# The IAEA Nuclear Data Programme - Its Role in the Nuclear Community and its Services to Developing Countries

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## INTRODUCTION

Nuclear physics data, or more briefly nuclear data, encompass all quantitative results of nuclear physics research and comprise the areas of nuclear reaction, nuclear structure and nuclear decay data. Nuclear data find widespread use in all branches of nuclear science and technology, with neutron data and radioactive decay data playing a prominent role. A few selected examples may illustrate the fundamental importance of nuclear data for the development of nuclear science and technology. Neutron-induced fission, the means of energy production in nuclear fission reactors, is quantified in terms of nuclear data which are dependent on neutron energy. The fusion reaction between deuterons and tritons, basic to present-day fusion reactor design, is expressed in terms of nuclear data. The decaying nuclide states of fission product and actinide isotopes determine the energy and intensity of alpha-, beta- and gamma-radiation, basic quantities for nuclear waste management, for the shielding of nuclear energy facilities, and for the accounting and safeguarding of fissile nuclear materials.

## IAEA NUCLEAR DATA SECTION

The extensive needs for nuclear data in the development of nuclear science and technology and the concurrent production of large quantities of such data in nuclear physics experiments all over the world have made international co-operation necessary in the compilation, exchange and dissemination of nuclear data internationally. At an early stage of this development, in 1964, the IAEA recognized the need for an international exchange of

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neutron data and established a nuclear data programme. This formed the basis of the international centre for nuclear data operated today by the IAEA Nuclear Data Section (IAEA/NDS).

IAEA/NDS has always been in a unique position, being exposed to all aspects of nuclear science and technology. Although initially designed primarily to satisfy neutron data requirements for the development of thermal and fast fission reactors, the IAEA nuclear data programme, reflecting the growth and emphasis of national and international nuclear programmes, has expanded its scope during the last several years to include all nuclear data. Today, in addition to neutron nuclear data required mainly for nuclear energy development, the IAEA/NDS programme scope includes nuclear reaction data and nuclear structure and decay data needed to support the continuous development of improved nuclear methods and techniques, as well as atomic and molecular data required in the field of plasma physics and fusion technology. Most important, in recent years IAEA/NDS has greatly increased its nuclear data services and support of nuclear data research in developing countries, to meet their growing demands arising from their increasing interest in nuclear energy and other nuclear applications. In summary, IAEA/NDS today is recognized as the nuclear data centre co-ordinating, on an international scale, part of the development, and the compilation, exchange and dissemination of accurate nuclear data, and being responsible for the transfer of nuclear data mainly from developed to developing countries, as well as for nuclear data exchange between Eastern and Western IAEA Member States.

## INTERNATIONAL NUCLEAR DATA COMMITTEE

The Agency's nuclear data programme has its own permanent advisory body, the International Nuclear Data Committee (INDC). This ensures that IAEA/NDS is guided in its programme and activities by the requirements of nuclear programmes in the major (developed and developing) nuclear Member States of the Agency.

The INDC was formed by the IAEA in 1967 as a continuing committee of the IAEA with the stated purpose of "serving as a means of promoting 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 of advising the Director General of the IAEA in the field of nuclear data". This committee, currently limited to thirteen members, is composed of leading nuclear scientists from IAEA Member States which have major nuclear data activities. For countries not represented on the INDC, forty appointed liaison officers provide direct communication links between scientists in these countries and the INDC through IAEA/NDS. The INDC secretariat functions are carried out by IAEA/NDS under the guidance of its head who serves at the same time as scientific secretary of the INDC. The committee meets at intervals of approximately eighteen months.

In addition to its advisory functions which it has with regard to the IAEA nuclear data programme, the INDC, in promoting international co-operation in nuclear data activities, works closely with IAEA/NDS in the co-ordination of a number of nuclear data activities of international impact. The committee's responsibilities for assessing the requirement for and availability of nuclear data, for co-ordinating their measurement, computation, collection, exchange and dissemination are reflected in many of IAEA/NDS's functions.

