Fast Reactors And The IAEA

by E.I. Inyutin, Scientific Secretary, International Working Group on Fast Reactors.

As nuclear power enters a new phase of development, several countries are carrying out intensive work on the fundamental engineering requirements of fast breeder reactors.

On 16 July 1973 the Soviet Union put into operation the 350 MW(e) dual-purpose fast reactor BN-350, designed for the desalting of water (120 000 m^3 per day) and the generation of electricity. In France, the Phénix reactor [250 MW(e)] has been brought to full power, while in the United Kingdom the PFR reactor [250 MW(e)] has reached criticality. In the Federal Republic of Germany, the construction of the demonstration fast reactor SNR-300 [300 MW(e)] has started. Italy began the construction of the PEC reactor [140 MW(th)]. The United States is building the FFTF reactor – the forerunner of a demonstration breeder. Japan will soon begin the construction of the fast reactor MONJU [300 MW(e)]. The Soviet union has started building its next demonstration reactor, BN-600, which will have a power of 600 MW(e). The current status of sodium breeder technology is such that, even before the programmes of the present generation of demonstration reactors are completed, design work can be started – and in fact has been started – on commercial fast reactors of 1000 MW(e) and above.

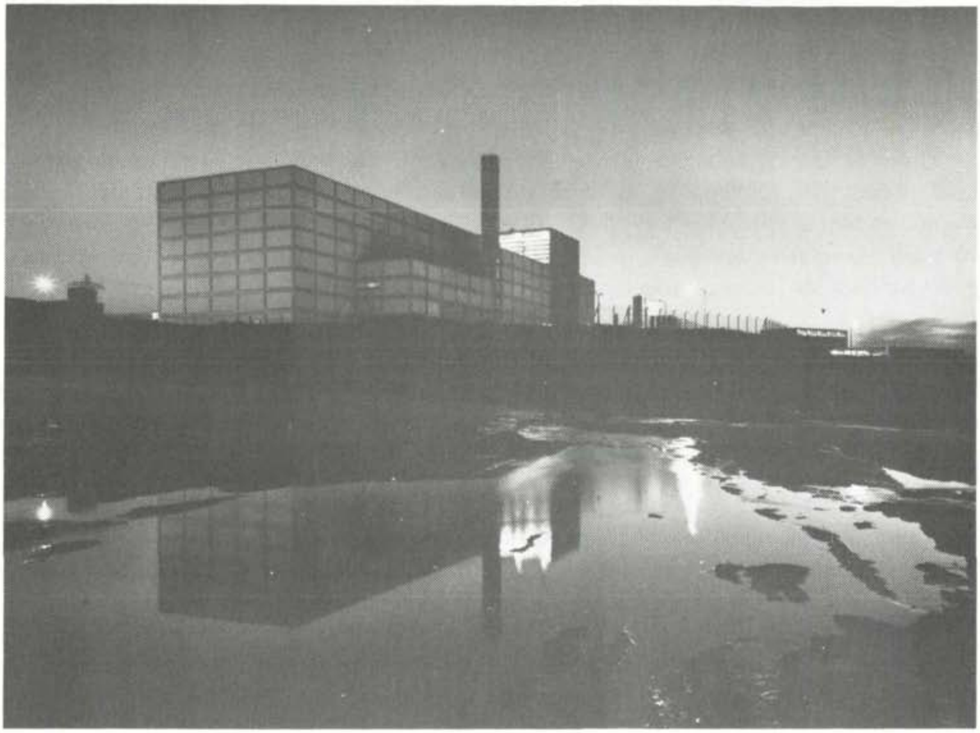
Thorough theoretical and practical studies are being made of the safety problems of fast reactors and of their influence on the environment. The results of these studies demonstrate to an increasing extent that a combination of active and passive measures, such as the provision of appropriate reactor monitoring and control devices and, in some cases, containments and the use of advanced technology in the manufacture of nuclear power plant equipment, can guarantee sufficient operating safety of fast reactors. It will take time, however, before this view receives general recognition. In this connection the experience gained with demonstration fast reactors in various countries will be of decisive significance.

