Developing a nuclear infrastructure: the need for nuclear data

by J.J. Schmidt and A. Lorenz*

Nuclear data are numerical constants of nature which describe the nuclear behaviour of all elements and isotopes which make up the human environment. They are the indispensable numbers which scientists and engineers need to solve nuclear problems. Scientists and engineers designing nuclear fission and fusion reactors most frequently need data in the form of neutron-nuclear cross-sections. Nuclear and non-nuclear sciences employing nuclear methods (physical, earth, life and social sciences, industry and agriculture) need mostly comprehensive up-to-date handbooks and computer files of data on nuclear structure and radioactive decay. All researchers and industries around the world working in nuclear science and technology need nuclear data. It follows, therefore, that progress in nuclear science and in technology depends on the availability of accurate nuclear data.

The measurement, theoretical computation and evaluation, and the processing of nuclear data is referred to collectively as nuclear data technology. It is part of the indispensable infrastructure in every country which has, or is, developing a nuclear programme.

Because it costs so much to generate this information, and because most developing countries lack the necessary data processing technology, the IAEA co-operates with the established nuclear countries to provide the required nuclear data services. At the same time, the Agency is helping develop the nuclear infrastructure of the developing countries by systematically transferring the expertise and technology required to use and process nuclear data effectively.

The Agency's Nuclear Data Section supported by international networks of nuclear data centres has taken the lead in establishing over the last two decades an efficient international system of compilation, exchange, and dissemination of nuclear data. Currently more than seventy countries contribute to and benefit from this computer-based international data-exchange, which ensures that up-to-date nuclear data and associated documentation, as well as data-processing codes, can be made available to every nuclear scientist or engineer in the world in any desired form.

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Meeting the need for nuclear data

To meet the demand for reliable and freely available nuclear data, the Agency established the nuclear data programme as part of the Department of Research and Isotopes in 1964. It started by developing, in co-operation with established national nuclear data programmes, a world-wide systematic collection and exchange of nuclear data, and gradually built up the dissemination services to users in Member States.

In this co-operative arrangement, the IAEA agreed to share the responsibility of providing nuclear data services with three other regional nuclear data centres: the OECD Nuclear Energy Agency (NEA) Neutron Data Compilation Centre (today part of the NEA Data Bank) located at Saclay (France), servicing mainly the developed countries in Western Europe and Japan; the National Neutron Cross-Section Center (today National Nuclear Data Center) located at the Brookhaven National Laboratory (USA), servicing the USA and Canada; and the USSR Nuclear Data Centre located at the Institute for Physics and Energetics at Obninsk (USSR), servicing the USSR. The IAEA Nuclear Data Section services mainly developing countries in Asia (except Japan), Africa, Latin America, Eastern Europe (except USSR), Australia, and New Zealand.

In 1967 the Agency set up the International Nuclear Data Committee, as a continuing advisory body, to promote international co-operation in all phases of nuclear data activities of general usefulness to nuclear energy programmes and other peaceful applications of nuclear science and technology, and to advise the Director General in the field of nuclear data. In addition to its advisory functions, the committee has worked closely with the Nuclear Data Section in assessing the requirement for nuclear data world-wide, in co-ordinating both the measurement and evaluation of nuclear data, and their collection, exchange and dissemination to users.

From the mid-seventies on, changes have taken place which have imposed a continuously increasing demand on the Agency's nuclear data programme and services, as a growing number of developing Member States started to introduce the peaceful application of nuclear science and technology. Several developing Member States have begun in the last few years to develop their own nuclear power and fuel cycle technologies, and many more have introduced nuclear techniques, nuclear radiation and isotopes, into science and industry.

Several developing Member States are interested in nuclear techniques because they already operate or plan to introduce nuclear power plants, and need specialists in nuclear technology and nuclear fuel management to determine their countries' future energy options. Many more are applying nuclear techniques to medicine, food preservation, radiological protection, geological exploration, industry, and many other vital purposes. So that these countries can derive full benefit from these techniques, many specialists are needed.