## INTERNATIONAL DATA CENTRE CO-OPERATION

In 1970, under the aegis of IAEA/NDS, four regional neutron data centres agreed to share their responsibilities on a geographical basis and to start exchanging experimental neutron nuclear data in a common computer-compatible exchange format, called EXFOR. These data centres are:

- 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;
- the USSR Nuclear Data Centre located at the Institute for Physics and Energetics at Obninsk (USSR), servicing the USSR; and
- the IAEA Nuclear Data Section, located in Vienna (Austria), mainly servicing developing countries in Asia (except Japan), Africa, Central and South America, Eastern Europe, as well as Australia and New Zealand.

Each of the four neutron data centres compiles all experimental neutron data from its service area, distributes these data to the other centres in the agreed format, and answers requests for neutron data from users in its service area. All operations are fully computerized. The data exchange assures that every user in the world has access to the complete body of experimental neutron data.

A similar objective to arrange the free exchange and distribution of evaluated neutron data through the "Four-Centre" network has been slower to materialize. Today, however, most of the existing evaluated neutron data files are made available without restrictions. Meetings of the four neutron data centres are convened every year by IAEA/NDS to co-ordinate the international compilation, exchange and dissemination of neutron nuclear data.

The continuously growing importance of nuclear techniques and isotope applications has led, more recently, to the development of new data centre networks for charged particle nuclear reaction data and for nuclear structure and decay data, to ensure the efficient collection of these data and dissemination to their users.

## COMPUTER-BASED NUCLEAR DATA LIBRARIES AND PUBLICATIONS OF IAEA/NDS

As a result of the co-operation among data centres, IAEA/NDS has acquired most of the nuclear data generated all over the world. Apart from the EXFOR library of experimental neutron and other nuclear reaction data, which at present comprises 2.6 million numerical data records, IAEA/NDS maintains today about 40 different evaluated nuclear data libraries and their periodic updates ranging from large comprehensive general purpose files to smaller files for special applications. These libraries contain 1.8 million numerical data records; a break-down is given in the table below. A small programming group within IAEA/NDS develops and maintains the program systems necessary for the computer handling of these libraries and performs associated data input/output operations.

**Computerized Nuclear Data Libraries held by IAEA/NDS**

| A. Experimental nuclear reaction data library | Number of numerical data records |
|---|---|
| EXFOR library | 2 600 000 |
| **B. Evaluated nuclear data libraries** | |
| 1. Standard cross-sections | 15 000 |
| 2. General purpose files of neutron cross-sections | 700 000 |
| 3. Yields, cross-sections and decay data of fission-product isotopes | 500 000 |
| 4. Nuclear data for reactor neutron dosimetry | 40 000 |
| 5. Nuclear data for radiation damage estimates | 7 000 |
| 6. Neutron cross-sections and nuclear decay data of actinides | 50 000 |
| 7. Specific multigroup neutron cross-section data | 40 000 |
| 8. Neutron resonance parameters | 100 000 |
| 9. Nuclear structure and decay data | 350 000 |
| 10. Atomic masses | 2 000 |
| | 1 800 000 |
| Total (A+B) | 4 400 000 |

From these libraries IAEA/NDS distributes, upon request, large quantities of nuclear data in a variety of formats, ranging from small retrievals for specific data types to complete data files on magnetic tape, as well as the related documentary and descriptive information, such as catalogues, descriptions of data library formats and contents, etc. In order to advertise its services and updates or new additions to its data files, the Section sends out a Nuclear Data Newsletter a few times a year to all the customers in its service area.

Perhaps the best known publication resulting from the co-operative effort of the centres is the index to the literature on microscopic neutron data, CINDA, published annually by the IAEA on behalf of these data centres. CINDA is the result of a systematic scanning of neutron physics literature published all over the world; it represents a comprehensive and up-to-date handbook of all references on the measurement, calculation and evaluation of neutron data and has become an indispensable tool for nuclear scientists and engineers.

The CINDA compilation is fully computerized, is being kept up-to-date by the four neutron data centres, and serves also as the index to the international EXFOR library of experimental neutron data; the CINDA master file is held by the NEA Data Bank.

The Section issues three report series: the annual "Progress in Fission Product Nuclear Data" with information on activities in the field of measurements, compilations and evaluations of fission product nuclear data, the biennial "Compilations and Evaluations of Nuclear Structure and Decay Data" giving information on the availability of published compilations of nuclear structure and decay data, and the usually biennial "World Request List for Nuclear Data", WRENDA, which lists the requirements of 15–20 IAEA Member States for improved nuclear data for fission and fusion reactors and for nuclear materials safeguards.