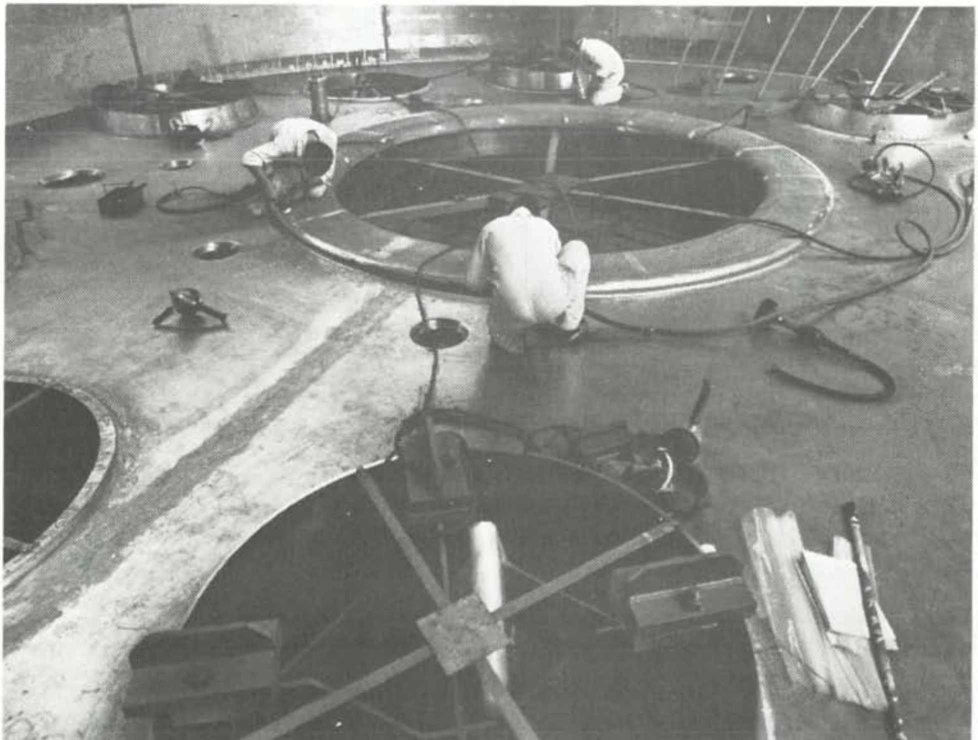
As is known, the main feature of fast reactors is that they open the way to using the isotopes of heavy elements which do not undergo thermal-neutron-induced fission. The fuel cycle can make use of the reserves of uranium-238 and thorium-232, which are much more abundant in nature than uranium-235, the principal fuel used in thermal reactors.

Fast reactors provide the practical means of breeding nuclear fuel. This means that in fast reactors the fission of one nucleus of fuel leads, on an average, to slightly more than one new nucleus which can undergo fission. The excess fuel thus formed can be recovered and used for operating new nuclear reactors. This will solve, for a long time to come, the fuel problem created by an intensive development of nuclear power based on thermal reactors.

A night-time view of the U.K.A.E.A's 250 megawatt prototype fast reactor (PFR) Dounreay, at Caithness, Scotland. The reactor is now operating at low nuclear power, and following final tests, power will be gradually increased and electricity generation commenced. Photo: U.K.A.E.A. ▲

Still during its construction stage, the French Phénix 250 MW(e) fast reactor at Marcoule, during the machining of the reactor lid in 1972. Phénix went critical in August, 1973. Photo: P. Jahan. ▶





The technology of sodium-cooled fast reactors has been most thoroughly developed so far. The use of different gases — for example, helium, carbon dioxide and nitrogen dioxide — as fast reactor coolants is also being studied.

The development of power plants using fast reactors is a more complex problem than the development of thermal reactor plants. The different reactor kinetics and dynamics, the hard neutron spectrum, the higher integral radiation doses to fuel and structural materials, the higher core temperatures and the use of an essentially new coolant give rise to a whole complex of problems which only countries with a highly-developed scientific and technical potential have the resources to solve in a comprehensive manner.

Some developing countries are taking an interest in the development of fast reactors, and a few are themselves carrying out research. With time, fast breeders as sources of energy and nuclear fuel will take their place in the power programmes not only of the advanced, but also of the developing, countries.

With a view to promoting international co-ordination in the development of liquid-metal coolant fast reactors, the IAEA in 1967 established the International Working Group on Fast Reactors (IWGFR), consisting of representatives from the Federal Republic of Germany, France, Italy, Japan, the USSR, the United Kingdom and the USA — the countries which have the most extensive national programmes in this field. The members of the Working Group were nominated by their Governments and can be replaced only by them.

