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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

Report of the

IAEA Nuclear Data Section

to the

International Nuclear Data Committee

July 1990 - December 1992

Abstract: This progress report by the IAEA Nuclear Data Section, which covers the period from July 1990 to December 1992, is submitted to the 19th Meeting of the International Nuclear Data Committee in Vienna, 8-12 March 1993.

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Editors

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INTRODUCTION

The 18th Meeting of the International Nuclear Data Committee (INDC) took place in Vienna, 15-19 October 1990.

References: INDC(NDS)-239/LNA
Report of the Nuclear Data Section to the INDC

INDC/P(91)-1 (July 1991)
Minutes of the 18th INDC Meeting (A.J. Deruytter, ed.)

According to the traditional 18-months cycle, the 19th INDC Meeting had been scheduled for the spring of 1992. At that time, however, the posts of the Head of the Nuclear Data Section (J.J. Schmidt) and of the Deputy Head (D.W. Muir) were vacant, and it was decided to postpone the meeting and hold it only after these two essential posts would be occupied again. Unfortunately, these posts remained vacant for a longer period than expected.

Meanwhile the Agency encountered the need to review its programmes, and the 19th INDC Meeting was scheduled for the week 8-12 March 1993, although the leading positions of the Nuclear Data Section were still vacant.

The staff of the Nuclear Data Section prepared the present report at rather short notice. It is submitted to the INDC in a preliminary form, of which the final printed version will become available only after the Meeting.

The staff wishes to express its sincere gratitude to Dr. J.J. Schmidt who was the Head of the Nuclear Data Section for more than 22 years from 1969 to 1992. As most of the INDC members have co-operated with him for many years, it is not necessary to explain here Joe Schmidt's merits for the development and implementation of the Agency's nuclear data programme.

The staff welcomes the recent decision that Dr. C.L. Dunford from the US National Nuclear Data Center has been nominated as the new Section Head, though he will not yet be in office at the time of the INDC Meeting. There has always been an excellent co-operation with NNDC. Recently Charlie Dunford installed the NNDC on-line nuclear data system on the Agency's new VAX computer. To obtain this computer, was one of the merits of Dr. D. Muir who was the Deputy Head of the Section until spring 1992 and whose efforts for the Section the staff wishes to acknowledge.

CONTENTS

C. CO-ORDINATION OF NUCLEAR DATA CENTERS

D. THE IAEA NUCLEAR DATA CENTER

E. COMPUTER

GLOSSARY OF ABBREVIATIONS

A+M	Atomic and Molecular Data for fusion applications
AGM	Advisory Group Meeting of the IAEA
BNL	Brookhaven National Laboratory, Upton, N.Y., USA
BROND-2	Russian evaluated neutron reaction data library
CAJaD	Center for Nuclear Structure and Reaction Data, Kurchatov Institute, Moscow, Russia
CDFE	Centr Dannykh Fotojad. Eksp., Moscow State University, Russia
CENDL-2	Chinese evaluated neutron reaction data library
CINDA	A specialized bibliography and data index on neutron nuclear data operated jointly by NNDC, NEA-DB, NDS and CJD
CJD	USSR Nuclear Data Center at F.E.I., Obninsk, Russia
CNDC	Chinese Nuclear Data Center, Beijing, P.R. China
CP...	Numbering code for memos exchanged among the NRDC
CPND	Charged-particle nuclear reaction data
CRP	Coordinated Research Programme of the IAEA Nuclear Data Section
CSEWG	US Cross-Section Evaluation Working Group
CSISRS	Cross-Section Information Storage and Retrieval System, the EXFOR-compatible internal system of NNDC
EFF	European evaluated nuclear data file for fusion applications
ENDF-6	International format for evaluated data exchange, version 6
ENDF/B-6	US Evaluated Nuclear Data File, version 6
ENSDF	Evaluated Nuclear Structure Data File
EXFOR	Format for the international exchange of nuclear reaction data
FEI	Fiziko-Energeticheskij Institut, Obninsk, Russia
FENDL	Evaluated nuclear data file for fusion applications, developed by IAEA-NDS
FPND	Fission-product nuclear data
IAEA	International Atomic Energy Agency
IFRC	Intenational Fusion Research Council
INDC	International Nuclear Data Committee
INIS	International Nuclear Information System, a bibliographic system
IRDF	The International Reactor Dosimetry File, maintained by the IAEA-NDS
ITER	International Thermonuclear Experimental Reactor

JAERI	Japan Atomic Energy Research Institute
JCPRG	Japan Charged-Particle Nuclear Reaction Data Group, Sapporo, Japan
JEF	The Joint Evaluated File of neutron data, a collaboration of European NEA member countries and Japan
JENDL-3	Japanese evaluated neutron reaction data library
LEXFOR	Part of the EXFOR manual containing physics information for compilers
NDS	IAEA Nuclear Data Section, Vienna, Austria
NEA	Nuclear Energy Agency of the OECD, Paris, France
NEA-DB	NEA Data Bank, Saclay, France
NEANDC	NEA Nuclear Data Committee, discontinued, see NSC
NND	Neutron Nuclear Data
NNDC	National Nuclear Data Center, Brookhaven National Laboratory, USA
NNDEN	Neutron Nuclear Data Evaluation Newsletter
NRDC	the Nuclear Reaction Data Centers
NSC	Nuclear Science Committee of NEA
NSDD	Nuclear structure and decay data
NSR	Nuclear structure references, a bibliographic system
OECD	Organization for Economic Cooperation and Development, Paris, France
PC	Personal Computer
PhND	Photonuclear data
RCM	Research Co-ordination Meeting
RI	Radievyj Institut, Sankt Peterburg, Russia
RIKEN	Nuclear Data Group, RIKEN Inst. of Phys. and Chem. Res., Wako-Shi, Saitama, Japan
SG,SGIP	Study Group for Information Processing, Sapporo, Japan. Changed to JCPRG
TRANS	Name of transmission tapes for data exchange in the EXFOR system
WRENDA	World Request List for Nuclear Data
4C...	Numbering code of memos exchanged among the four Neutron Data Centers

PART I: NUCLEAR DATA

A. SCIENTIFIC MEETINGS

This chapter includes summaries on scientific meetings for nuclear data assessment. See chapter B. for research co-ordination meetings and chapter C. for data centre co-ordination meetings.

A.1. Nuclear Data for Neutron Multiplication in Fusion-Reactor First-Wall and Blanket Materials (AGM, Chengdu, China, 19-21 November 1990)

The IAEA Advisory Group Meeting on Nuclear Data for Neutron Multiplication in Fusion-Reactor First-Wall and Blanket Materials was hosted by the Southwest Institute November 1990. This AGM was organized by the IAEA Nuclear Data Section (NDS), with the cooperation and assistance of local organizers at the SWINPC.

This meeting was convened in response to a recommendation of the Second IAEA Specialists' Meeting on the Fusion Evaluated Nuclear Data Library (FENDL), held in Vienna from 8 to 11 May 1989. The basic objective of the meeting was to assess the status of nuclear data important to the calculation of neutron multiplication and net tritium breeding in fusion reactors. Therefore special emphasis was placed on the discussion of past and future integral experiments using 14 MeV neutron sources and on the potential value of such experiments in testing and improving the relevant nuclear data.

A major overall conclusion of the meeting was that integral measurements and theoretical predictions are now approaching consistency, at least with the stated uncertainties in the measurements and in the basic data that underly the predictions. In this sense, the previously worrisome "discrepancies" between predictions and measurements of beryllium multiplication have been resolved. Even so, unexplained differences of 5 to 10% still exist between the two most recent measurements of thick-sphere neutron multiplication in beryllium (namely, those in the United States and in China). In addition there are 3-5% differences between the latest predictions, on the one hand, and the best measurements of multiplication in lead, possibly attributable to deficiencies in the microscopic data. Also, participants noted the lack of covariance data in many of the important data evaluations, and solicited help from data evaluators to improve this situation.

Participants strongly recommended the processing and international distribution of the Fusion Evaluated Nuclear Data Library (FENDL), to serve as a unique reference data file. Another important recommendation was that the IAEA Nuclear Data Section collect and distribute a series of documents describing, in a consistent format, high-quality experimental fusion-relevant benchmark experiments. These documents

should be produced by the responsible experimental groups and then reviewed for completeness and consistency by the Nuclear Data Section. A short summary of the meeting was published in the report by D.W. Muir and A.B. Pashchenko INDC(NDS)-264/G.

A.2. Reference Nuclear Parameter Library for Nuclear Data Computation (Consultants' Meeting, Vienna, Austria, 13-15 November 1991)

The IAEA Consultants' Meeting on "Reference Nuclear Parameter Library for Nuclear Data Computation" was convened by the International Atomic Energy Agency in order to provide the Agency with technical advice on its plan to assemble a reference library of nuclear-model input parameters. A second topic of discussion was the availability, validation and documentation of modern nuclear reaction model codes, especially codes that are suitable for use in the developing countries.

Since the project to create a reference library of parameters is still at a very early stage, it was necessary to review in broad terms the needs of the data modelling and evaluation community, the opportunities provided by recent advances in both physics and computers, and the difficulties that may impede future progress.

The scope of the meeting included both

- solutions that are practical immediately or in a short time and that are based on selected methodologies, codes and parameterizations currently in use;

- proposals for solutions, to be pursued over a longer time period, aimed at providing better physical understanding of nuclear-reaction phenomena.

Accordingly, a number of practical steps and actions have been proposed, to be taken under the guidance and/or under the sponsorship of the Agency.

More details about the meeting can be found in the report INDC(NDS)-266/G by G. Reffo et al.

A.3. FENDL-2 and Associated Benchmark Calculations (Advisory Group Meeting, Vienna, Austria, 18-22 November 1991)

Following the recommendation of the 18th INDC Meeting, the IAEA Nuclear Data Section convened an Advisory Group Meeting on "FENDL-2 and Associated Benchmark Calculations" at the IAEA Headquarters in Vienna on 18-22 November 1991.

The scope of the AGM was considered at the IAEA Consultants' Meeting on "First Results of FENDL-1 Testing and Start of FENDL-2", Vienna, 25-28 June 1990.

The objectives of the AGM were the following:

(i) to review present evaluation activities and future plans in the area of application to fusion research,

(ii) to discuss multigroup processing issues and benchmark testing of FENDL-1,

(iii) to discuss the results of the International Comparison Study of Fusion Activation Calculations,

(iv) to identify the sources of activation cross-section and decay data for inclusion in the FENDL-2 activation library,

(v) to discuss the comparison of new charged-particle evaluations for fusion application and approve charged-particle nuclear data for incorporation into FENDL-2,

(vi) to discuss opportunities for future co-operation with regional and national fusion-relevant nuclear data programmes.

The Meeting was attended by 27 leading experts from the major national programmes on fusion research (US, EC, The Russian Federation, Japan) and corresponding ITER home teams.

Considering the progress in the development of the Fusion Evaluated Nuclear Data Library and in view of the urgent need for one consistent evaluated nuclear data library such as FENDL for the Engineering Design Activity phase of ITER and other fusion reactor projects, the Advisory Group recommended to the Agency to issue FENDL-1 by July 1992 and to make it available to ITER and other fusion reactor projects.

The main conclusion of the Meeting was that, despite the significant progress in the development of the nuclear data base, FENDL-1 is still not adequate to fulfill all demands of fusion reactor design activities.

The Advisory Group strongly recommended that, after the completion of FENDL-1, the FENDL-related activities be continued and an improved version of FENDL-1, i.e., FENDL-2, be established.

The Advisory Group emphasized that the improvements in the FENDL files and the reduction of the data uncertainties resulting from these efforts will lead to significant cost savings, for example for the ITER project, by reducing the engineering safety margins related to the uncertainties in the basic nuclear data.

A summary of the meeting was published in a report by A.B. Pashchenko and D.W. Muir in INDC(NDS)-260/L+F.

A.4. Advisory Group Meeting on Nuclear Data Requirements for Fission Reactor Decommissioning

The meeting took place in Vienna from 7 to 11 September 1992 and was attended by 12 participants from 8 Member States and 2 International Organizations. The participants have stressed that the key aspect in the development of methodologies for the decommissioning of nuclear reactors is a knowledge of the radioactive inventory. The radioactive inventory external to the fuel assemblies (which are removed before decommissioning) is produced from activation arising from neutron reactions with the materials from which the components are made and from contamination of the surfaces of components. The activity levels and their distribution dictate the design of equipment and procedures for decommissioning. The participants reviewed uncertainties in the results of radioactive inventory calculations arising from different factors: neutron flux calculations, uncertainties in specifiactions of material compositions, computer codes and nuclear data.

Activation reactions important for determination of the radiation field (γ-emitters) and reactions important for waste disposal were identified. It was recommended that the Nuclear Data Section prepare a starting set of data (special library) in fine group structure broadened to different temperatures for these reactions.

It was also noted that the use of the *ORIGEN* code for activity calculations is not justified in the locations remote from the reactor vessel. It was recommended to look for a possibility of creating a new code for calculations of activities at the out-of-core locations. Such a code should allow for the arbitrary number of energy groups and a detailed power history input.

It was acknowledged that the feasibility and accuracy of different cross-section data sets and of different calculation methods should be tested by a benchmark study, based either on experimental data for a real reactor inventory, or on a simplified model of a real reactor for which such data is available. It was agreed that the most complete set of measured activation data exists now for the JPDR reactor in JAERI. It was recommended to evaluate the applicability of the JPDR data on PV steels and concretes as a benchmark for the accuracy of calculations and, if appropriate, to distribute these data for test purposes.

A.5. Consultants' Meeting on Charged-particle and Photonuclear Data Libraries for FENDL (8-9 October 1992, Brookhaven National Laboratory, Upton, NY, USA)

This meeting was organized in response to a recommendation of the IAEA AGM on "FENDL-2 and Associated Benchmark Calculations", held in Vienna from 18-20 November 1991. The meeting was organized by the IAEA Nuclear Data Section with co-operation and assistance of local organizers from the Lawrence Livermore National Laboratory and the US National Nuclear Data Center adjacent to the BNL-92

Symposium on Nuclear Data Evaluation Methodology in the Brookhaven National Laboratory in order to maximize the interactions between the data developers and users.