In its function as secretariat to the INDC, IAEA/NDS co-ordinates the recording and distribution of INDC documents, consisting primarily of technical reports on nuclear data topics, which originate in the Member States. At the same time, the INDC report series is used by IAEA/NDS as a publication medium for its own reports. IAEA/NDS also sponsors the translation into English of selected USSR nuclear data publications and reports and distributes them world-wide. The proceedings of meetings convened by IAEA/NDS are normally published as IAEA Technical Reports in the IAEA-TECDOC series.

Occasionally, in the case of a widespread need for a large variety of small data sets, a handbook is the most useful data dissemination medium. This was the case with a handbook on nuclear activation cross-sections which IAEA/NDS compiled and published in 1974 Ref. [1], to meet the nuclear data requirements for the manifold applications of nuclear activation analysis techniques.

## SERVICES TO THE DEVELOPING COUNTRIES

The Agency's Nuclear Data Section acts as a focal point for the transfer of nuclear data and associated information and know-how, from the developed to those developing countries with a nuclear interest. This entails the following activities and commitments:

- dissemination of reliable nuclear data and associated information upon request with guidance for their appropriate use;
- compilation of nuclear data generated in developing countries and their international dissemination through the nuclear data centre networks;
- stimulating the creation of nuclear data committees and centres in larger developing countries (e.g. Argentina, Brazil, India, Romania);
- training of nuclear scientist Fellows from developing countries at the Agency in the build-up and use of computerized nuclear data libraries (e.g. Brazil, Romania);
- stimulation and support for the measurement and evaluation of required nuclear data through research contracts and the supply of high purity materials and isotopes needed for these measurements. So far, research laboratories in Argentina, Bangladesh, Brazil, Egypt, Greece, Hungary, India, Pakistan, Poland, Romania, Turkey and Yugoslavia have received such support;

- organization of biennial training courses, in co-operation with the International Centre for Theoretical Physics in Trieste, for nuclear scientists from 25–30 developing countries, on the use of nuclear theory for nuclear data calculations and on methods for the evaluation and computer processing of nuclear data Refs. [2, 3].

In summary, today IAEA/NDS provides cost-free data centre services to scientists in approximately forty IAEA Member States, primarily developing countries. Through these services, IAEA/NDS has developed an awareness of the needs for nuclear data in science and technology in all parts of the world.

## NUCLEAR DATA REQUIREMENTS IN NUCLEAR SCIENCE AND TECHNOLOGY

Generally speaking, an accurate knowledge of nuclear data is required wherever in science and technology nuclear reactions, radiations and isotopes are applied. Nuclear data therefore have a bearing on many nuclear programmes of the Agency and its Member States. The following sections give very brief summaries of these requirements for selected fields.

### Fission reactor design

The largest and most severe requirements for accurate nuclear data, particularly neutron cross-sections, are in the design of fission reactors. Reactor parameters such as the effective multiplication factor $K_{eff}$, critical mass, fuel enrichment, critical reactor size, neutron flux, breeding ratio, safety coefficients, kinetic and dynamic characteristics are calculated from mathematical equations in which neutron cross-sections and related nuclear data enter as basic quantities.

The answer to the question Which nuclear data are needed for fission reactors and with which priority? is determined by the material composition and the neutron energy spectrum of a given reactor. Generally speaking, neutron cross-sections are needed for all reactor materials over the whole energy range covered by the reactor neutron energy spectrum.

Reaction rates in a thermal reactor are centered between 0.01 and 1 eV; fast reactor neutrons are spread over a much larger energy range extending from eV energies to about 10 MeV, with an emphasis on energies between keV energies and several MeV.

Therefore in a thermal reactor, a knowledge of fission, capture and elastic scattering cross-sections particularly in the small energy range between 0 and 1 eV as well as the properties of the first few resonances in fertile and fissile materials is required and is crucial for the determination of the physics characteristics of the reactor.

In fast reactors, in addition to fission, capture and elastic scattering, resonance parameters over the entire resonance range, cross-sections for inelastic scattering, at higher energies (n,p), (n,$\alpha$), (n,2n), (n,3n) reactions, and the angular and energy distributions of emitted neutrons have to be known as a function of neutron energy from keV to MeV energies.