As they become technically more sophisticated, more and more developing countries are expanding their computing facilities, at the same time as they acquire nuclear analytical laboratories equipped with neutron generators, nuclear accelerators, and data acquisition and processing instrumentation. While the number of nuclear facilities and amount of sophisticated equipment in developing countries has grown, most of these countries lack the trained scientific and technical manpower to use and maintain the equipment effectively.

As a consequence of these developments, not only the number but also the sophistication of requests for nuclear data from developing countries have increased considerably over the last five to ten years. Today some forty developing Member States use the Agency's nuclear data service, and the number of requests satisfied annually by the Nuclear Data Section has grown at an average rate of 20% annually during the last six years. In 1982 alone, the Agency received more than 700 requests from 64 Member States, 250 for numerical nuclear data, 60 for data processing codes, and more than 400 for reports. During the same period, the number and diversity of nuclear data files received and maintained by the Nuclear Data Section has been growing. There are now more than fifty such files*.

The Nuclear Data Section has re-oriented its programme to satisfy the new requirements of the developing countries. In-house data processing is increasingly being automated, and quality control of the disseminated data improved. To strengthen its role in technical assistance and co-operation, the Section is implementing projects to develop self-supporting nuclear scientific infrastructures in developing Member States. Today, about two-thirds of the manpower and budget of the Nuclear Data Section are spent on the transfer to developing countries of nuclear data, and of nuclear data technology and expertise.

Transfer of nuclear data

The section supplies nuclear data, associated documentation, and nuclear data processing codes to scientists in developing Member States on request. The numerical data are supplied on magnetic tapes or as computer listings retrieved from the data files. The Section publishes and disseminates handbooks of nuclear data, proceedings of meetings, review articles and research reports (under the auspices of the International Nuclear Data Committee, and data indexes such as the computer index of neutron data*. It issues a nuclear data newsletter which advertises new data libraries, documents, and data-handling codes available from the Nuclear Data Section. The formats and contents of the nuclear data files maintained by the Section are documented in a reference report series.

The Section can give detailed guidance in the use of the supplied data as well as the processing codes. The data are used mainly in nuclear reactor design calculations; in the development of national nuclear fuel management strategies; in the planning, performance, and analysis of nuclear measurements; and in the production and application of isotopes and radiation.

In some of the larger developing countries which have begun a nuclear power programme, the Nuclear Data Section can give technical guidance to and collaborate in the establishment of nuclear data processing groups and dissemination centres.

Individual scientists from developing countries can participate in common projects to verify the quality and accuracy of nuclear data files and nuclear data processing codes.

Scientists from developing countries are actively participating in the Nuclear Data Section's co-ordinated research programmes devoted to the generation and evaluation of nuclear data, their computer processing and their intercomparison with other evaluations, and to the measurement and analysis of 14 MeV neutron cross-section data needed for the development of fission and fusion reactor technology.

Transfer of technology and expertise

The transfer of nuclear data technology and expertise through technical assistance and co-operation consists primarily of education to build up a technical cadre in developing Member States which would be part of the needed nuclear infrastructure.

A multi-year interregional project on nuclear data techniques and instrumentation was started in 1981 within the Agency's programme of technical co-operation. Its primary objective is to train young nuclear scientists at universities, research laboratories, and other research institutes in developing countries in the methods of measurement and analysis, and in the techniques and instrumentation used in the field of nuclear data. The project will twin research groups from developing and developed countries in common research work. It will give developing countries an opportunity to participate in an internationally co-ordinated effort and to do

* Further information on the amount of data held by the Nuclear Data Section, and on the fields of application for such data, can be found in the article by Mr Schmidt and Mr Lorenz on p.65 of *IAEA Bulletin* Vol.22 No.2 (April 1980).

* Computer Index of Neutron Data (CINDA) is published annually in the form of a main volume and supplement.

necessary and useful measurements using up-to-date methods. In this way the project should contribute significantly to the education of nuclear scientists in developing countries. The expertise which they have gained during work for the project can be usefully employed in many fields of nuclear science and technology of vital importance to developing countries. Among such applications are nuclear techniques in agriculture, medicine and industry, nuclear reactor planning, operation, and safety. During the initial phase of the project, experts went on mission to 37 nuclear institutes in 12 developing countries. Scientists from Algeria, Bangladesh, Brazil, Chile, Hungary, Pakistan, Poland, and Turkey have received fellowship awards and undertaken scientific visits in the course of this project. Auxiliary equipment and special materials (tritium targets and isotopic foils) were supplied to nine institutes in eight developing countries to assist them in the start-up phase of their measurement programmes.