The basic objective of the meeting was to assess the requirements, present status and availability of evaluated charged-particle and photonuclear data files for the IAEA Fusion Evaluated Nuclear Data Library (FENDL) Project. Therefore, special emphasis was placed on the discussion of the discrepancies revealed in thermonuclear reaction cross-sections for helium and hydrogen isotopes from most important CPNDL files - *ECPL-86* (Lawrence Livermore National Laboratory) and ECPNDL (Institute of Experimental Physics, Arzamas) with the purpose to come to an agreement on the verification of CPNDL files.

The meeting was attended by 16 scientists from 6 Member States.

A major overall conclusion of the meeting was that the ENDF/B-VI charged-particle sublibrary of the important energy-producing charged-particle reactions for fusion energy application, i.e. $D(d,n)^3He$, $D(d,p)T$, $T(d,n)^4He$, $T(t,2n)^4He$ and $^3He(d,p)^4He$, be adopted for the FENDL project. However, a difference of $\sim 4\%$ still exists in the low-energy cross section for the $T(d,n)^4He$ reaction, which is larger than the uncertainty placed on this cross section by the evaluators. The participants recommend that the $T(d,n)^4He$ reaction be investigated at low energy by evaluators from three laboratories (Arzamas, Russia; Los Alamos and Livermore, USA) so that it can be resolved. Also, participants recommend that the FENDL library be expanded to include angular distribution data for the reactions listed above and integrated cross sections and angular distributions of the reactions between the isotopes of hydrogen and lithium, beryllium and boron. In addition it was recommended that the ENDF/B-VI format extension for charged-particle representation be adopted.

The participants noted that the analysis of nuclear processes for the International Thermonuclear Experimental Reactor (ITER) Project shows the necessity to take into account photonuclear reactions produced by high-energy photons. The principal sources of these photons are reactions of radiative capture of charged particles in the plasma ($E_\gamma < 21$ MeV), and inelastic scattering of neutrons from the DT reaction ($E_\gamma < 14$ MeV). Therefore, another important recommendation was that the library of photonuclear data for energies up to 25 MeV should be prepared for incorporation into FENDL for the structural, superconducting and shielding materials for ITER.

Finally, the participants noted that new experimental, evaluational and theoretical efforts have been started or are planned in several countries in the area of Evaluation of Charged-particle and Photonuclear Data for Fission and Fusion Application, and the co-ordination of these efforts by the Agency appears to be very timely and desirable. So the Consultants' Meeting recommended that the IAEA should set up a new Co-ordinated Research Programme on this topic to support the Agency's FENDL project.

More details about the meeting can be found in the summary report INDC(NDS)-268/G by A.B. Pashchenko.

A.6. Consultants' Meeting on Nuclear Data for Neutron Emission in the Fission Process, Vienna, Austria, 22-24 October 1990

Upon recommendation of the International Nuclear Data Committee, the IAEA convened a Consultants' Meeting on Nuclear Data for Neutron Emission in the Fission Process. The meeting took place in Vienna, Austria, 22-24 October 1990.

The papers presented in the meeting reviewed the status of experimental and theoretical data on neutron emission in spontaneous and neutron induced fission with reference to the data needs for reactor applications, and, discussed methods of calculations of neutron data for unknown cases for minor actinides etc. The specific topics that were covered in the meeting by participants from Australia, China, France, Germany, India, Japan, former USSR and USA include experimental measurements and theoretical predictions and evaluations of fission neutron energy spectra, average prompt fission neutron multiplicity, correlation in neutron emission from complementary fragments, neutron emission during acceleration of fission fragments, statistical properties of neutron rich nuclei by study of emission spectra of neutrons from the excited fission fragments, integral qualification of nu-bar for the major fissile isotopes, nu-bar total of ^{239}Pu and ^{235}U, and related problems. The participants of the meeting formulated and established the specific tasks and goals for a new Co-ordinated Research Programme on "Physics of Fission Neutron Emission and its Nuclear Data Applications". The CRP has been proposed as INDC/P-paper (Ref. INDC/P(93)-26) to the 19th INDC Meeting. The papers presented in the meeting, summary, conclusions and recommendations have been published as report INDC(NDS)-251/l in November 1991.

B. RESEARCH CO-ORDINATION MEETINGS

B.1. 3rd IAEA CRP Meeting on Nuclear Data Needed for Neutron Therapy, Brussels, Belgium, 8-11 January 1990

This was the final meeting of the CRP, which was attended by 10 participants from 7 countries. The goal of the meeting was to review the material for the technical IAEA report providing up-to-date information on the status and needs of nuclear data for neutron therapy. The report is intended to be of use to both the radiation therapists who need these data and the nuclear physicists who produce them.

The document includes the following information:

- Present status of fast neutron therapy - a survey of the clinical data and of the clinical research programmes.
- Protocols for the determination of absorbed dose in mixed neutron-photon beams.
- Neutron source reactions.
- Collimation and shielding.
- Microscopic data and kerma factors.
- Absorbed dose and radiation quality.
- Conclusions and recommendations.
- Calculated kerma factors from LLNL evaluated neutron data library.

It is stressed that the differential between the dose necessary to kill the tumor and that which is unacceptable to the patient is less than 5%. It is also stated that the highest priority nuclear data requirements for dose determination at present are measurements of the oxygen kerma factor for neutrons in the energy range 20 to 70 MeV.

The text of the final report is being edited.

B.2. 2nd IAEA CRP Meeting on Atomic and Molecular Data for Radiotherapy

The meeting took place in Brussels from 14 to 17 January 1991. 19 participants from 10 countries and two International Organizations attended the meeting. The participants of the CRP are working on the preparation of the Handbook on Atomic and Molecular Data for Radiotherapy to be published by the IAEA upon completion.

The contents of the book was discussed and the drafts for separate chapters were reviewed.

It was agreed that the Handbook will contain the following material:

Chapter 1. Development of charged-particle therapy and requirements for atomic and molecular data.

Chapter 2. Ionization cross-sections for charged particles.

Chapter 3. Electron-collision cross sections.
Chapter 4. Low-energy electron interactions with condensed matter.
Chapter 5. Photoabsorption, photoionization and photodissociation.
Chapter 6. Rapid conversion of initial ions and excited species in collision with other molecules.
Chapter 7. Stopping powers, ranges and straggling.
Chapter 8. Yields of ions and excited species.
Chapter 9. Track structure quantities.

The schedule for the completion of the Handbook was agreed upon. The final meeting of this CRP was scheduled for June 1992 but due to budgetary limitations in the IAEA was later deferred to June 1993. It is planned to stop all activity in this field after publication of this Handbook.

B.3. Compilation and Evaluation of Fission Yield Nuclear Data (RCM, Vienna, 2-4 October 1991)

Following a recommendation of a previous meeting on the subject (see last progress report, INDC(NDS)-239, page 21); meeting summary published as INDC(NDS)-261), a Co-ordinated Research Programme (CRP) on the Compilation and Evaluation of Fission Yield Nuclear Data commenced mid 1991. The first Research Coordination Meeting (RCM) was attended by the 7 CRP members and 2 observers who also cooperate in the CRP. The group included all the main evaluators in the field.

At the RCM, the problems in fission yield measurements, compilation and evaluation, were discussed, the progress since the previous meeting was reviewed, and improvements were proposed. The CRP tasks as defined at the previous meeting and during the discussions were distributed among participants. Some of the most important tasks are:

- further development of semi-empirical models for the prediction of unmeasured or unmeasurable fission yields;

- resolution of discrepancies among measured data;

- evaluation of fission yields as a function of incident neutron energy;

- introduction of correlations and covariances in the evaluation process.

A review paper by M. Lammer, presented at the NEANSC Specialists' Meeting on Fission Product Nuclear Data at JAERI, Japan (25-27 May 1992), included a description of the CRP work as well as all the conclusions and recommendations and the tables of discrepant and/or unmeasured yield data issued by CRP participants. The review paper will be included in the meeting proceedings. It will also be distributed at the INDC meeting as paper INDC/P(93)-21.

B.4. CRP on Activation Cross-Sections for the Generation of Long-lived Radionuclides

The first Research Co-ordination Meeting (RCM) of the IAEA Co-ordinated Research Programme (CRP) on activation cross sections for the generation of long-lived radionuclides of importance in fusion reactor technology was convened by the IAEA Nuclear Data Section in Vienna, from 11-12 November 1991. The summary report has been issued as INDC(NDS)-263/G+Sp (July 1992).

The second RCM will be convened in San Diego, California, U.S.A. on 19-20 April 1993.

B.5. CRP on Measurement and Analysis of 14 MeV Neutron Induced Double-Differential Neutron Emission Cross-Sections

The third (final) Research Co-ordination Meeting of the IAEA CRP on Measurement and Analysis of 14 MeV Neutron-Induced Double-Differential Neutron Emission Cross Sections (DDCS) needed for Fission and Fusion Reactor Technology was held at Chiang Mai, Thailand, during 31 March - 2 April 1992.

The summary report will be published as INDC(NDS)-272 in April 1993.

The objectives of the CRP were to improve the current status of data for 14 MeV neutron-induced DDCS of Li-6, Li-7, Be-9, V, Cr, Fe, Nb, Mo, W, Ta, U-238 and Bi. Under the CRP, the DDCS data for all above nuclei have been measured and re-evaluated. It is concluded that the objectives of the CRP are fulfilled. The CRP has been closed. All the new data are strongly recommended to the FENDL nuclear data library for the ITER project.

B.6. Improvement of Measurements, Theoretical Computations and Evaluation of Neutron Induced Helium Production Cross Sections (RCM, Debrecen, Hungary, 17-19 November 1992)

The Co-ordinated Research Programme on "Improvement of Measurements, Theoretical Computations and Evaluations of Neutron Induced Helium Production Cross Sections" was established following the recommendations of the 18th INDC Meeting and the IAEA scientific programme with the goal to provide an improved base of neutron-induced He-production data to the International Thermonuclear Experimental Reactor (ITER) Project and other national and regional fusion reactor projects as required for the development of radiation-resistant and low-activation structural materials for fusion reactor technology.

To reach this goal will require the following three types of research activities:

(i) improvement of the theoretical models and their parameterization for the computation of (n,Xα) data;

(ii) extension of the base of experimental (n,Xα) data by precise measurements between reaction threshold (several MeV) and 15 MeV neutron energy; and

(iii) improvement of existing and production of new (n,Xα) data evaluations.

The objectives of this first meeting were:

- to review the theoretical models and their parameterization for the computation of (n,Xα) data;

- to discuss the results of measurements obtained so far by participating institutes;

- to review the status and remaining gaps in the required data and, if necessary, identify further measurements and calculations needed to fill these gaps; and

- to develop a detailed work-plan for the Co-ordinated Research Programme.

The RCM was attended by 25 scientists from 10 Member States.

The main objectives of the first CRP Meeting have been achieved to a large extent and, as a result of discussions, the next steps in the work programme under the CRP have been worked out.

A short summary was published in a report by A.B. Pashchenko as INDC(NDS)-273/L, 1993.

C. *CO-ORDINATION OF NUCLEAR DATA CENTERS*

NDS has the double function of

- co-ordinating national and regional nuclear data centers, and
- operating a nuclear data center for countries outside OECD and former USSR.

The co-ordinative function is described in the present chapter. The functions of the IAEA Nuclear Data Center are described in chapter D.

C.1. Nuclear Reaction Data

The following data center co-ordination meetings took place in the reporting period

- Vienna, 13-15 November 1990. Technical meeting without center heads. For the Minutes see Memo CP-D/210.
- Obninsk, 7-11 October 1991. Meeting of center heads, and technical meeting. For the Minutes see report INDC(NDS)-262.
- Vienna, 1-3 September 1992. Technical meeting without center heads. For the Conclusions and Actions see Memo CP-D/230. The Minutes will be issued as an INDC report.
- The next meeting is scheduled to take place in Paris, 18-22 October 1993 as a full meeting will center heads and technical staff.

The status of these meetings had to be upgraded to "Advisory Group Meetings" in order to provide funding for the attendance of the Russian centers and the Chinese center. Nevertheless, the Agency could pay for two Russian centers only so that the attendance of the Moscow Photonuclear Data Center (V. Varlamov) could not be accomplished.

The present network of Nuclear Reaction Data Centers is given in Table C.1. Ten of the eleven centres listed contributed to the data compilation in EXFOR. The eleventh, i.e. JAERI, has been included for its contribution of evaluated data (JENDL-3).

The main problem with which the nuclear reaction data centers are confronted, is the adverse manpower situation. See also INDC/P(93)-9 for a paper on Nuclear Data Statistics.

Table C.1

The network of Nuclear Data Centers

National and regional nuclear reaction data centers, co-ordinated by the International Atomic Energy Agency, co-operate in the compilation, exchange and dissemination of nuclear reaction data, in order to meet the requirements of nuclear data users in all countries. A brief summary of the data centers network is given below.

The nuclear reaction data centers:

NNDC	-	US National Nuclear Data Center, Brookhaven, USA
NEA-DB	-	OECD/NEA Nuclear Data Bank, Saclay, France
NDS	-	IAEA Nuclear Data Section
CJD	-	USSR Centr po Jadernym Dannym (= Nuclear Data Centre), Obninsk, Russia
CAJaD	-	USSR Centr po Dannym o Stroenii Atomnogo Jadra i Jadernykh Reakcikh (= Nuclear Structure and Nuclear Reaction Data Centre), Moscow, Russia
CDFE	-	Centr Dannykh Fotojad. Eksp. (= Centre for Experimental Photonuclear Data), Moscow, Russia
CNDC	-	Chinese Nuclear Data Centre, Beijing, P.R. China
ATOMKI	-	Nuclear Data Group of the ATOMKI Institute, Debrecen, Hungary
RIKEN	-	Nuclear Data Group, RIKEN Institute of Physical and Chemical Research, Wako-Shi, Japan
JCPRG	-	Japan Charged-Particle Nuclear Reaction Data Group, Sapporo, Japan
JAERI	-	Nuclear Data Center of the Japan Atomic Energy Research Institute, Tokai-Mura, Japan

1. Neutron Nuclear Data

1.a Bibliography and Data Index CINDA:
Input prepared by NNDC, NEA-DB, NDS, CJD, CNDC
Handbooks published annually by IAEA
Online services by NNDC, NEA-DB and NDS

1.b Experimental data exchanged in EXFOR format:
Input prepared by NNDC, NEA-DB, NDS, CJD
Online services by NNDC, NEA-DB and NDS

1.c Data Handbooks based on EXFOR published by NNDC
Last issues of "Neutron Cross-Sections" 1981/84 for resonance parameters and thermal cross-sections; 1988 for curves.