For the different variants of both thermal and fast reactors, neutron cross-sections have to be known for a large variety of materials and isotopes such as:

| | |
|---|---|
| fissile isotopes | uranium-233, 235, plutonium-239, 241; |
| fertile materials | uranium-238, plutonium-240, thorium-232; |
| structural materials | iron, chromium, nickel, zirconium; |
| cooling materials | light water, heavy water, helium, carbon dioxide, sodium; |
| moderating materials | light water, heavy water, beryllium, carbon; |
| control rod materials | boron, tantalum; |
| shielding materials | iron, lead, barium, silicon; |
| fuels | oxygen for oxide fuel, carbon for carbide fuel, |

to mention only the most important materials.

Contemporary reactor theory calculations performed with the aid of computers are so refined that they allow accurate predictions of the physics characteristics of fission reactors under the condition that the neutron cross-sections involved are available to sufficient detail and accuracy. While the low energy neutron cross-section data needed for thermal reactors are now mostly known to sufficient accuracy, fast neutron cross-sections of the major fast reactor constituents still have to be improved Ref. [4] and are being investigated particularly in countries with fast breeder reactor projects.

**Fission product and actinide waste management**

More recently, due to the growing development of nuclear programmes in many countries, comprising few to many power reactors, plants for fuel fabrication and chemical reprocessing, transport of fresh and spent nuclear fuel, etc., increasing attention is being given to the problem of accumulating fission products and actinides produced in the reactors. With the exception of some specific applications such as the use of the $\alpha$-decay of plutonium-238 and curium-244 as a heat source in nuclear batteries of earth satellites, neither fission products nor most actinides can be used further in the reactor (except for potential incineration of actinides in special purpose reactors) and have to be disposed of.

Experimental and theoretical investigations are currently being pursued in Member States on the following topics:

- build-up of fission products and actinides in reactors and their influence on reactor operation;
- release of heat after reactor shut-down, so-called afterheat, caused by $\alpha$, $\beta$ and $\gamma$-decay of fission product and actinide nuclides and by fissions induced by delayed, spontaneous fission and ($\alpha$,n) neutrons;
- short-term shielding problems of fission products and actinides during fuel handling, reprocessing and transport; and

- long-term radioactivity hazards of fission product and actinide wastes and criticality hazard of actinide waste, which represents a neutron source due to spontaneous fissions, $(\gamma,n)$ and $(\alpha,n)$-reactions.

For these investigations a large amount of accurate nuclear data is needed. The size of the requirements can be partially illustrated by the number of isotopes involved as seen from the table below.

| Type of nuclide | Total number occurring | Important |
|---|---|---|
| Fission products | 800 | $\gtrsim 50$ |
| Actinides | 200 | $\gtrsim 30$ |

Long half-lives, high yields and high capture and fission cross-sections were used as criteria in this selection. The many nuclides with short half-lives have only short-term importance, such as short-lived fission products in afterheat calculations, and are omitted from the important category.

In summary the nuclear data needs are (Ref. [4])

**inside the reactor:** all neutron cross-sections, especially capture, yields, and delayed neutron data for fission products; all neutron cross-sections, especially fission and capture, for actinides; neutron energy range: 0–15 MeV;

**outside the reactor:** $\alpha$-, $\beta$-, $\gamma$-, and spontaneous fission decay characteristics, half-lives, radiation energies and intensities for both fission products and actinides; $(\gamma,n)$ and $(\alpha,n)$ reactions, particularly in low-Z materials.

Extensive experimental and theoretical efforts are still being pursued in a number of countries to satisfy these data needs.

**Nuclear materials safeguards**

Generally speaking, the nuclear data requirements in this area pertain mostly to non-destructive assay techniques. We quote two important examples from current requirements. For accurate determinations of the isotopic composition of nuclear fuel by burn-up measurements, for example, the yields of individual keV to MeV $\gamma$-rays for selected fission products (e.g. ruthenium-103, caesium-134, lanthanum-140, caesium-144, praseodymium-144) are required to an accuracy of 1% Ref. [4]. Another example is the $\gamma$-spectrometric assay of plutonium isotopes in fuel for which the yields per $\alpha$-disintegration of individual $\gamma$-rays for the isotopes plutonium-238, 239, 240, 241 are required, again to an accuracy of 1% Ref. [4]. The available experimental yield data are still far from this accuracy.