The international co-ordination carried out with the help of the IWGFR takes various forms.

Firstly, the Working Group meets once a year mainly to review and discuss national programmes in the fast reactor field — the progress achieved in the preceding year, and plans for the following year. The one-year interval between meetings has been found appropriate for information exchange in this fast-developing branch of science and technology.

Secondly, the Working Group discusses and recommends topical subjects for international symposia and conferences on liquid-metal fast breeders.

Thirdly, on the initiative of the Working Group, specialists' meetings involving a limited number of experts (15 - 20 persons) are convened regularly, three or four times a year, on important but highly specific theoretical and pracitcal problems. The subjects for such meetings are discussed carefully and selected in accordance with the views of the majority of the Working Group.

Fourthly, as a result of discussions at the annual meetings of the Working Group or at meetings held on its recommendation, suggestions emerge for joint efforts relating to international comparison of particular methods of research, calculation or drafting of agreed procedures.

The Working Group maintains close contact with other international organizations, e.g. the Nuclear Energy Agency of the OECD and EURATOM, through their representatives on the Working Group.

The expenses connected with the measures recommended by the Working Group are borne by the IAEA and the Member States represented on the group. To assist the group in *its work, the IAEA provides the Scientific Secretary, services its annual meetings and arranges reproduction of its annual reports and the reports of the specialists' meetings.*

The development of power reactors embraces a wide range of problems relating to nuclear and reactor physics, thermophysics, the chemistry, physics and technology of coolants, structural materials and nuclear fuel, the design of reliable fuel elements and operational equipment, reactor monitoring and control, spent fuel reprocessing, fuel cycle economics, nuclear safety and so on.

Since its very inception the Working Group has at every step concentrated its attention on the main problems of sodium-cooled fast reactor development. Since 1967, about 30 international meetings have been held under the auspices, or with the co-operation, of the Working Group. These include the International Conferences on Irradiation in Fast Reactors and on the Physics of Fast Reactor Design and Operation (1969), the IAEA symposium on Progress in Sodium-Cooled Fast Reactor Engineering (1970), the International Conference on Engineering of Fast Reactors for Safe and Reliable Operation (1972), the IAEA Symposium on Fuel and Fuel Elements for Fast Reactors and the International Symposium on Physics of Fast Reactors (1973).

In March 1974 an International Conference on Fast Reactor Power Stations was held in London to discuss experience acquired in the commissioning and early operation of the first demonstration breeders in the USSR, France and the United Kingdom and future prospects in this field. In the second half of 1974 the IAEA plans to hold a Study Group Meeting on Steam Generators for Liquid-Metal Fast Reactors.

Of the 14 specialists' meetings, two have been devoted to fast-reactor physics: one to the "alpha" value for plutonium (1969) and one to the measurement and interpretation of neutron spectra in fast reactors (1970). The purpose of the remaining 12 meetings was to discuss the engineering and technological problems associated with the design and operation of demonstration fast breeders and large sodium rigs: the interaction between sodium and water (1968 and 1971), sodium vapour control (1970), measurement and control of impurities in sodium (1972), behaviour of fission and corrosion products in the primary circuits of liquid-metal fast reactors (1971), decontamination of plant components from sodium and radioactivity (1973), operational safety of sodium circuits (1971), sodium combustion and its extinguishment (1972), failure cladding detection (1970), handling and transportation of LMFBR spent fuel elements (1972), development and application of absorber materials for fast reactors (1973) and core monitoring instruments for sodium-cooled fast reactors (1969). In 1973, the IAEA held a panel meeting on the Principles of Hot Channel Factor Calculations.

Specialists' meetings are organized by the countries participating in the Working Group and held at their respective research centres, where participants have an opportunity to view the progress achieved by the host country in their area of interest. Each meeting is prepared and conducted in such a way that agreed "Conclusions and Recommendations" can be discussed and adopted at the end. Some time later a summary report on the meeting, containing a brief review of the papers and discussions, the conclusions and recommendations and the texts of the papers presented, is circulated to the participants. Thus each specialists' meeting is a self-contained unit, so to speak, and reflects the current status of the problem considered.