Table C.1 (cont.)

1.d Evaluated data exchanged in ENDF format:
NNDC, NEA-DB, NDS, CJD, CNDC, JAERI and others. Main data libraries:

BROND-2 (USSR)	IRDF-90 (IAEA)
CENDL-2 (China)	JEF-2 (NEA)
ENDF/B-6 (USA)	JENDL-3 (Japan)

Online services for BROND, CENDL-2, ENDF/B-6, JEF-1, JENDL-3 by NNDC, NEA-DB and NDS.

1.e Computer retrieval services upon request of customers:
NNDC, NEA-DB, NDS, CJD.

1.f WRENDA: compilation of requested data that are known with insufficient accuracy. Compiled by NNDC, NEA-DB, NDS, CJD, published by IAEA.

2. Charged Particle Nuclear Data (including heavy-ion reaction data)

2.a Bibliography published by NNDC
Discontinued in 1990; partly incorporated in the bibliographic system "NSR" for nuclear structure and decay data.

2.b Numerical data exchanged in EXFOR format:
Input prepared by CAJaD, RIKEN, CNDC, ATOMKI (from 1993), NDS, NNDC, JCPRG.
Online services by NNDC, NEA-DB and NDS.

2.c Data Handbooks based on EXFOR published by NDS, CAJaD

2.d Computer retrieval services upon request of customers:
NNDC, NEA-DB, NDS, CAJaD

3. Photonuclear Data

3.a Bibliography published by CDFE

3.b Numerical data exchanged in EXFOR format:
Input prepared by CDFE, occasional contributions from NNDC, NDS. Online services by NNDC, NEA-DB and NDS.

3.c Computer retrieval services upon request of customers:
NNDC, NEA-DB, NDS, CAJaD

C.2. CINDA

Input to CINDA continues to be prepared by NNDC, NEA-DB, NDS, CJD. CNDC has started to prepare CINDA entries for Chinese language literature. The following issues of CINDA have been published:

1990: A new "archival" issue of CINDA could be published due to an incidental favorable financial situation. CINDA-A, 5 volumes, 1935-1987 and CINDA 90 (1988-1990). The publication was preceded by a strong effort of all CINDA centers (i.e., NNDC, NEA-DB, NDS, CJD) to significantly improve the completeness and correctness of the CINDA files, including the removal of large amounts of superseded references such as old progress-reports) and the addition of EXFOR index lines.

1991: CINDA 91 (1988-1991)

A change in the phototypesetting equipment at the IAEA required rewriting of the book production program system. This was a major effort because we had no programming staff continuity and our new production programmer (R. Arcilla) had to familiarize himself with the related software and hardware. The publication of the book was delayed towards the end of the year.

1992: Due to financial shortcomings, CINDA 92 could be published only as a relatively thin supplement to CINDA 91.

1993: Probably it will not be possible to print a complete issue CINDA 93 (1988-1993) of about 450 to 500 pages but only, as in 1992, a supplement issue of about 150 pages.

C.3. EXFOR Neutron Data

The compilation of neutron reaction data in EXFOR continued. A special effort was done by all centers to make the fission-product yield database in EXFOR more complete and more reliable. The compilation rules for fission-product yield data had to be revised significantly in order to have precise definitions of the experimental data and their uncertainties in computer-intelligible form. Earlier compilations, which did not have sufficient precise definitions of the experimental fission yield data, had to be re-compiled.

During the years 1991 and 1992 lack of staff at the centers led to delays and incompleteness of compilation.

NNDC: Only data provided by experimenters to the center are compiled. More complex cases cannot be compiled. For example, for many *ORELA* data, only the derived resonance parameters have been compiled but not the cross-sections.

NEA-DB: Vacancy of a post has led to a temporary end of EXFOR compilation which ended with the literature of 1990.

NDS: A vacant post had led to a significant delay in compilation in 1991/1992. At present the compilation is on schedule.

CJD: Compilation continues. However, EXFOR transmission tapes are received at the other centers usually with significant delays.

For more details see separate papers on Data Statistics and on Manpower Situation at the Data Centers.

EXFOR Programming suffers from lack of manpower. All centers have now similar computer configurations on VAX computers. Programming done at one center would help all centers. However, almost no programming is done. Exfor checking codes are not up-to-date so that Exfor processing is handicapped by occasional mistakes in the files. Exfor plotting routines (including simultaneous plotting with ENDF data) are functioning, but only for straight forward cross-section data, not for more complex data.

The Exfor system provides for automatic renormalization of experimental data. But the required programming has never been done. Graphical EXFOR-ENDF comparisons will show discrepancies that would disappear if a renormalization procedure for EXFOR had been programmed.

C.4. Charged-particle reaction data in EXFOR

There are seven centers or groups that contribute to the compilation of charged-particle induced nuclear reaction data in EXFOR. Compare the separate paper on Nuclear Data Statistics. The most active center is CAJaD in Moscow (F.E. Chukreev), and it is hoped that this center continues to find sufficient support. The completeness of the EXFOR database cannot be verified because a CINDA type data inventory is lacking. It appears that the completeness is still insufficient, and the compilation of new data is by no means complete.

To improve the situation, a CRP is proposed. See separate paper.

C.5. Photonuclear Data in EXFOR

By a co-operative effort between CDFE Moscow (V. Varlamov) and NNDC Brookhaven, the photonuclear database in EXFOR grew considerably. See separate paper on Nuclear Data Statistics.

To continue this effort, a CRP is proposed. See separate paper.

C.6. Nuclear Structure and Decay Data (NSDD)

The last NSDD network meetings took place

- in Kuwait, 10-14 March 1990; see report INDC(NDS)-250;

- in Geel, Belgium, 9-3 November 1992; INDC report in preparation.

The next meeting is planned to be held in Asilomar, California, in the spring of 1994, organized by R. Firestone and C. Stone.

The presently active NSDD evaluation groups are given in Tables C.6 a+b. After the discontinuation of the British and the German groups, we tried hard to stimulate the respective authorities to make it possible that these groups could continue their active participation in the NSDD network. We also tried to find new participants in other countries. However, these efforts were in vain.

The rate of new experimental data continues to be such that the evaluation activities should remain at least at the present level. Data for a given mass chain should be re-evaluated after 5 or 6 years at the latest. Fig. C.6. shows the age of the presently available evaluations. Of the 222 mass chains in ENSDF 75, i.e. more than one third, are older than the desired 5 to 6 years. 17 thereof are older than 10 years up to 18 years. Most but not all of these old mass chain calculations are being updated now so that the average cycle period will be around 8 years.

Meeting participants were surprised about plans within the US NSDD network to reorganize the ENSDF activities and to replace the publication of the Nuclear Data Sheets by electronic media. Several participants stated the need that their mass chain evaluations get published in a recognized journal. Therefore, a discontinuation of the printed Nuclear Data Sheets would have serious consequences for the network. If a CD-ROM system were developed, this would be welcome as a parallel effort which should not be at the expense of the existing scheme.

Table C.6.a

NUCLEAR STRUCTURE AND DECAY DATA (NSDD)

EVALUATED NUCLEAR STRUCTURE AND DECAY DATA FILE (ENSDF)

DATA EVALUATION CENTERS

a National Nuclear Data Center
Brookhaven National Laboratory
Upton, NY 11973, U S A
Contact C. L. Dunford

b Nuclear Data Project
Oak Ridge National Laboratory
Oak Ridge, TN 37831 U S A
Contact M J Martin

c Isotopes Project
Lawrence Berkeley Laboratory
Berkeley CA 94720, U S A
Contact E Browne/R B Firestone

d Idaho National Engineering
Laboratory
E G and G Idaho, Inc
P O Box 1625
Idaho Falls, ID 83415, U S A
Contact: C. W. Reich

e Triangle University Nuclear Lab
Duke University
Durham, NC 27706, U S A
Contact: H. R. Weller/D. R Tilley

f Center for Nuclear Structure
and Reaction Data
Kurchatov Institute of Atomic Energy
46 Ulitsa Kurchatova
Moscow, Russia
Contact: F. E. Chukreev

g Data Centre
St Petersburg Nuclear Physics Inst
Gatchina, Leningrad Region
188350, Russia
Contact: I. A. Kondurov

h Fysisch Laboratorium
Princetonplein 5, Postbus 80 000
3508 TA Utrecht, The Netherlands
Contact: C. van der Leun

i Institute of Atomic Energy
P O Box 275 (41), Beijing
People's Republic of China
Contact: Cai, Dunjiu

j Centre d'Etudes Nucleaires
DRF-SPH
Cedex No 85
F-38041 Grenoble Cedex France
Contact: J Blachot

k Nuclear Data Center
Tokai Research Establishment
JAERI
Tokai-Mura Naka-Gun
Ibaraki-Ken 319-11, Japan
Contact: Y Kikuchi

l Institute of Physics
University of Lund
Solvegatan 14
S-223 62 Lund, Sweden
Contact: P. Ekström

m. Nuclear Data Project
Kuwait Institute for
Scientific Research
P O Box 24885
Kuwait, Kuwait
Contact: A Farhan

n Laboratorium voor Kernfysica
Proeftuinstraat 86
B-9000 Gent, Belgium
Contact: D. De Frenne

o Tandem Accelerator Laboratory
McMaster University
Hamilton, Ontario L8S 4K1
Canada
Contact: J. A Kuehner

EVALUATION RESPONSIBILITY

Center	Mass Chains
a US/NNDC	45-50,57,58,65-73,94-97,99,136-148, 150,152,165,199
b US/NDP	81-85,200-205,207-209,213-236 (excepting 215,219,223,227), 237-243(odd),244-266
c US/LBL	89-93,167-194,206,210-212,215,219, 223,227
d US/INEL	87,153-163
e US/TUNL	3-20
f. USSR/MOS	1,2,164,166,238-244(even)
g. USSR/LEN	86,88,130-135

Center	Mass Chains
h Holland	21-44
i. PRC	51-56,195-198
j France	101,104,107-109,111,113-117
k. Japan	118-129
l. Sweden	59-63
m Kuwait	74-80
n. Belgium	102,103,105,106,110,112
o. Canada	64,98,100,149,151

Table C.6.b

NSDD DISTRIBUTION CENTERS

National Nuclear Data Center
Brookhaven National Laboratory
Upton, NY 11973, U.S.A.
Contact: *J.K. Tuli*

NEA Data Bank
Le Seine Saint-Germain
12, boulevard des Iles
F-921130 Issy-les-Moulineaux, France
Contact: *N. Tubbs*

Center for Nuclear Structure and
Reaction Data
Kurchatov Institute of Atomic Energy
46 Ulitsa Kurchatova
Moscow, Russia
Contact: *F.E. Chukreev*

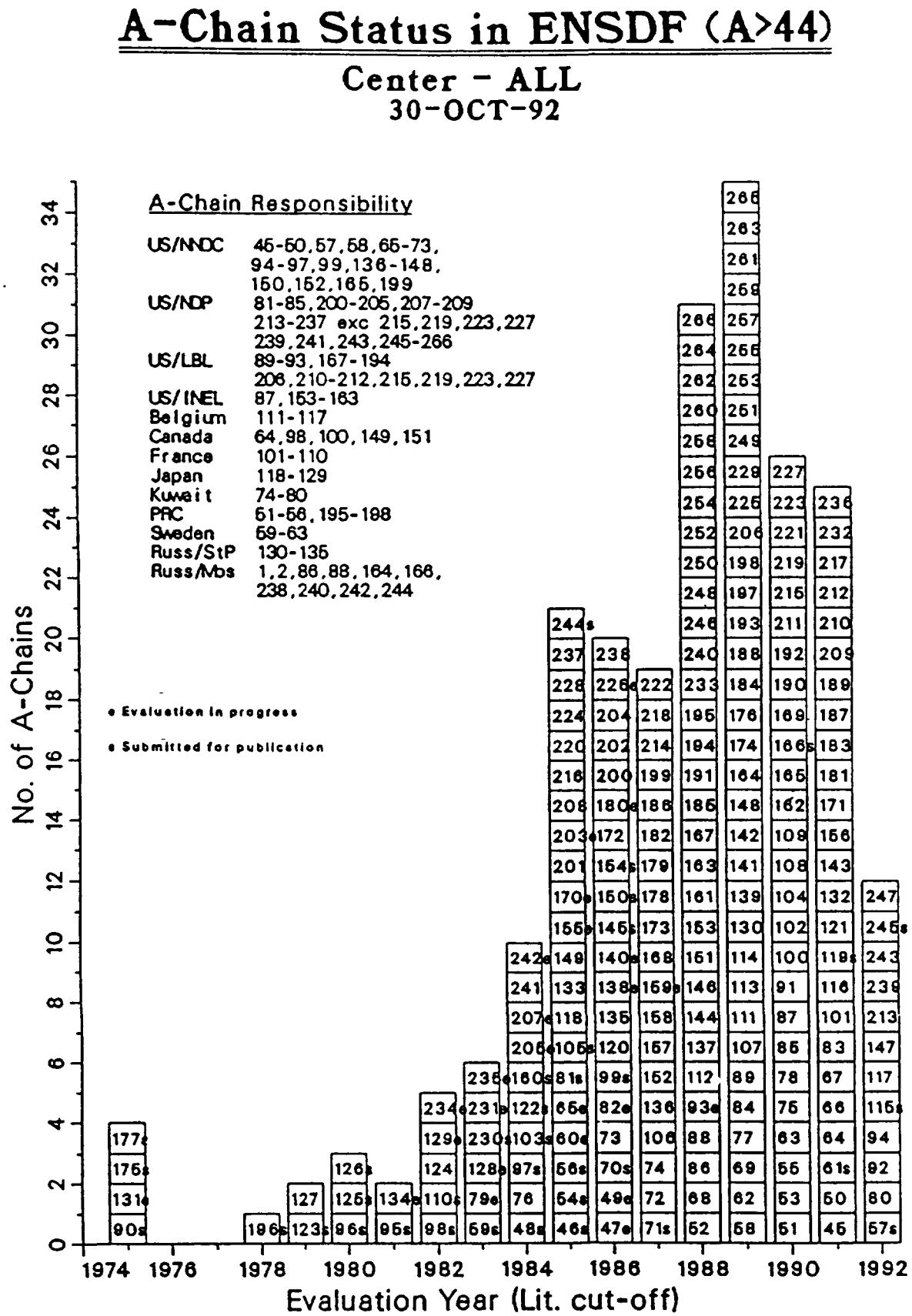
IAEA Nuclear Data Section
P.O. Box 100
A-1400 Vienna, Austria
Contact:

Fachinformationszentrum Energie,
Physik, Mathematik GmbH
Kernforschungszentrum
D-W 7514 Eggenstein-Leopoldshafen 2
Germany
Contact: *H. Behrens*

X-RAYS EVALUATION CENTRE

Bureau Central de Mesures Nucléaires
C.E.C.
Steenweg naar Retie
B-2440 Geel, Belgium
Contact: *W. Bambynek*

Fig. C.6


A-Chain Status in ENSDF (A>44)
Center - ALL
30-OCT-92
A-Chain Responsibility
US/NNDC 46-50,57,58,65-73, 94-97,99,136-148, 150,152,165,199
US/NDP 81-85,200-205,207-209 213-237 exc 215,219,223,227 239,241,243,245-266
US/LBL 89-93,167-194 206,210-212,215,219,223,227
US/INEL 87,153-163
Belgium 111-117
Canada 64,98,100,149,151
France 101-110
Japan 118-129
Kuwait 74-80
PRC 51-56,195-198
Sweden 59-63
Russ/StP 130-135
Russ/Mbs 1,2,86,88,164,166, 238,240,242,244
e Evaluation in progress
s Submitted for publication
No. of A-Chains
Evaluation Year (Lit. cut-off)

D. THE IAEA NUCLEAR DATA CENTER

D.1. Data Compilation in EXFOR/CINDA

Compilation of experimental neutron reaction data in the systems EXFOR and CINDA continued. V. Osorio has produced a PC software "ANDEX" which assists the EXFOR compilation on the PC, from where the data are transferred to the IBM mainframe computer for checking and producing EXFOR TRANS tapes to be sent to the other centers.

When V. Osorio left, the post was vacant for some time until H. Wienke could be hired. Due to the vacancy no EXFOR data could be compiled during most of 1991. However, the accumulated backlog could be worked up during the year 1992, so that the NDS EXFOR compilation is presently complete and up-to-date to a satisfactory degree.

The responsibility of the CINDA compilation for (former) USSR literature has been fully transferred to CJD Obninsk with the only exception that NDS remains responsible for the coverage of the English translations of Russian originals, because these are usually not available in Obninsk. CINDA coverage of English language publications from China remains the responsibility of NDS whereas CNDC Beijing is responsible for the coverage of Chinese language literature. It is envisaged that Chinese EXFOR entries are compiled at CNDC, but so far most Chinese data have still been compiled at NDS.

Compilation of selected
- evaluated neutron reaction data
- charged particle reaction data
- photonuclear data

in EXFOR continued at a low rate subject to available manpower.

See separate paper for EXFOR and CINDA statistics.

D.2. Acquisition of Evaluated Data

In the reporting period five large evaluated data libraries have been received:

- *BROND-2* from CJD
- *CENDL-2* from CNDC
- *ENDF/B-6* from NNDC, with various sublibraries and updates
- *JEF-1* from NEA-DB, with various sublibraries; JEF-2 is expected in February 1993
- *JENDL-3.1* with separate fission-product sublibraries, from JAERI.

A. Blokhin and V. Pronyaev from CJD spent several weeks at NDS to test and finalize the BROND-2 library on the IAEA computers.

In addition, several specialized data libraries have been received from various originators, such as the UK Fission Product Yield Library Rev. 2.

NDS produced the following libraries:

- *IRDF-90*, the International Reactor Dosimetry File
- *INGDB-90*, a nuclear database for geophysics applications
- *XG-Standards*, a PC diskette with X-ray and gamma-ray standards for detector efficiency calibration
- *FENDL* Multigroup libraries
- *Neutron activation* data libraries for fusion and other applications.

For a complete list of available nuclear data libraries see the document IAEA-NDS-7. It is an essential service to data users, to provide with each data file a compact description of contents and format. This is the purpose of the NDS documentation series IAEA-NDS-... For a complete list of such documents see IAEA-NDS-0. In the years 1991/1992 documentations for more than 25 data libraries have been produced or updated, plus documentations for two ENDF data processing code packages.

D.3. Advertisement

The IAEA Nuclear Data Newsletter serves the important function to advertise available services, nuclear data libraries, related codes and documents. It has a distribution of 3200 addressees in "area 3" of which 55(!) percent have responded by requesting data or documents or at least by requesting to remain on the distribution list. Although this Newsletter is primarily meant for scientists in "area 3", more than 600 scientists outside the NDS service area have requested to be on the distribution list.

The following Nuclear Data Newsletters were issued in the reporting period:

No. 14 July 1990
No. 15 March 1991
No. 16 November 1991
No. 17 September 1992
No. 18 in preparation

D.4. Publications

The main data center oriented publications were:

(1) *Nuclear Data for Radiation Damage Assessment*
N. Kocherov, (ed.), IAEA-TECDOC-572, 1990

(2) *X-ray and Gamma-ray Standards for Detector Calibration*
H.D. Lemmel (ed.), IAEA-TECDOC-619, Sept. 1991

(3) *Progress in Fission-Product Nuclear Data, Issue 13*
M. Lammer, report INDC(NDS)-222, Nov. 1990

This series was first issued in annual intervals. Although it is found useful by the community of fission-product scientists, the frequency was reduced due to lack of manpower at NDS. Issue 14 is envisaged to be published in the fall of 1993.

(4) *Handbook of Nuclear Data for Safeguards*
M. Lammer, O. Schwerer, report INDC(NDS)-248, June 1991

Over 200 copies of this preliminary issue were distributed to safeguards and data experts for review. Feedback came from 9 data experts and 3 safeguards experts. Valuable information on some data types for an update of the present issue was received from data experts.

Further needs:

(a) The data compiled require continuous monitoring to realize when updates are necessary. A future update of the publication would also include some additional data types as requested by some experts.

(b) A database of the compiled data may have to be assembled in a suitable format for use in lap-top or notebook computers that will be used by safeguards inspectors.

(6) *Handbook on Nuclear Data for Borehole Logging and Mineral Analysis*

The Handbook and the accompanying computer files were finalized in the beginning of 1991 and sent for printing. The Handbook contains the following chapters:

(a) *Introduction* (J. Schweitzer, C.G. Clayton)

(b) *Table of Nuclides* (J.K. Tuli)

(c) *Prompt Gamma Rays from Thermal Neutron Capture* (M.A. Lone, R.A. Leavitt, D.A. Harrison)

(d) *Nuclear Decay Gamma Rays with Intensities Higher than 5%.* Extracted from the "Radioactivity Data Base" (P. Ekström and L. Spanier).

(e) *Spectra of Neutron Sources* (N.P. Kocherov)

(f) *Neutron Induced Reaction Cross-Section Data for Nuclides Required for Borehole Logging and Mineral Analysis* (N.P. Kocherov)

(g) *Neutron Source Averaged Cross-Sections* (N.P. Kocherov)

D.5. "NDIS"

The most important event in the reporting period was the installation of "NDIS", the on-line Nuclear Data Information System, on the new VAX computer. For technical details see chapter E: Computer. The NDIS database which has a size of one Gigabyte, includes the following systems:

- CINDA
- EXFOR, all parts: neutron-induced
  charged-particle induced
  photon induced
  spontaneous fission parameters
- ENDF-formatted libraries

  BROND-2
  CENDL-2
  ENDF/B-6
  JEF-1; being updated by JEF-2
  JENDL-3

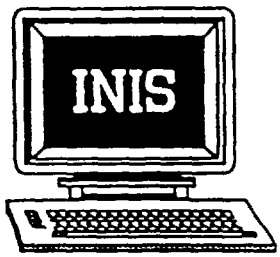
- ENDF/B-6 photo-atomic interaction data
- NUDAT
- ENSDF
- NSR

The software for NDIS has been made available by NNDC.

Fig. D.5

ON-LINE DATABASES

OF THE INTERNATIONAL ATOMIC ENERGY AGENCY



Database name
International Nuclear Information System (INIS)

Type of database
Bibliographic

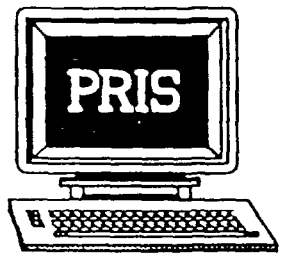
Producer
International Atomic Energy Agency in co-operation with 80 IAEA Member States and 16 other international member organizations

IAEA contact
IAEA, INIS Section, P.O. Box 100,
A-1400 Vienna, Austria
Telephone (43) (1) 2360
Telex (1)-12645
Facsimile +43 1 234564
Electronic mail via EARN/BITNET
ID NIE@IAEA1

Number of records on line from January 1976 to date
more than 1.3 million

Scope
Worldwide information on the peaceful uses of nuclear science and technology, economic and environmental aspects of other energy sources

Coverage
The central areas of coverage are nuclear reactors, reactor safety, nuclear fusion, applications of radiation or isotopes in medicine, agriculture, industry, and pest control as well as related fields such as nuclear chemistry, nuclear physics, and materials science. Special emphasis is placed on the environmental, economic, and health effects of nuclear energy, as well as the economic and environmental aspects of non-nuclear energy sources. Legal and social aspects associated with nuclear energy also are covered.



Database name
Power Reactor Information System (PRIS)

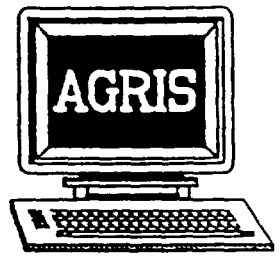
Type of database
Factual

Producer
International Atomic Energy Agency in co-operation with 29 IAEA Member States

IAEA contact
IAEA Nuclear Power Engineering Section, P.O. Box 100
A-1400 Vienna, Austria
Telephone (43) (1) 2360
Telex (1) 12645
Facsimile +43 1 234564
Electronic mail via EARN/BITNET
ID NES@IAEA1

Scope
Worldwide information on power reactors in operation, under construction, planned or shutdown, and data on operating experience with nuclear power plants in IAEA Member States

Coverage
Reactor status, name, location, type, supplier, turbine generator supplier, plant owner and operator, thermal power, gross and net electrical power, date of construction start, date of first criticality, date of first synchronization to grid, date of commercial operation, date of shutdown, and data on reactor core characteristics and plant systems, energy produced, planned and unplanned energy losses, energy availability and unavailability factors, operating factor and load factor.



Database name
International Information System for the Agricultural Sciences and Technology (AGRIS)

Type of database
Bibliographic

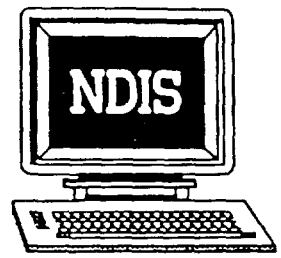
Producer
Food and Agriculture Organization of the United Nations (FAO) in co-operation with 159 national, regional, and international AGRIS centres

IAEA contact
AGRIS Processing Unit
c/o IAEA, P.O. Box 100
A-1400 Vienna, Austria
Telephone (43) (1) 2360
Telex (1)-12645
Facsimile +43 1 234564
Electronic mail via EARN/BITNET
ID FAS@IAEA1

Number of records on line from January 1991 to date
more than 170 000

Scope
Worldwide information on agricultural sciences and technology including forestry, fisheries, and nutrition

Coverage
Agriculture in general, geography and history, education, extension, and information, administration and legislation, agricultural economics, development and rural sociology, plant and animal science and production, plant protection, post harvest technology, fisheries and aquaculture, agricultural machinery and engineering, natural resources, processing of agricultural products, human nutrition, pollution, methodology



Database name
Nuclear Data Information System (NDIS)

Type of database
Numerical and bibliographic

Producer
International Atomic Energy Agency in co-operation with the United States National Nuclear Data Centre at the Brookhaven National Laboratory, the Nuclear Data Bank of the Nuclear Energy Agency, Organisation for Economic Co-operation and Development in Paris, France, and a network of 22 other nuclear data centres worldwide

IAEA contact
IAEA Nuclear Data Section
P.O. Box 100
A-1400 Vienna, Austria
Telephone (43) (1) 2360
Telex (1) 12645
Facsimile +43 1 234564
Electronic mail via EARN/BITNET
ID RNDS@IAEA1

Scope
Numerical nuclear physics data files describing the interaction of radiation with matter and related bibliographic data

Data types
Evaluated neutron reaction data in ENDF format, experimental nuclear reaction data in EXFOR format, for reactions induced by neutrons, charged particles or photons, nuclear half-lives and radioactive decay data in the systems NUDAT and ENSDF, related bibliographic information from the IAEA databases CINDA and NSR, various other types of data

Note: Off-line data retrievals from NDIS also may be obtained from the producer on magnetic tape.

For access to these databases, please contact the producers
Information from these databases also may be purchased from the producer in printed form
INIS and AGRIS additionally are available on CD-ROM

NDIS is the fourth on-line system of the Agency; these systems are advertised in the quarterly "IAEA Bulletin", see Fig. D.5.

NDIS is in its first stage. Many more improvements are needed, e.g.:

- for each of the ENDF formatted libraries the original file with resonance-parameters and the point data file must be included in the system; otherwise one cannot obtain a cross-section value at a specific energy. So far, only for ENDF/B-6 both library formats are available on-line.

- there are many more data libraries that should be added to the on-line system, specifically

  - the INDC/NEANDC Standards File
  - IRDF-90 for reactor dosimetry
  - and others

- although the system is most useful already in the present stage, programming needs continuous improvements to make the system more and more user-friendly.

Since all centers have now similar computer configurations, improvements made to NDIS at one of the centers will be beneficial to all centers.