### Fusion reactor design

In current fusion reactor research and development, the neutron data requirements by far exceed those for charged particle data. With the use of the T(d,n) reaction the fusion reactor is actually a strong source of 14 MeV neutrons with fluxes at the inner plasma wall comparable in magnitude to those of high neutron flux fission reactors. These neutrons penetrate the lithium blanket and in slowing down assume an energy distribution of which a major portion lies between 5 and 14 MeV. This energy range thus becomes of major interest. Because these neutron energies are only of very limited importance for fast breeder reactors, gaps exist in a number of reaction cross-sections which now have to be filled Ref. [4]. (n,p), (n,d), (n,$\alpha$), (n,T), (n, $^{3}$He), (n,2n) reactions as well as the angular and energy distributions of the emitted secondary particles become important. The materials for which these and other data are needed (for the calculation of neutron economy, radiation damage and transmutation rates) are mostly structural materials suggested for use in a fusion reactor, such as titanium, vanadium, chromium, manganese, iron, nickel, zirconium, niobium, molybdenum and tungsten. Of particular interest is the (n,2n) reaction in first wall materials because it leads to a multiplication of the neutrons available for tritium breeding in the lithium blanket. Tritium is produced in the blanket by the reactions $^{6}$Li (n,$\alpha$)T and $^{7}$Li (n,n'$\alpha$)T.

Much work is presently going on to determine accurately the neutron energy dependence of these and the many competing reactions between neutrons and the two lithium isotopes in the MeV neutron energy range. Current accuracy requirements for the most important breeding reaction, $^{7}$Li(n,n'$\alpha$)T, are about 5–10% Ref. [4]; the available experimental data are still accurate only to about 25%, thus affecting strongly the results of tritium breeding predictions.

## NUCLEAR DATA REQUIREMENTS FOR NUCLEAR SCIENCE APPLICATIONS OF ISOTOPES AND RADIATIONS

In contrast to the rather compact requirements for nuclear energy purposes, the requirements for nuclear scientific applications are more heterogeneous and widespread; their size becomes large due to the large variety of applications. Nuclear data requirements have appeared in such diverse fields as medical nuclear dosimetry, diagnostics and therapy, nuclear chemistry, geoscience, archaeology, hydrology, environmental research, and astrophysics Ref. [5]. Several of the more important applications, and their use of nuclear data, are discussed below.

### Nuclear activation analysis

In this analytic method, nuclear activation cross-sections for neutrons, charged particles and photons, data on half-lives, and the energies and intensities of the emitted secondary radiations have to be known. As one out of many examples we mention the project of the IAEA Department of Research and Isotopes on neutron activation analysis of pollutants in human hair to measure the degree of environmental pollution by poisonous non-radioactive substances. For this project, best values of neutron activation cross-sections, half-lives, and $\gamma$-ray energies and intensities were needed for all isotopes of the following elements: arsenic, silver, bromine, cadmium, chlorine, copper, mercury, potassium, manganese, sodium, antimony, selenium and zinc.

**Tracer techniques**

Tracer techniques require a knowledge of the half-lives and characteristic decay properties of the radioisotopes used as tracers. Out of many possible examples, we quote the use of tritium and other radioisotopes in surface water hydrological investigations and the use of iodine radioisotopes in medical diagnostics.

**Radioisotope production**

To estimate and optimize the production rate and purity of a desired radioisotope one has to consider all the reactions which lead to this isotope while taking into account competing reactions leading to other unwanted isotopes. An example is the production of pure plutonium-238 which is used as a heat source for thermoelectric conversion in heart pace-makers Ref. [5]. Plutonium-238 can be produced by neutron irradiation of neptunium-237 in a reactor according to the reaction

$$^{237}\mathrm{Np}(n,\gamma)^{238}\mathrm{Np} \xrightarrow{\beta^-} {}^{238}\mathrm{Pu}.$$

Competing reactions such as

$^{237}\mathrm{Np}(n,2n)^{236}\mathrm{Np}$ and
$^{237}\mathrm{Np}(\gamma,n)^{236}\mathrm{Np}$

occur simultaneously and lead through $\beta$-decay of neptunium-236 to plutonium-236. This isotope is an undesirable by-product because it emits more energetic $\gamma$-radiation of higher intensity than does plutonium-238 whose $\gamma$-radiation is mostly at energies below 150 keV and can easily be shielded. The neutron irradiation energy thus has to be optimized so that plutonium-236 is produced only at the tolerable minimum. To calculate the optimum irradiation conditions, the cross-sections of the above mentioned reactions with the surrounding reactor materials have to be known.