The meeting on The Alpha Value for Plutonium recommended international calculations on a simplified model of a large fast power reactor in order to determine to what extent the critical load and breeding ratio depend on the set of nuclear constants used in a particular country or organization. The results of 17 calculations from 10 countries were considered in the summary report, and there emerged a picture of the influence which different nuclear constants have on calculations of the effective multiplication constant, the internal and external breeding ratio, neutron spectrum, spectral indices and the effect of the different cross-sections of the fission products and higher isotopes of plutonium on the calculation results.

The Working Group took the initiative in compiling manuals on the first-aid methods used in different countries in cases of sodium burns. These methods were then commented upon by the IAEA's Division of Nuclear Safety and Environmental Protection. The methods and the commentaries thereon will help the health services of countries that are developing sodium-cooled fast breeders to determine the most efficient method of giving aid to operating personnel who have suffered sodium burns.

On the recommendation of the specialists' meeting on the Operational Safety of Sodium Circuits, experts from the United Kingdom have prepared the preliminary draft of a manual on "The Principles of Good Practice for Safe Operation of Sodium Circuits". This draft is now being discussed by the specialists of other countries. Their comments will be taken into account in the final version of the manual, which will thus reflect international experience and be useful to designers and operational personnel.

The participants of the IAEA Panel on Principles of Hot Channel Factor Calculations agreed that an international comparison of different calculation procedures should be carried out on the basis of a test sample. It is assumed that, depending on the results obtained at this stage, the Working Group will consider the next step — an international comparison of methods of calculating the "subfactors" which determine the calculation of the hot channel factor — and will then make its recommendations.

It is evident from the foregoing, that the IAEA is achieving much at a very low cost by arranging for an international co-ordination of efforts directed towards the development of sodium-cooled fast reactors. This is due to the interest shown by the countries represented in the Working Group. The group is able to function efficiently because of the high qualifications, sense of responsibility and small number of its members and because its composition does not change. The experience of the Working Group has been useful, on the whole, and could profitably be applied to the organization of activities in some other areas.

Besides the activities of the International Working Group on Fast Reactors there are several allied fields of science and technology in which the IAEA is actively assisting the development of fast reactors.

The belief exists that, of all the promising new sources of energy, liquid-metal fast breeders are likely to be available earliest for practical power generation. It was for this reason that the IAEA resolved to give careful attention to such reactors during a particular period; and for the same reason the IAEA must devote close attention to the next stage in fast breeder development, namely gas-cooled fast reactors. These have a number of clear advantages over liquid-metal designs, but are technically even more complex.

In 1972, the IAEA held a Study Group Meeting on Gas-Cooled Fast Reactors in Minsk, USSR. The conclusions reached at that meeting have found a positive response in the scientific press.

Recognizing the growing importance of fast breeder reactors for meeting world energy requirements, the International Atomic Energy Agency will continue its efforts towards international co-ordination in this area.

Excerpts from the opening and closing addresses at the Symposium on Applications of Nuclear Data in Science & Technology, Paris, 1973

Applications of Nuclear Data

The expansion of nuclear technology during the last twenty years has created a growing demand for an organized and easily accessible body of nuclear information needed by the scientific community. Nowadays, trends in the nuclear power industry, such as the current development of more efficient nuclear reactors and the planning of thermonuclear fusion reactors, as well as the increased use of nuclear methods and techniques in practically all fields of science and technology, are continuously increasing the demand for more and better numerical nuclear information, commonly referred to as nuclear data.

In the past few years nuclear data compilation and its use has grown considerably in magnitude, scope and depth, and an even greater increase is foreseeable for the future. This was the dominating impression gained by the participants in the International Symposium on Applications of Nuclear Data in Science and Technology, which the International Atomic Energy Agency organized in Paris last year.
The conference confronted the "state of the art" of nuclear data compilation with the nuclear data requirements of science and technology.

The Symposium showed that while nuclear power continues to present the most important and most strongly supported challenge to the compilation of nuclear data, an increasing number of applications of nuclear techniques in many branches of science and technology, and a growing need to protect man against nuclear radiations, call for a considerable broadening of the scope and depth of nuclear data compilation.
Accurate nuclear data and an easy access to them are becoming increasingly important to scientists applying nuclear radiations and isotopes in radiobiology, medical diagnostics and therapy, activation analysis, geology, material research and other fields. The refinement in recent years of nuclear experimental techniques which has led to an enormous increase in the volume of measured nuclear data has created the additional problem of how to compile and digest the data produced and make it available in adequate and timely form to its users, and has accentuated the need for appropriate justification and priority choice of nuclear data compilation.