D.6. Requests and Dissemination Statistics

Table D.5.a gives the request statistics for all nuclear data requests received between 1965 and 1992, for the categories experimental data, evaluated data, documents and bibliographic data, and computer codes.

For the purpose of the present statistics, any query for one of these categories defines a request. If an "incoming letter" asks e.g. for both experimental and evaluated data, it is counted as 2 requests. The 854 requests received in 1992 correspond to 715 "incoming letters". The total number of requests received from 1965 to 1992 is shown in Figure D.5.b. It shows that the annual number fluctuates around 700 incoming letters with around 800 requests. Table D.5.c gives a breakdown of requests by country for the period 1989 to 1992.

81 countries were served by the Section's services within this period.

Magnetic tapes and diskettes sent out

The total number of tapes and PC diskettes sent out between 1985 and 1992 is shown in Figure D.5.d.

Table D.5.a

Data Request Statistics 1965 - 1992

Year	Experimental Data	Evaluated Data	Experimental and Evaluated Data	Documents + Bibliogr. Data	Computer* Codes	Totals per year	Totals Cumulative
1965	3	-	3	-	-	3	3
1966	40	-	40	-	5	45	48
1967	118	-	118	9	8	135	183
1968	119	-	119	16	9	144	327
1969	48	15	63	25	5	93	420
1970	95	20	115	34	8	157	577
1971	76	33	109	43	8	160	737
1972	48	23	71	60	8	139	876
1973	43	22	65	54	6	125	1 001
1974	49	24	73	61	6	140	1 141
1975	43	49	92	114	3	209	1 350
1976	34	43	77	153	9	239	1 589
1977	45	49	94	232	3	329	1 918
1978	62	71	133	193	17	343	2 261
1979	63	93	156	95	18	269	2 530
1980	40	86	128	239	42	407	2 937
1981	59	185	244	369	31	644	3 581
1982	76	174	250	403	60	713	4 294
1983	52	115	167	508	45	713	5 007
1984	54	113	167	462	38	667	5 674
1985	24	221	245	587	12	844	6 518
1986	37	93	130	407	32	569	7 087
1987	18	72	90	667	136	893	7 980
1988	34	108	142	684	67	893	8 873
1989	32	100	132	579	62	773	9 646
1990	34	199	233	520	30	783	10 429
1991	31	260	291	426	25	742	11 171
1992	22	208	230	495	129	854	12 025

* Since 1978 this category contains exclusively data processing computer programs.

Table D.5.b

Nuclear Data Requests

received by the IAEA Nuclear Data Section

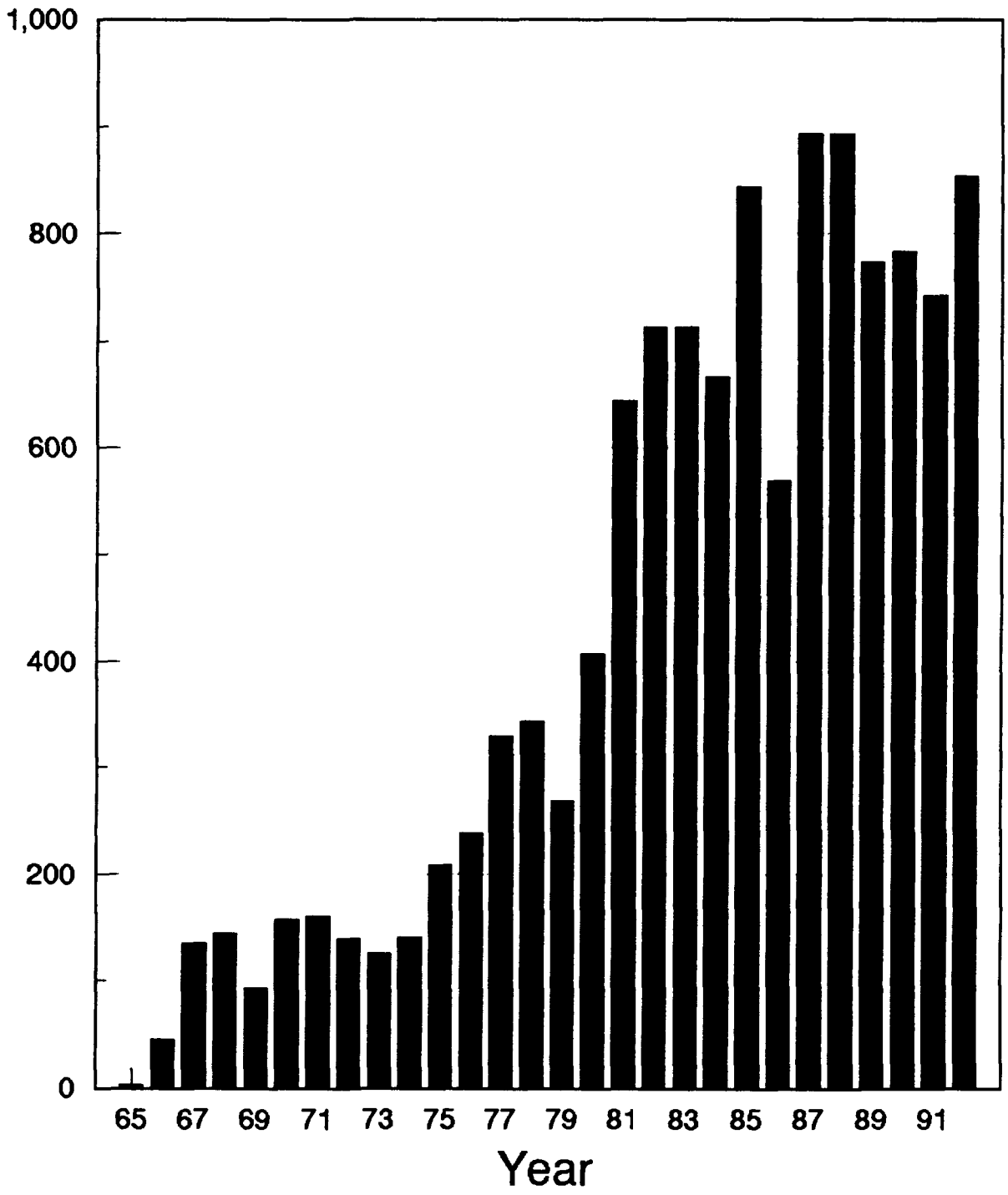


Table D.5.c: REQUESTS 1989 - 1992

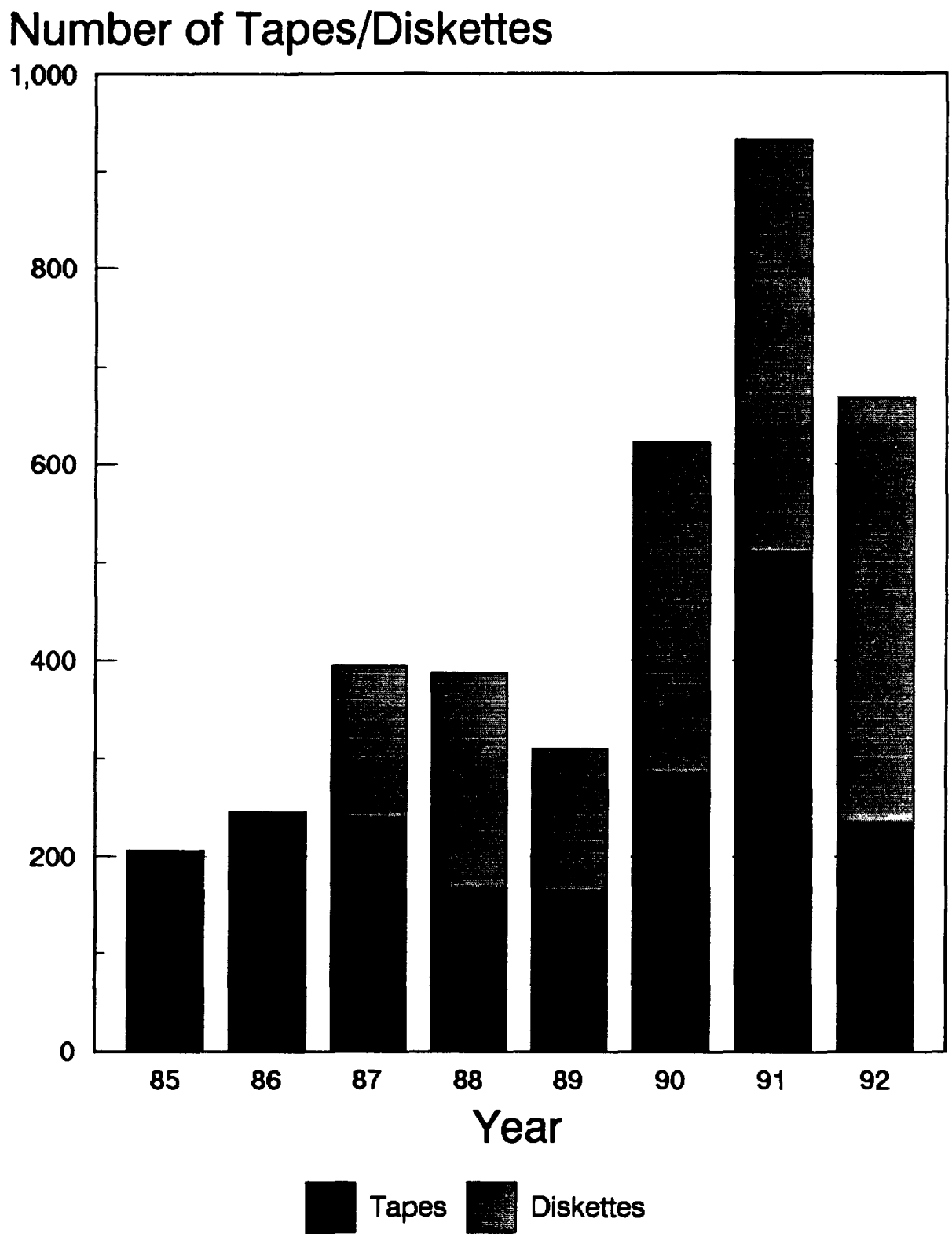
COUNTRY STATISTICS

COUNTRY	TOTAL	BIBL.	CODES	DOCUM.	EVAL.	EXPT.
India	309	0	28	196	76	9
China	270	3	20	166	51	30
USA	205	1	10	148	44	2
Soviet Union	173	1	16	72	75	9
Hungary	143	1	13	84	37	8
Japan	131	0	1	115	15	0
Germany	128	0	2	97	29	0
Brazil	121	1	12	66	40	2
Poland	116	0	14	71	27	4
Czechoslovakia	108	0	7	62	34	5
Romania	87	0	7	56	23	1
Argentina	60	0	10	35	14	1
Austria	57	1	2	29	11	14
United Kingdom	57	1	2	46	7	1
German Dem.Rep.	56	0	3	41	12	0
Egypt	54	0	7	33	13	1
Yugoslavia	53	0	8	30	14	1
Pakistan	50	2	9	27	7	5
Korea	40	0	7	26	7	0
Algeria	39	0	2	26	9	2
Bulgaria	36	0	3	20	11	2
South Africa	36	0	2	22	12	0
Indonesia	35	1	1	23	8	2
Iran	35	0	1	22	11	1
Italy	34	0	1	28	5	0
Vietnam	32	1	3	15	13	0
Israel	31	0	1	20	10	0
Cuba	28	0	7	8	9	4
Thailand	27	0	3	16	8	0
Bangladesh	25	0	4	13	7	1
France	25	0	1	21	3	0
Mexico	25	0	3	13	9	0
Saudi Arabia	25	0	5	15	5	0
Australia	24	1	1	9	13	0
Belgium	24	0	0	23	1	0
Nigeria	24	0	3	16	5	0
Libya	23	0	1	14	8	0
Malaysia	22	0	2	17	3	0
Canada	20	0	1	19	0	0
Taiwan	19	0	4	9	6	0
Netherlands	16	0	0	9	7	0
Burma	17	0	1	13	3	0
Albania	14	0	2	8	4	0
Morocco	14	0	1	8	2	3
Sweden	14	0	1	12	1	0
Peru	13	0	0	6	7	0
Zaire	12	0	2	10	0	0
Kenya	11	0	1	9	1	0
Switzerland	11	0	1	4	5	1
Turkey	11	0	0	9	1	1
Finland	9	0	3	3	3	0
Sri Lanka	9	0	1	1	5	2
Zambia	9	0	2	5	2	0
Iraq	8	0	1	7	0	0
Venezuela	8	0	2	4	2	0
Bolivia	7	0	0	7	0	0
Philippines	7	0	1	5	1	0
Russia	6	0	1	3	2	0
Spain	5	0	0	5	0	0
Syria	5	0	0	4	1	0
Ghana	4	0	0	2	2	0
Portugal	4	0	0	2	2	0
Sudan	4	0	0	3	1	0
Chile	3	0	0	3	0	0
Denmark	3	0	0	3	0	0
Uruguay	3	0	1	1	1	0
Ecuador	2	0	0	2	0	0
Jordan	2	0	0	2	0	0
New Zealand	2	0	0	0	2	0
Costa Rica	1	0	0	1	0	0
Cyprus	1	0	1	0	0	0
Ivory Coast	1	0	0	1	0	0
Kuwait	1	0	0	1	0	0
Madagascar	1	0	0	1	0	0
Norway	1	0	0	1	0	0
Senegal	1	0	0	1	0	0
Swaziland	1	0	0	1	0	0
Tunisia	1	0	0	1	0	0
Uganda	1	0	0	1	0	0
United Arab Emirates	1	0	0	1	0	0
Zimbabwe	1	0	0	1	0	0

81 countries served between 1989 and 1992

Table D.5.d

Tape/Diskette Media sent out



While PC diskettes were sent out almost exclusively for data requests, magnetic tapes are used both to fulfill requests from customers and for the regular data exchange with other data centres (EXFOR and dictionary transmissions; the CINDA exchange is done exclusively by electronic mail and is therefore not included in these numbers).

MAGNETIC TAPES

Year	Requests	Data Exchange	Total
1990	214	72	286
1991	457	54	511
1992	143	92	235

The peak of 1991 resulted from the evaluated data libraries that became available during this year.