**Nuclear particle irradiations**

In nuclear irradiations, the cross-sections for the interactions of the incident nuclear particles with the nuclei of the specimen to be irradiated have to be known as well as the angular and energy distributions of emitted particles and radiations resulting from these interactions.

As an example we quote a typical biomedical application, i.e. cancer therapy by neutron irradiation of the afflicted tissue. Cyclotrons are used to produce the neutrons, typically by the $^{9}\mathrm{Be}(d,n)$ reaction. The cross-section for this reaction and the yields, angular and energy distributions of the emitted neutrons need to be known for a variety of target thicknesses and for deuteron energies up to about 50 MeV. Moreover, cross-sections and secondary particle distributions are needed for all possible interactions of 15–50 MeV neutrons, produced in the $^9Be(d,n)$ reaction, with the major constituents of the human body, (hydrogen, carbon, nitrogen, oxygen, phosphorus and calcium) in order to predict the radiation dose distributions in the irradiated part of the body. Particularly the neutron data are still largely lacking.

## ASSESSMENT OF NUCLEAR DATA STATUS AND REQUIREMENTS

As a consequence of these increasing demands for accurate nuclear data by the scientific and technical community, a world-wide co-operative effort among nuclear data centres, research laboratories and nuclear data users has been established over the past 20 years, under the guidance of national, regional and international nuclear data committees. This effort aims to identify and evaluate critically the needs for nuclear data, and to initiate, support and co-ordinate the systematic generation and dissemination of the required data.

## WRENDA: WORLD REQUEST LIST FOR NUCLEAR DATA

One aspect of this co-operative effort has been the establishment of a computer-based world request list for nuclear data, called WRENDA. IAEA/NDS maintains the WRENDA master file, updates it with the input supplied by 15–20 IAEA Member States, and publishes it at biennial intervals on behalf of the four data centres. The most recent issue, WRENDA 79/80 Ref. [4], contains close to 1800 requests for measurements and evaluations of (primarily neutron) nuclear data, requests which were originated by members of the fission reactor, fusion reactor, and safeguards development communities and critically reviewed and selected by national nuclear data committees before submission to the IAEA. The status of requested standard reference and other data of crucial importance are under continuous review by the Agency's INDC and the OECD Nuclear Energy Agency's Nuclear Data Committee (NEANDC).

In this list, each individual request provides information on the requested parameter of a specific nuclide, the energy range of interest, the required accuracy and priority, and the origin and justification of the request.

A typical request is the following:

| | |
|---|---|
| Requested quantity: | 3 Lithium 6 (n,triton) Alpha |
| Energy: | 1 keV–3 MeV |
| Accuracy: | 1% |
| Priority: | 1 |
| Country: | USA |
| Requestor: | C.E. Till, Argonne National Laboratory<br>P.B. Hemmig, US Department of Energy |
| Comments: | Accuracy of 3% useful; energy resolution must reproduce true shape. |
| Justification: | For use as a standard. |

The following table gives a breakdown of the WRENDA 79/80 requests into the major application areas in comparison to the previous edition, WRENDA 76/77.

| Application area | WRENDA 76/77 | WRENDA 79/80 |
|---|---|---|
| Fission | 1194 | 1210 |
| Fusion | 328 | 449 |
| Safeguards | 150 | 121 |
| Total | 1672 | 1780 |

For fission reactors the number of requests has remained almost constant; while the number of nuclear data requests for fission products has been reduced, an increase in requests is noted for radiation damage, shielding and secondary actinides. The only other substantial change in the number of requests is in the field of nuclear fusion, i.e. an increase by more than 100 requests, reflecting the increasing interest in fusion. The request turnover from the previous edition, however, is rather considerable: from WRENDA 76/77, 465 requests were withdrawn and 487 requests modified; 573 requests, i.e. roughly one third, are new.