The utilization of neutron generators was the subject of an interregional technical co-operation training course held in Debrecen, Hungary, in June and July 1982. This course was to enable the participants to acquire expertise in fast-neutron data measurements, using neutron generators which have been supplied by the IAEA to a number of Member States, in the study of neutron interactions with reactor materials, and in technological applications of immediate benefit to their countries. The course lectures were supplemented by laboratory exercises on a variety of practical applications of neutron generators. The course was attended by 24 participants from 23 developing Member States.

In September 1983, an interregional technical co-operation training course and study tour will be held in the USSR to familiarize participants with the neutron physics and neutron nuclear data measurements currently performed with electrostatic generators, cyclotrons, linear accelerators, and research reactors in a number of institutes in the USSR.

Another interregional technical co-operation training course this time on the methodology of evaluation and processing of nuclear data for reactor applications is planned for 1984, at IAEA Headquarters in Vienna. This course will consist of lectures and computer exercises in methods of nuclear data evaluation and in the handling and multi-group processing of evaluated nuclear data to carry out reactor neutronics calculations. The course will be designed as a computer- and tutor-intensive exercise for a limited number of nuclear and reactor physicists from developing countries.

So far three four-week training courses on applications of nuclear theory to nuclear data calculations for nuclear reactors have been held. These were organized jointly with ICTP* Trieste in 1978, 1980, and 1982. Nuclear scientists from developing countries who are implementing a nuclear science and technology programme attended the courses which reviewed the contemporary developments in low-energy nuclear reaction theory and models, and their application to the computation of nuclear data needed for nuclear reactor core design and safety analysis. The courses also included an introduction to nuclear model computer codes and some practical exercises. These courses were attended by between 70 and 90 scientists from 25 to 30 developing Member States.

Also in co-operation with ICTP Trieste, a workshop on the use of nuclear model computer codes is planned for 1984. This workshop will assess the usefulness of the transfer of nuclear model computer codes to developing countries effected as a result of the three earlier ICTP courses mentioned above. In a course of introductory lectures followed by extensive computational exercises, the workshop will familiarize participants with nuclear model computer codes which are being widely used for the computation of neutron cross-sections needed for nuclear technology applications. The workshop will also give the participants an opportunity to discuss their experiences and problems in the use of nuclear model computer codes.

Nuclear and atomic data available from the IAEA

The IAEA's Nuclear Data Section serves as an international data centre, and offers extensive nuclear data services to all Member States. One of its main activities is the systematic collection and dissemination of nuclear and atomic data. For this purpose it keeps extensive collections of computer-based numerical data files which it continuously supplements and updates. Among these files are:

Compilations of neutron, charged particle, and photonuclear reaction cross-sections for all nuclides of importance to nuclear science and technology. The compilations include several million data-points of experimentally determined neutron reaction data, ranging in energy from thermal to 20 MeV; and more than fifty individual libraries of evaluated neutron reaction data and associated parameters. Among the applications for which such libraries are designed are: standards for nuclear measurements; fission and fusion reactor design calculations; radiation safety analysis; fission product and actinide inventory and decay heat calculations; and radiation damage estimation and neutron dosimetry.

Compilations of radionuclide parameters used in nuclear techniques and in the application of isotopes and radiations, comprising: nuclear masses and isotopic abundances; evaluated nuclear structure and decay parameters for all radionuclides; energies and intensities for gamma-rays and half-lives for activation analysis; and photon interaction cross-sections for all elements.

Compilations of atomic data for fusion and plasma technology, comprising: atomic collision data, particularly electron ionization, excitation and charge exchange; and data for plasma interaction with surfaces, including processes such as particle reflection, trapping, and sputtering.

* International Centre for Theoretical Physics. A complete list of the activities of the Centre for 1983 can be found on p.57 of IAEA Bulletin Vol.24 No.4 (December 1982).