E. COMPUTER

E.1. Computing Facilities Installed

During the last quarter of 1991, the Agency purchased and installed a VAXcluster as part of its central-computing facilities upgrade program, and strategy to move towards a decentralized computing architecture. The new computing facility is intended to meet the following objectives of the IAEA Nuclear Data Section:

(1) To maintain a high-degree of compatibility, in terms of data and programs exchanged, with other co-operating nuclear data centres which use the VAX/VMS platform.

(2) To provide remote users in the Agency's member states online access to the popular nuclear databases maintained at NDS, and

(3) To enable NDS staff to perform test calculations involving long-running jobs during daytime working hours.

E.2. Hardware and Software Components

Most of the VAXcluster components were installed and made operational in December 1991. A VAX-4000 Model 200 running under VMS acts as the central server. Client nodes are a VAXstation 3100 Model 38 and 12 NDS PC's which are connected to the VAX-4000/200 using DECNET protocol. However, the VAXstation could as well act as a secondary server node by allowing two users to log-in to it simultaneously.

A DECsystem 5100 running under Ultrix acts as the VAXcluster's INTERNET Gateway and provides any VAXcluster user TCP/IP-based INTERNET services like: electronic mail (SMTP), remote log-in (TELNET), and copying of files between INTERNET nodes (FTP). Outside INTERNET users will also come in through the same DECsystem 5100 to access the Agency's VAXcluster.

A DECnet/SNA Gateway connects the VAXcluster to the IBM mainframe which runs under MVS/ESA. Through this VAX-to-IBM connection, VAXcluster users could

(a) Copy files to and from the IBM mainframe;
(b) Submit IBM jobs under the VAX/VMS environment, and
(c) Perform 3270-terminal emulation under VMS.

A PROTEON Bridge/Router connects hundreds of PC users in the Agency's Token-Ring network to the VAXcluster. This make VAX/VMS services readily available to the rest of the Agency's staff.

VAXcluster components dedicated to NDS includes:

(1) the VAXstation 3100/38 with 16-MB RAM, 665-MB fixed disk, and a TSZ07 tape drive. The tape drive could read and write standard-sized tapes both at 1600 and 6250 bpi density.

(2) 3 VT420 terminals connected to the VAXcluster via a 16-port DECserver terminal using LAT protocol.

(3) A DEClaser 220 Postscript printer.

(4) 12 386-based PC's connected to the VAXcluster via PATHWORKS, a network operating system from Digital Equipment Corporation (DEC).

Two 600-dpi HPLaserjet-4M printers will soon be added to the NDS-dedicated peripherals to beef up NDS's graphics-intensive printing capabilities.

E.3. VMS-based Applications and Databases Installed

In February 1992, two consultants, Dr. Ch. Dunford and Mr. William Kropp, both from the National Nuclear Data Centre (NNDC), installed the Nuclear Data Information System (NDIS) and its associated nuclear databases, and various subroutine packages developed at NNDC on the VAX-4000 computer. In addition, they assisted the NESI and DEC engineers test and establish the X.25 communications link, configured the VMS environment and conducted lecture-demonstration on the use of NDIS.

The nuclear databases installed were; CINDA, EXFOR (CSISRS), ENDF, ENSDF, NUDAT and X-RAY(GAM-ATOM).

IBM RISC/6000 Model 7012/340

The system is being installed for the A+M data unit and will be used to:

(1) Maintain and further develop the ALADDIN (A Labled Atomic Data Interface for Fusion Applications) data base and interface programs.

(2) Produce recommended data of atomic and molecular processes of interest in thermonuclear fusion research.

(3) Compute cross-sections of similar quantities to fill gaps in the existing data. For this, sophisticated computer programs such as R-Matrix, Distorted-wave, FEM and Monte Carlo will be installed.

(4) Produce the International Bulletin on Atomic and Molecular Data for Fusion. This will be done with a modem and flexible document preparation system, Tex. The programs to translate the current output to Latex are already finished.

Application Systems

IBM- and VAX-based versions of CINDA and EXFOR systems currently run in parallel. This will be the case for quite a time until the migration process for both systems to the VAX/VMS environment is complete and proven stable. Stability here means that the master files for both CINDA and EXFOR are identical in all the co-operating centres, and that production runs using the IBM- and VAX-based versions yield identical results. Currently, an intercomparison of the CINDA master files from NNDC, NEA-DB and NDS is being undertaken as one of the prerequisites for the final changeover to the NEA-DB CINDA system adapted by NDS.

The ENDF database is still being maintained on the IBM mainframe for batch retrieval purposes. On the other hand, the VAX-based ENDF is also maintained for use in the online services system (NDIS); CENDL2 and BROND-2.1 libraries have already been added. NDIS is also being used in the generation of FENDL libraries using WIMS, NJOY and ENDF pre-processing codes. The latter activity is rapidly consuming the network's disk storage space; thus, additional large-capacity disk drives are urgenly needed for the VAX-4000/200 or else the overall FENDL processing will considerably slow down.

ENSDF, NUDAT and NSR database could now be accessed under NDIS. Data files generated during an NDIS session could be copied to a remote user's computer using INTERNET's File Transfer Protocol (FTP) facility.

Two A+M databases are maintained, updated and developed by the A+M unit. The bibliographical data base, with more than 30,000 entries of atomic and molecular bibliographic references of interest to fusion research since 1954. This data is currently on the IBM mainframe under ADABAS. Biennial updates are published as the International Bulletin on Atomic and Molecular Data for Fusion. The ALADDIN data base consists of recommended atomic and molecular data relevant to fusion. It is currently on PC. A new C-Interface is almost finished and will be distributed, together with a new manual, within this year.

The Request and Dissemination Log System, the NDS Profile and other NDS administrative systems continue to be maintained on the IBM mainframe and/or on the PC.

Existing and Future LAN Connections

Most NDS physicists and programming staff now have PC's, generally 386DX-based machines connected via Token-Ring/3270 Emulation to the IBM mainframe and via Ethernet/PATHWORKS to the central VAX. These PC's serve also as platforms for the development and testing of PC-based nuclear data processing codes and graphical packages for eventual distribution to Member States, and use in NDS-organized workshops and fellowship programs.

The NDS secretarial staff have recently migrated from a WANG-based work processing environment to the graphical WordPerfect for Windows environment. The new environment utilizes 486DX-based 33MHz PC's which are connected to a common HPLaserjet-4M printer via Token-Ring. These PC's will eventually be connected to the Agency's e-mail, FAX and Telex services via the department-wide Microsoft LAN Manager.

E.4. Nuclear Data Processing for Thermal, Fast and Fusion Reactor Applications using the NJOY System

After a development period of 10-15 years, improved basic evaluated nuclear data libraries such as ENDF/B-VI, JENDL-3.1, BROND and JEF-2 have become available. There are many reactor physicists around the world who are interested in updating and improving the multigroup nuclear data input to neutronic codes and point-data input to Monte-Carlo codes. The International Atomic Energy Agency has a number of activities in the area of nuclear data processing toward satisfying the urgent needs of such calculations. The IAEA activities on nuclear data processing consist of four different tasks which cover applied calculations for thermal, fast and fusion research and power reactors using NJOY which is well known as the most general purpose and versatile nuclear data processing code system. These are as follows:

(a) Using the NJOY to process selected basic data libraries for elements of interest to the Agency's program to develop a Fusion Evaluated Nuclear Data Library (FENDL). The intermediate results can also be post-processed by the interested users for fast reactor applications.

(b) Co-ordination and participation in the WIMS Library Update Project (WLU Project) which aims towards updating and improving the multigroup nuclear data input to the thermal reactor lattice cell code WIMS.

(c) Training activities in the use and applications of NJOY at the IAEA Headquarters, Vienna, mainly for IAEA fellowship applicants from the IAEA Member States.

(d) Verification of the accuracy of data processing using the NJOY code system and other processing code systems that are available, i.e., the continuation of the IAEA nuclear data processing code verification project. The IAEA pre-processing codes *LINEAR/RECENT/SIGMA/GROUPIE* are treated as benchmarks at present.

These four activities, all of which heavily use the NJOY system, are discussed in the reference: S. Ganesan and D.W. Muir, "IAEA Activities in Nuclear Data Processing for Thermal, Fast and Fusion Reactor Applications using the NJOY System", Paper presented in the OECD/NEA Seminar on NJOY-91 and THEMSIS, OECD/NEA Data Bank, Saclay, 7-9 April 1992.

F. TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES

F.1. African Regional Project "XRF Laboratory Network"

A new regional project on X-ray fluorescence laboratory network in Africa (RAF/8/015) has been established for 1992 - 1994. 14 XRF laboratories from 12 African countries joined the project. Under the project, the first workshop was organized in Nairobi, Kenya, from 31 August to 4 September 1992. In addition to the lectures and demonstrations on the analytical techniques, the working experience was exchanged and the laboratories became aware of each others equipment and working plans. As a result, sub-regional co-operation in the field of XRF application of environmental pollution and mining has been established. Under the project, some spare parts will be provided, training courses will be organized in 1993 and 1994 and an intercomparison exercise will be carried out.

F.2. Training Course on Target and Sample Preparation and Assay in Nuclear Analytical Techniques and Nuclear Data Measurements

This training course was organized in St. Petersburg, Russia, from 3 - 21 June 1991. It was attended by 10 participants from 18 developing countries. Lectures on environmental sample preparation, fission sample preparation, preparation and assay of geochemical rock samples for geochronological purposes, and measurement of radioactive gases in the atmoshpere and in effluents from nuclear power plants, etc. were presented. The practical exercises on sampling and software for gamma-ray spectrometry were arranged. The objectives of the course were fulfilled.

F.3. IAEA Interregional Training Course on Application of Nuclear Data and Measurement Techniques in Nuclear Reactor and Personal Neutron Dosimetry, Obninsk, Russian Federation, 15 June to 10 July 1992

Following the recommendations of the 18th INDC Meeting, the above Training Course (TC) was jointly organized by the IAEA and the Ministry of the Russian Federation for Atomic Energy and was conducted at the Institute of Physics and Power Engineering (IPPE), Obninsk, (now Scientific Research Nuclear Reactor Centre of Russia) from 15 June to 10 July 1992.

The purpose of the course was to train scientists from developing countries in modern neutron spectrum measurement and unfolding techniques used in neutron dosimetry at research reactors, neutron generators and isotopic neutron sources, with special attention to the determination of neutron field characteristics including neutron flux and energy spectra. The programme of the course covered general problems of neutron dosimetry, experimental methods of nuclear data measurements for the purpose of dosimetry, nuclear data for application in neutron dosimetry and was supplemented by

extended practical exercises, discussion sessions and technical visits to research reactors and to the Obninsk nuclear power plant.

The course was technically designed jointly by Dr. B. Fursov, the Course Director, Dr. Zolotarev, Scientific Secretary and A.B. Pashchenko, the IAEA Technical Officer, on the policy to give priority to practical aspects over theoretical ones to help participants in the dissemination of these methods to meet demands in their home countries. For this purpose a lot of practical exercises were planned and conducted throughout the course as well as guided exercises in the class rooms.

18 participants from 13 developing countries (Algeria, Argentina, Brazil, China, CSFR, India, Libya, Mexico, Pakistan, Romania, Thailand, Turkey, Vietnam) participate in the Course.

All participants were divided into 6 groups for experimental practical exercises and into 5 groups for calculational ones. During the last day of the course, a round table discussion took place where the participants compared their experimental and calculational results and discussed with the staff differences in results measured by each group as well as the reason of deviations.

The course programme was divided into 4 sessions. For each session a session leader was assigned to assist the lecturers in the presentation of lectures or to organize discussions and technical visits. Most of the lecturers were from the Russian Federation, in particular from the Institute of Physics and Power Engineering, Ecological Center (Moscow), Research Center of the State Atomic Energy Surveillance (Moscow), Institute of Atomic Energy I.V. Kurchatova (Moscow), Institute of Atomic Energetics (Obninsk), Moscow Institute of Engineering Physics (Moscow) and Institute of Phys. Technical and Radio Technical Measurements (Mendeleev). They were recruited by the IPPE. In addition, the IAEA recruited 3 lecturers from outside the host country: Dr. J.J. Schmidt, IAEA/NDS, Dr. R. Dierckx, Commission of the European Communities, Joint Research Centre, Ispra Establishment and Dr. D.L. Smith, Argonne National Laboratory, USA.

The objectives of the course have been fully achieved and trainees have been made familiar with modern techniques of neutron spectra measurement and unfolding, and of nuclear data processing in particular related to reactor neutron dosimetry.

Participants were requested to assimilate essential parts of this course, to bring this knowledge back to their home countries, and to apply it to actual cases in their respective countries.

F.4. Joint IAEA/ICTP Workshop on Computation and Analysis of Nuclear Data Relevant to Nuclear Energy and Nuclear Safety

This Training Course took place at the ICTP in Trieste from 10 February to 13 March 1992.

The detailed report is given as report INDC/P(93)-24 by Dr. J.J. Schmidt.

F.5. Training Activities on NJOY

An in-house group fellowship training on nuclear data processing and reactor applications was organized at the IAEA Nuclear Data Section by the Agency during the period March - June 1991 in which six IAEA fellows successfully participated. The training programme, which was conducted by D.W. Muir and S. Ganesan and the staff of the Nuclear Data Section, involved the following IAEA Fellows:

(1) Fortunato Aguilar Hernandez (Mexico)
(2) Vesselin Lalov (Bulgaria)
(3) Abderrahmane Malki (Algeria)
(4) Muhammad Arshad (Pakistan)
(5) Shafiqul Islam Bhuiyan (Bangladesh)
(6) Riyanto Raharjo (Indonesia).

The training program consisted of several informal lectures on ENDF/B formats and procedures, physical meaning of the input options used in NJOY for the generation of PENDF and GENDF files and practical computer exercises using the NJOY system. The version NJOY 89.31 was extensively used during that period by the Fellows to obtain experience in the use of NJOY to generate PENDF and GENDF files from ENDF/B-VI and JENDL-3 files for a few selected isotopes. A preliminary generation of 69 group constants in WIMS format was also attempted with some success for some light isotopes. It is planned to continue this training activity on NJOY in the future, depending on the level of interest from the developing countries and the availability of funds. One of the future activities of the Agency in the area of nuclear data processing will be to provide selected PENDF and GENDF files produced as a result of these training activities for free distribution to those who are interested to post-process such files to suit their specific application requirements. Such in-house fellowship training on NJOY is recognized as very useful to scientists even if they are interested to undertake only post-processing in their countries, where the resources are limited in terms of computer resources and manpower to undertake a complete NJOY computation starting from the basic evaluated data file.