The WRENDA request list, aside from identifying specific gaps in the required nuclear data, has the advantage of giving a concise summary in one place of current requirements for nuclear data and has proven to be very useful in the stimulation and co-ordination of nuclear data measurements. It is also being used by IAEA/NDS as justification for the support of nuclear data measurements in smaller and developing countries.

## SCIENTIFIC MEETINGS

A further means of ascertaining comprehensively the current needs of nuclear data in a specific field of application and the extent to which these needs are satisfied, is through various types of scientific meetings. In such meetings, IAEA/NDS brings together users and producers of nuclear data. Topics which have been reviewed at recent meetings are: fission product nuclear data Refs. [6, 7], transactinium isotope nuclear data Refs. [8, 9], nuclear data for nuclear reactor dosimetry Ref. [10] and nuclear data for fusion reactor technology Ref. [11].

In addition to these meetings which are specifically designed for the simultaneous assessment of data status and needs, IAEA/NDS also convenes conventional scientific meetings with the object of reviewing a given nuclear data topic or field(s) of application. These meetings have ranged from large conferences such as the conferences on Neutron Data for Reactors in 1966 and 1970 Refs. [12, 13] and on Nuclear Data for Science and Technology in 1973 Ref. [5], through medium-sized specialists' meetings on nuclear data standards Refs. [14, 15], data compilation and evaluation Refs. [16, 17] and neutron source properties Ref. [18], to small consultants' meetings Refs. [19, 20, 21].

## NUCLEAR DATA RESEARCH CO-ORDINATION AND SUPPORT BY IAEA/NDS

Within the context of the IAEA's statutory responsibility to assist Member States in advancing the peaceful uses of atomic energy, IAEA/NDS has over the last 10 years supported research programmes, whereby it can allocate funds for the measurement and evaluation of nuclear data. These activities range from individual research contracts and agreements with single research groups to co-ordinated research programmes with the participation of a number of laboratories from developing as well as developed countries. The recommendations of the INDC, the conclusions and recommendations of scientific meetings held by IAEA/NDS and the WRENDA request lists are being used as the basic background material for decisions relating to the support and co-ordination of this research.

As a consequence of recommendations by the Agency's first Advisory Group Meeting on Transactinium Isotope Nuclear Data Ref. [8], two co-ordinated research programmes were initiated in 1977 with the participation of eight developed countries (Federal Republic of Germany, France, Italy, Japan, Sweden, UK, USA and USSR), three developing countries (India, Israel and Romania) and one international organization (the Central Bureau for Nuclear Measurements of the Commission of the European Communities). The subject of the first of these two programmes is to compare the methods and results of different evaluations of actinide neutron nuclear data. It has the two-fold objective of improving the accuracy of actinide neutron data evaluations, required for the reliable computation of actinide build-up and burnup in fission reactors, and of training participants from developing countries in the evaluation of those data of particular interest in their own nuclear energy programmes. Evaluations produced by the participants are compiled in the IAEA Nuclear Data Library for Actinides.

The second programme consists of the measurement and evaluation of decay parameters (half lives, $\alpha$- and $\gamma$-spectra) of actinide isotopes. This programme aims to produce highly accurate and consistent sets of decay data to meet the requirements in nuclear fuel analysis, safeguards applications, mass determination and the preparation and application of radioisotope standards.

## FUTURE DIRECTIONS

As developing countries become more involved in nuclear power and applications of nuclear science, the scientific and technical capabilities of these countries will need to be strengthened. This will demand an increased effort in the transfer of technologies and know-how required for nuclear measurements and in the training of scientists in developing countries in nuclear methods and techniques. It will also demand better co-ordination of the isolated and dispersed research efforts that are found in many of these countries. As identified in the last WRENDA publication, a large body of work still remains to be done in certain areas of nuclear data. The significant value of nuclear data measurements for the training of nuclear scientists in widely applicable nuclear methods and techniques, and the availability of relevant measurement facilities in a number of developing countries suggest for the future, more extensive co-operation on an interregional basis. This would include the twinning of research groups in developing and developed countries in common, useful and required nuclear data research work.

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