Safety Series No.9. Considerable flexibility was given in assigning subject priorities, and other publications which followed dealt with such topics as the organization of radiation protection programmes, physical and medical surveillance of workers, and personnel and area monitoring.

The early 1960s saw the first international symposium on safety sponsored by the Agency. Reactor safety evaluation techniques and the safety of research reactors were subjects of two early meetings. As nuclear power programmes rapidly increased, a symposium in 1963 on the siting of nuclear power plants signalled their growing impact on the Agency's safety activities.

With the swelling of nuclear power plant orders, the world's attention focused on the protection of the general public and the environment. In 1971 the division was reorganized and renamed the Division of Nuclear Safety and Environmental Protection. In 1974 it significantly expanded its work to include the *NUSS* programme — the development of an internationally agreed set of codes of practice and safety guides for nuclear power plants*. In 1978, the five codes which cover the main areas of governmental organization, siting, design, operation, and quality assurance were published, and by 1985 the complete set of codes and guides will have been published in English with translations into French, Russian, and Spanish.

The accident at Three Mile Island in 1979 led to a reassessment of the Agency's programme. Nuclear safety activities were further expanded and in 1981 became the responsibility of a separate Division of Nuclear Safety concerned solely with the safe utilization of nuclear energy. Although it was determined that there is no need for a drastic change in safety requirements or technology of nuclear power plants, it was clear that the lessons learned at Three Mile Island would have to be reflected in future activities. Operational safety including the so-called man-machine interface, the need to understand the limits of human ability to cope with an increasingly complex environment, must be a significant consideration in future planning.

Implementation of the NUSS programme, now that the basic documents are nearing completion, will be a focal point of nuclear safety activities in the next few years. Not only must standards be agreed upon, but also they must be implemented. Many of the answers to Member States' problems are already in the codes and guides; thus an important part of the Agency's role is to encourage their use. Training courses, special advisory missions, and seminars are being organized to promote the standards as the basis for national regulations for the domestic development of nuclear industries, and for use in international commerce.

* See the article by Mr Andres on page 17 for an account of the Nuclear Safety Standards (NUSS) programme.

In looking at the new needs in nuclear safety, effective emergency planning and preparedness are also high on the agenda, and the Agency has strengthened its programme in this area. Here also, in addition to the published technical guidance, the enhanced activities include training programmes and special assistance missions. Other new safety activities underway include the setting up of a system for reporting abnormal events, promotion of the interchange of information on safety research, and use of computer codes to help Member States in solving safety problems.

The Agency has also responded to the growing public controversy. In some countries today, the development of nuclear power is limited not only by technical constraints, but also by the fact that it is considered unacceptable by a significant part of the population. The IAEA is analysing this opposition. Work includes the analysis of the risks and benefits of nuclear power, identifying areas of public concern so that societal values can be taken into account in making safety decisions. The trade-off between protecting against low-probability, high-consequence risks and high-probability, low-consequence risks is one of the considerations in this area.

Some of the early problems in nuclear safety have been resolved. But as new developments arise in the nuclear field, so do new issues. In this complex subject, answers can best be found when countries share their resources. International co-operation under the leadership of the IAEA has proved to be a useful mechanism for devising solutions to common problems.

Waste management

In the early days attention was focused on general waste-management technology, but the emphasis shifted progressively to more detailed and specific fields. Handling and treatment of waste covers solid waste treatment, liquid waste treatment, and conditioning of waste concentrates; it includes all processing short of final disposal. Although this was pursued throughout the 1960s, it has received more attention from the early 1970s to the present day: in recent years particularly the technology for the treatment of some specific wastes, for example, spent ion-exchange resin, tritium-bearing wastes, etc. has been studied.

With the increasing number of nuclear power plants in the world, the Agency began to pay more attention to the management of reactor waste, particularly in the light of the inevitable link between the releases of radioactivity into the environment and the protection of man and his environment. Taking into account further development of nuclear energy, waste-management aspects of advanced fission reactors and fusion reactors will be considered in the 1980s.

Gaseous effluent treatment is of particular importance in protecting the environment from harmful effects of the airborne radionuclide releases from nuclear facilities. The Agency has reviewed the techniques for retaining and removing the most important airborne radionuclides, particulates, and other effluents, and will review the operation of off-gas cleaning systems at various nuclear facilities, beginning with nuclear power plants. The treatment of gaseous waste from unplanned events will also be studied.

Reprocessing produces high-level and long-lived alpha-bearing waste. In the Agency's programme, first of all the techniques for storage of liquid high-level waste were reviewed. Over the past 20 years considerable research and development on high-level waste solidification has taken place. Incorporating the waste into stable glass or ceramic has become the most popular system. The review of solidification techniques was an important part of the IAEA activities in the 1970s, and the evaluation of characteristics of solidified high-level waste formed part of an Agency-sponsored co-ordinated research programme. In future, attention will be focused on the handling, storage and disposal of conditioned high-level waste. Activities on waste management in mining and milling of radioactive ores and in decommissioning of nuclear facilities will continue.

Underground disposal of radioactive waste was earlier dealt with mainly in the context of the general waste-management technology. Thus the subject received relatively low priority in the mid-1960s. However, since the early 1970s the disposal of radioactive waste has become more pressing; underground disposal is now considered to be the most feasible technique. Disposal of high-level and long-lived alpha-bearing waste in deep geological formations is an important consideration. Consequently, the Agency launched an integrated programme on underground waste disposal in 1977.

Demand following

The Agency's activities in nuclear power and safety have always responded to the needs of its Member States and have been designed and operated as a "demand following system" sensitively reacting to the changing technical, economic and social factors influencing the world's nuclear power development. Although the growth of nuclear power programmes has slowed down in many countries since the mid-1970s, further hindered by the Three Mile Island accident, the productiveness of the Agency's programme did not decline. Rather increased vigilance has been exercised in the areas of design, engineering, siting, operation, quality control, and in safety issues.