F.6. Nuclear Data Processing Capabilities in Developing Countries

China

A Technical Co-operation Project (CPR/1/004) entitled "Development of a Nuclear Data Library" was successfully completed in January 1993 in the Institute of Atomic Energy, National Nuclear Data Centre, in Beijing. The project, originally started in 1987 was helped by the Agency's TC project with three expert services, 40 man-months of IAEA Fellowship training to five staff members of the CNDC, Beijing, and provision of MicroVAX-II equipment. The project strengthened the infrastructure for nuclear data services in China in addition to promoting co-operation between IAE/CNDC and IAEA/NDS.

Algeria

Within the scope of a Technical Co-operation (TC) Project (ALG/1/011), the Agency has been assisting the Centre for the Development of Energy Systems in Draria, in strengthening its nuclear data processing facilities for compiling, updating, processing and disseminating nuclear data in Algeria. Efforts have been concentrated in 1992 in the provision of an appropriate data acquisition and processing system together with training in the management of nuclear data for reactor applications in Algeria. Further assistance is expected to be provided in 1993 in the form of additional training and expert missions. Under the TC project, Mr. Zidi Tahar is being trained during the period 1 October 1992 to 31 May 1993 in the Nuclear Data Section as an IAEA Fellow under the supervision of Dr. S. Ganesan in the area of nuclear data processing to generate a new WIMS library for thermal reactor applications. The TC project, when successfully completed, is expected to lay a strong foundation to support the nuclear data and reactor physics requirements in Algeria in its nuclear power programme in the long term and in the near term to support the infrastructure in the utilization of the existing 15 Megawatt heavy water research reactor and the 1 MW open pool research and training reactor.

Indonesia

Within the scope of a TC project (INS/4/027), the Agency is assisting Indonesia to enhance the local capability for undertaking reactor physics calculations using nuclear data files in order to verify the operational and safety aspects of existing and planned reactors in Indonesia. For 1992-93, the Agency has been providing expert services to advise on the establishment of a workable and comprehensive set of codes and to train BATAN staff to perform all reactor physics calculations rigorously, starting from ENDF/B and similar data files. Fellowship training is also foreseen. It is expected that the project will enhance the local capability for undertaking reactor physics calculations using nuclear data files in order to verify the operational and safety aspects of the existing 30 MW(th) research reactor, and that the expertise gained will serve for the design and safety studies of nuclear reactors planned for the future.

F.7. Establishment of a computational nuclear physics laboratory in Myanmar (Burma) (MYA/1/013)

The Agency has been requested to upgrade the computational nuclear physics laboratory in the Department of Physics at the University of Mawlamyine where a program of training MSc students and research in computational nuclear physics has been earlier initiated by the University through their own resources. The Agency is assisting the project to establish a computational nuclear physics laboratory within the scope of a TC project MYA/1/013 with a number of Personal computers with related software and hardware for nuclear applications. A gamma ray and an alpha Spectrometer system are also being installed with the assistance from the Agency. The project, whose main objective is "computational nuclear physics," when completed, is expected to provide a training base in the subject area of computational nuclear physics and basic measurements capability with gamma and alpha ray spectrometers and thus help improve the basic infrastructure for training in the field of nuclear applications in the country.

Part II: ATOMIC AND MOLECULAR DATA FOR FUSION

Report on Activities of IAEA A+M Data Unit

for the Period July 1990 - December 1992

(Prepared by R.K. Janev)

1. INTRODUCTION

The IAEA A+M Data Unit operates within the IAEA Nuclear Data Section and is responsible for the execution of Agency's programmes in the area of atomic and molecular (A+M) and plasma-material interaction (PMI) data for fusion. The objectives of these Agency's programmes are to establish an international bank of recommended atomic, plasma-wall interaction and material properties data for fusion energy research and reactor design, to promote, co-ordinate and integrate the world's efforts in providing the fusion community with evaluated A+M and PMI data, and to disseminate the data information to national fusion laboratories, international fusion projects and other users in the Agency's Member States. In implementing these objectives, the IAEA A+M Data Unit conducts, organizes and initiates the following activities:

(a) Organization of international forums and assistance to standing advisory bodies for definition and review of Agency's programmes in this area;

(b) Initiation and co-ordination of international programmes for enhancement of fusion related data generation and evaluation efforts;

(c) Co-ordination of data compilation programmes of national A+M and/or PMI data centres;

(d) Initiation, assistance and participation in the establishment of recommended A+M and PMI databases for fusion;

(e) Maintenance, up-dating and development of the recommended A+M/PMI databases, and the ALADDIN data system for storage, management and exchange of A+M/PMI data;

(f) A+M/PMI data publication and dissemination; and

(g) Publication of a bibliographic International Bulletin on Atomic and Molecular Data for Fusion (semi-annually) and of the Computerized Index for Atomic and Molecular Data (CIAMDA) (periodically).

In conducting these activities, the IAEA A+M Data Unit enjoys a strong support and assistance of the fusion, atomic physics and material science communities, which is provided through a continuous, working-level interaction and collaboration. This support and interaction have been essential for all the A+M Data Unit accomplishments and for maintaining a close correlation and compatibility of Agency's programmes in this area with the changes and developments in the fusion research programmes.

The IAEA A+M Data Unit's activities in the reporting period are briefly described below. It should be noted that in this period the A+M Data Unit operated with reduced staff, because the substitution of one professional staff member was delayed by one year. Thus, in the reporting period the Unit operated with 1.5 effective professional staff and one secretary.

2. A+M AND PMI DATA PROGRAMME DEFINITION AND IMPLEMENTATION

2.1. Programme Definition: The Role of the IFRC A+M Subcommittee

Under its Terms of Reference, the Subcommittee on Atomic and Molecular Data for Fusion of the Agency's International Fusion Research Council (IFRC) is authorized "to review periodically the planning and execution of the Agency's atomic and molecular data programme and to advise the Director General on its direction in accordance with the needs of fusion reactor design". The Subcommittee is composed of about ten prominent fusion and atomic physics scientists, nominated by the IFRC. The IAEA A+M Data Unit, which is executing the Agency's A+M Data programmes, annually reports to the IFRC on its activity. The major role in the definition and the supervision of the Agency's A+M data programmes is played by the IFRC A+M Subcommittee. The Subcommittee exercises this role through a continuous interaction with the Head of A+M Data Unit and at its biennial meetings. The last two (6th and 7th) IFRC A+M Subcommittee meetings were convened on 27-28 September 1990 in Vienna, and on 17-18 October 1992, in Cadarache, France, respectively. Besides a comprehensive review of work performed by the IAEA A+M Data Unit for the preceeding two years (based on a detailed report from the Data Unit), the most important items on the agenda of the 6th (September 1990) Subcommittee meeting were the establishment of the short- and long-term priorities in the fusion related A+M data compilation, evaluation and generation activities of the A+M Data Unit and the international programmes under its co-ordination or supervision, the enhancement of the data evaluation effort in the international A+M Data Centre Network, and the extension of the Agency's data activity in the area of material properties data. The proceedings and the conclusions and recommendations of this Subcommittee meeting can be found in the report INDC(NDS)-244/M9.

The main items on the agenda of the 7th (October 1992) IFRC A+M Subcommittee meeting were the analysis of the results and recommendations of a major recent IAEA Technical Committee Meeting on "A+M Data for Fusion Reactor Technology" (see 2.2. below), the enhancement of the IAEA A+M Data Unit involvement in the international co-operation on fusion research and reactor design, and the strengthening

of the A+M data processing potential of the international A+M Data Centre Network and the IAEA.

A summary of the proceedings and conclusions of this meeting are given in report INDC(NDS)-278. The role of the IFRC A+M Subcommittee in the Agency's A+M data programme definition, as well as a schematic presentation of the programme execution and its implementation in the fusion research, are given in Appendix 1.). The current members of the Subcommittee are given in Appendix 2.

2.2. Interaction with the Fusion, A+M, and PMI Physics Communities

Both the IAEA A+M Data Unit and several of the national A+M data centres are in a continuous interaction and working relationship with the world's leading fusion research laboratories. This interaction allows to follow the dynamics of A+M data needs evolution in the fusion research programmes and to provide a prompt response to the data need changes. This interaction has been particularly intensified during the conceptional design activities on ITER. The interaction with the fusion community includes not only delivery of required A+M data and exchange of information on data needs and sources, but also joint work on database establishment, data implementation into fusion modelling and diagnostic codes and the formulation of certain short-term data activity projects.

The most standard form of this interaction are the experts meetings organized on specific subjects in which atomic physicists, fusion researchers and representatives of national A+M data centres participate. Periodically, however, large technical committee meetings are organized by the Agency to assess the overall impact of A+M data activities on the development of fusion energy research programmes and to set the general directions and long-term priorities of this activity for a longer period.

The third meeting of this kind was held on October 12-16, 1992 in Cadarache, France, and was devoted to the analysis of the atomic, molecular (A+M), plasma-materal interaction (PMI), and material properties (MATPROP) data needs for the design of next-step, reactor level fusion devices (IAEA TCM on "A+M data for fusion reactor technology"). The meeting was attended by about 60 participants, representing the most active parts of the fusion an atomic physics research communities, as well as the national A+M data centres.

Special emphasis at the meeting was given in the A+M, PMI and MATPROP needs for the engineering design phase of ITER project. The main results of the work of this major meeting and its conclusions and recommendations, are given in the IAEA report INDC(NDS)-277. The meeting proceedings, containing the extended abstracts of invited talks, poster contributions and the reports of three meeting Working Groups will be published as an IAEA TECDOC publication by June 1993. Extended versions of the invited talks at the meeting will be published in book format by Elsevier. One of the conclusions of the meeting was that the role of the IAEA is essential in providing the

required A+M, PMI and MATPROP data for the design of next-step fusion devices, and that this role should be further strengthened.

3. A+M AND PMI DATA STATUS AND NEEDS ASSESSMENTS, AND DATA EVALUATION

3.1. Evaluation of thermo-mechanical properties data of carbon-based plasma facing materials (CM, Vienna, December 17-21, 1990)

A small group of experts performed a critical analysis of the available thermo-physical and thermo-mechanical data for carbon-based materials (various types of graphites, doped graphites, carbon fiber composites) presently considered as candidate materials for fusion reactor plasma facing components. The consultants' group also formulated the scope and the structure of the Agency's material properties database for fusion, the *ALADDIN* dictionaries for formatting material properties data, and prepared an ALADDIN file of evaluated data for anisotropic pyrolytic graphites. Specific recommendations were also formulated regarding the Agency's future activity in this data area. Results of this evaluation effort are described in more detail in the report INDC(NDS)-246/MO.

3.2. He-beam database for alpha particle diagnostics of fusion plasmas (CM, Vienna, June 3-5, 1991)

The objectives of this consultants' meeting were to assess the needs and the available data for the He-beam based diagnostics of fusion plasmas, including the alpha particle diagnostics of fusion reactors, to perform a critical evaluation of the existing data and recommend selected data sets for use in He-beam attenuation and diagnostic codes. These objectives of the meeting were fully achieved. Many of the participants provided newly generated cross section data for the collision processes of the atoms with other plasma constituents. Many of the meeting participants committed themselves to continue the data generation and evaluation effort at their home laboratories in order to improve the completeness and quality of the required He-beam data base. The results of the meeting are described in the report INDC(NDS)-253/N2 and most of the evaluated data are presented in Vol. 3 (1992), of the IAEA series on "Atomic and Plasma-Material Interaction Data for Fusion".

3.3. Atomic database for Be and B (CM, Vienna, June 10-12, 1991)

Berrylium and boron have become increasingly important impurities in many recent large tokamak experiments, and are likely to be present in the ITER machine. The consultants' meeting on the collisional database of these impurities was organized with the idea to assess the available data information and, through additional cross section calculations performed by the participants before the meeting, to improve the

completeness of the database. These meeting goals have been achieved, resulting in the establishment of complete sets of recommended data for the most important collision processes of these plasma impurities. The proceedings and the main results of the meeting can be found in the report INDC(NDS)-254, and the recommended data have been published in Vol. 3 (1992) of the IAEA series on "Atomic and Plasma-Material Interaction Data for Fusion".

3.4. Atomic and Molecular Data for Fusion Plasma Impurities (AGM, Vienna, September 25-27, 1991)

The objectives of the meeting were to provide a review of the available spectroscopic and collisional data information for all the impurities (both low- and high-Z, molecular) present in operating large tokamak devices, and anticipated in the future fusion reactors. A specific objective of the meeting was to determine the scope and priorities of an initiated Agency's Co-ordinated Research Programme (CRP) in this data area. The Advisory Group has produced a set of assessments and recommendations regarding the data status and needs for spectroscopic and collisional properties of plasma impurities, which should serve as guidelines for the Agency's activity in this data area, and for the programmatic scope of the above mentioned CRP. These assessments and recommendations are reproduced in the report INDC(NDS)-257/N8.

3.5. Atomic and Molecular Database for H-Recycling and He-removal from Fusion Reactors (CM, Vienna, June 11-12, 1992)

Hydrogen recycling in the divertor of a fusion device and helium removal from the divertor are important parameters defining the performance of the fusion reactor power and particle exhaust system.

The accurate knowledge of the atomic physics aspects of these transport phenomena is indispensible for a successful prediction of the divertor performance, and for its design. The Consultants' Group critically analyzed all the atomic and plasma-surface interaction (PSI) data information required for the corresponding modelling codes, and formulated an optimum ("standard") scheme for the A+M and PSI processes to be included in these codes.

The Group also identified all the A+M and PSI processes for which new data information is required to satisfy the necessary accuracy of the modelling codes. A set of urgent actions has been recommended to the Agency to improve the A+M and PSI physics basis of the modelling codes. The results of this meeting are described in the report INDC(NDS)-274.

4. CO-ORDINATED RESEARCH PROGRAMMES (CRPs) AND PROJECTS

4.1. CRP on "Atomic and Molecular Data for Fusion Plasma Edge Studies" (period: 1988-1992; number of participating laboratories: 11)

The purpose of this CRP was to improve the available database for the A+M collision processes involved in the edge plasma regions of fusion devices through both direct data generation and data collection of evaluation efforts. This CRP also included a spectroscopic data part. The emphasis in this activity was placed on completion of the spectroscopic and collisional databases for the basic plasma edge constituents (including all forms of hydrogen and its isotopes), molecular impurities, and low-charge states of most abundant atomic impurities. Two Research Co-ordination Meetings (RCMs) were organized during the activity on this programme, one of which during the reporting period (17-19 June 1992, Vienna). An interim report on the results achieved within this CRP has been published in Vol. 2 (1992) of the IAEA series "Atomic and Plasma-Material Interaction Data for Fusion". The numerical data generated or evaluated within this CRP has been introduced in the corresponding ALADDIN files. The final product of the research and evaluation activities of the Programme will be published during 1993.

4.2. CRP on "Plasma-Interaction Induced Erosion of Fusion Reactor Materials" (period: 1989-1994; number of participants: 10)

The objective of this CRP is to establish a co-ordinated effort, involving the most active experimental laboratories and theoretical groups in the field, directed in collection, evaluation and generation of data for all particle-surface and plasma-material interaction processes resulting in erosion of candidate plasma facing materials in fusion reactors. The final goal of this effort is to prepare a comprehensive data compendium on the erosion characteristics of fusion reactor candidate materials under various plasma-material interaction conditions (particle fluxes, fluences, material composition, temperature, etc.) which should provide an expert guidance to the fusion reactor designers in the process of reactor material selection. The material erosion rates should preferably be determined under realistic plasma-wall interaction conditions, i.e. they should include the effects of material redeposition, various synergistic effects, the material structural and other changes during the reactor operation, etc. Emphasis in the CRP is currently given on the carbon based materials (including carbon fiber composites), B-, Si- and Ti-doped graphites and berrylium. A RCM was held within this CRP activity (15-17 May 1991, Vienna) and some of the obtained results are published in Vol. 1 (1991) of the IAEA series on "Atomic and Plasma-Material Interaction Data for Fusion". It is likely that the work of this CRP will be extended to the erosion processes characterizing the off-normal plasma operation phenomena (such as plasma disruption, run-away electrons effects, etc.).

4.3. CRP on "Atomic Data for Medium- and High-Z Fusion Plasma Impurities" (period: 1991 - 1994; participating institutions: 9)

With increasing the atomic number of plasma impurities, both the spectroscopic and (especially the collisional data information became increasingly scarce. However, medium -Z impurities, such as Si, Ti, Cr, Fe and Ni, seem to be inavoidable in most of the current fusion devices, and high-Z elements (such as Mo, Ta, W) are candidate base structure divertor plate materials. The purpose of this CRP is, therefore, to promote a strong co-ordinated research effort to improve the spectroscopic and collisional database for these plasma impurities. This information is needed for the prediction of plasma cooling effects of these impurities, their transport in various plasma regions, as well as for the study of other associated phenomena (e.g. impurity recycling). The data generation, compilation and evaluation work within this CRP has considerably progressed, particularly for the metallic impurities. The work of this CRP is supported by the activity of several other experimental and theoretical groups, formally not members of the CRP. A first compendium of compiled, evaluated and generated collisional data on metallic plasma impurities (with emphasis on Ti, Cr, Fe and Ni) was published as a topical issue of Physica Scripta (T37, 1991).

4.4. Individual Research Contract Projects

In order to enhance the data generation and evaluation efficiency of the above co-ordinated research programmes, but also to assist the IAEA A+M Data Unit in the execution of other data related programmes (e.g. completion of specific databases), the Agency in the reporting period has financially supported ten Research Contracts with selected laboratories and theoretical groups from the developing countries. Three of these contracts were related to atomic and molecular processes in the fusion plasma edge, two of them have supported the completion of the database for H-beam attenuation in fusion plasmas, three of these projects are related to the plasma-material interaction data programmes, and two contracts were related to the data compilation work.

4.5. Special Service Agreement Programme

To accelerate the programme on establishment of specific (some of them purpose-oriented) recommended databases, the A+M Data Unit in the reporting period has extensively used the Agency's Special Service Agreement form for inviting individual visiting consultants to advise or assist the Unit in the completion (through additional data generation) and/or evaluation of specific sets of data. The visiting consultants' programme included visits (in the range from one week to three months) of about 20 top-level experts from the research areas relevant to the database projects. The joint work of these experts with the A+M Data Unit staff was essential for the completion or development of the recommended A+M and TMI databases described below.

5. DATABASE ESTABLISHMENT PROGRAMME

5.1. Recommended Database for State-Selective Electron Capture
(in collaboration with ORNL, Oak Ridge, NIFS, Nagoya, and JAERI)

A recommended cross section database has been established for the state-selective electron capture in collisions of fully stripped carbon and oxygen ions with ground state hydrogen atoms. The database contains more than 80 cross sections in the energy range relevant to fusion applications. This database is of paramount importance in the "charge-exchange recombination spectroscopy "diagnostics of central (hot) plasma regions" of the presently operating large tokamaks. The recommended cross sections are fitted to an analytical expression containing less than ten fitting parameters, and having appropriate physical behaviour in the asymptotic regions. The database has been ALADDIN formatted and stored in the IAEA ALADDIN databank. The data evaluation procedure and the recommended cross section data will be published in ADNDT (1993).

5.2. Recommended Database for Light Ion Reflection from Surfaces
(in collaboration with the IPP Garching and the Georgia Institute of Technology, Atlanta)

A critical assessment of all the available theoretical and experimental data on the particle and energy reflection coefficients for the ions of hydrogen and helium isotopes backscattered from a large number of elemental solid surfaces, was performed. The covered impact energy range extends from about 10 eV up to several hundred keV. Only the normal incidence case was considered. The data for self-ion reflection have also been included in this assessment. The recommended data have been fitted to a six-parameter analytical expression (nine parameters for the self-ion reflection), with an rms deviation below 5% in all cases. The recommended particle "number" and "energy" reflection coefficients, in their parametrized form, have been stored in the A+M Data Unit's ALADDIN system, and distributed to fusion laboratories and other interested research groups. This database has also been published in hard-copy format (IAEA report INDC(NDS)-249 (1991)), and in a condensed form (with elements of the background physics and assessment procedure) in Nucl. Instr. Meth. Phys. Res. B 69 (1992) p. 427.

5.3. Recommended Database for Physical Sputtering of Fusion Relevant Materials under Light Ion Impact
(in collaboration with the Georgia Institute of Technology, Atlanta, and the Institute of Applied Physics and Computational Mathematics, Beijing)

The available theoretical and experimental data for physical sputtering of a large number of elemental and composite fusion relevant materials under normal incidence bombardment of hydrogen- and helium-isotope ions have been critically assessed and a set of recommended sputtering yield coefficients (as function of incident ion energy)

has been established. The considered energy range extends from the threshold to several hundred keVs. The case of self-ion sputtering for the most important first wall candidate materials has also been included in this assessment. The recommended sputtering yield coefficients have been fitted to a single analytical expression containing only one fitting parameter. The recommended data are being stored in the IAEA ALADDIN system, and a hard-copy version of the database, as well as journal publication, are now in preparation.

5.4. **Recommended A+M Database for H-Beam Penetration into Fusion Plasmas**

A comprehensive recommended database for all collision processes of ground state and excited hydrogen atoms colliding with electrons, protons, alpha particles and other fully stripped (Be^{4+}, B^{5+}, C^{6+}, O^{8+}) and arbitrary stripped (A^{q+}, $q > 8$) ions, has recently been completed by the IAEA A+M Data Unit staff. The database contains recommended cross sections for more than sixty individual reactions in the energy range from a few eVs (or the threshold, for electron impact processes, and typically $\sim$ 100 eV/amu for heavy particle collision processes) (up to several MeV (or MeV/amu for heavy particle collisions). The database is also supplemented by a number of generalized (scaled) formulae for the reactions involving highly excited states and/or ions in high charge states ($q > 8$), which makes the entire database complete and self-consistent. The primary mission of this database is to meet the needs for modelling of neutral hydrogen beam penetration into fusion plasmas, but it can also be used in other (e.g. diagnostic) fusion applications. The recommended cross section data are presented by analytic-fit functions, having appropriate, physically based, asymptotic behaviour and containing usually not more than 10 fitting parameters. The entire database is ALADDIN formatted and stored in the Agency's A+M database. A handbook, containing a hard-copy version of this database and all the associated information (data sources, assessment procedures, data accuracies, etc.), is now in its final stage of preparation.

5.5. **Recommended A+M Database for He-Beam - Fusion Plasma Interaction**
(in collaboration with the JET Team A+M Group, FOM Institute, Amsterdam, National Institute for Fusion Science, Nagoya).

The establishment of this database has been initiated during the work at the Consultants' Meeting on "He-beam database for alpha particle diagnostics of fusion plasmas" (see 3.2.). A large part of the existing database has already been evaluated, and recommended cross section for all processes involving the ground state of He have been established. The part of the database involving collisions of excited He-atoms, particularly the transitions between excited states, is still of inadequate accuracy (50 - 100%) at low collision energies. These data uncertainties, however, do not have a significant impact on the calculation of He-beam attenuation in a plasma (due to the low population of excited states during the beam penetration). Part of the evaluated and recommended data are published in Vol. 3 (1992) of the IAEA Series on "Atomic and

Plasma-Material Interaction Data for Fusion", and some of them are stored in the Agency's ALADDIN database. It is expected that this database will be completed by the end of 1993.

5.6. **Recommended A+M Database for Li-Beam Edge Plasma Diagnostics**
(in collaboration with the Technical University, Vienna)

Neutral Li-probing beams are becoming a standard technique for diagnostics of edge plasmas in present tokamak fusion devices. The further developments of this technique, and its extension to reactor level edge plasmas, in particular, depend on the establishment of a complete database for all collisional processes of ground-state and excited Li atoms with plasma electrons, protons and impurity ions. The part of the evaluated database involving Li and Li^* collisions with electrons and protons is now being completed and stored in the ALADDIN system . The cross sections for electron-loss processes by multiply charged impurity ions are described by a scaling relationship, valid only for ion charge states above q = 5. The entire A+M database for the Li-beam attenuation kinetics in fusion plasmas is expected to be finished by May 1993.

5.7. **Collisional Database for Be and B Plasma Impurities**
(in collaboration with the Los Alamos National Laboratory, the Queen's University of Belfast, St. Petersburg University, Argonne National Laboratory, University College London, Oak Ridge National Laboratory, and Institute of Physics, Belgrade)

The establishment of the recommended collisional database for Be and B plasma impurities has been initiated by the work performed during and in connection with the IAEA Consultants' Meeting on this subject held on 10-12 June 1991 in Vienna (see 3.3.). Recommended cross sections have been established for all the electron-impact collision processes involving ground-state Be and B atoms and ions, and their first few excited states. The part of the database involving collisions of Be^{q+} and B^{q+} ions with edge plasma neutrals (H, H_2 and He) is less complete, and its completion is envisaged during 1993 through collaboration with the instituions cited above.

5.8. **Recommended Radiative Cooling Rates for Carbon and Oxygen Plasma Impurities**
(in collaboration with the University of Quebec, Varennes)

Using the available IAEA recommended database for collision processes involving carbon and oxygen plasma impurities, accurate calculations were performed for the radiative cooling rates of these impurities in a fusion plasma within a wide range of plasma parameters (temperature and density). The temperature dependences of recommended cooling rates for each ion have been represented by analytic-fit functions (for a number of fixed plasma densities around $10^{14}cm^{-3}$) containing nine fitting parameters. The recommended radiative cooling rates (together with the associated plasma electron energy cooling rates) due to the carbon and oxygen impurities have

been published in the report INDC(NDS)-255, and in a more condensed form (but including the background physics) in Vol. 2 (1992) of the IAEA Series on "Atomic and Plasma-Material Interaction Data for Fusion" (p. 117).

5.9. Evaluated Thermo-Mechanical Properties Data for Berrylium
(in collaboration with the Efremov Institute of Radio-Physical Aparatus, St. Petersburg)

The establishment of a comprehensive evaluated database for the thermo-physical and thermo-mechanical properties of berrylium materials has been initiated in May 1992. The available data for a large number of cast and plasma-sprayed Be materials have been collected, critically assessed, and stored in the ALADDIN material properties database. In view of the intense work currently underway in several laboratories on characterization of different types of Be-materials, the compilation and evaluation work related to this database will continue during 1993.

6. A+M AND PMI DATA PROCESSING AND EXCHANGE

6.1. A+M and PMI Data Centre Network Co-ordination

The IAEA A+M Data Unit co-ordinates the data evaluation and compilation programmes of 15 national data centres and groups (A+M/PMI Data Centre Network - DCN), to ensure their coherence and proper focussing on the priorities in the fusion research needs. The list of the Network members is given in Appendix 3. The A+M/PMI DCN convenes annual meetings at which each of the data centres reports on the results of its activity in the previous year, and at which the working plans for the next year are discussed and co-ordinated. Other regular items on the agenda of these meetings are: the adjustments of the next year working plans in accordance with the most recent short- and long-term priorities for fusion relevant A+M/PMI data, set by the IFRC A+M Subcommittee or another high-level forum, the recent developments in the data processing and exchange methodology, the technical developments of the ALADDIN system as a common tool for data processing and exchange, and the collaboration of the data centres among themselves and with the IAEA A+M Data Unit in the execution of the working plans.

In the reporting period, the 9th, 10th and 11th A+M/PMI Data Centre Network meetings were held at the IAEA Headquarters in Vienna, on 20-21 September 1990, 23-24 September 1991, and 15-16 June 1992, respectively. The summary reports of these meetings are published in INDC(NDS)-243/M7, INDC(NDS)-259/N7 and INDC(NDS)-275, respectively. We note that, due to the expansion of A+M/PMI DCN membership during the period 1987-1989, the DCN meetings have been reclassified by the decision of the Agency's Director General in 1991 from Consultants' to Advisory Group Meetings on "Technical aspects of atomic and molecular data processing and exchange."

6.2. ALADDIN System Maintenance and Development

One of the major responsibilities of the IAEA A+M Data Unit is to maintain and further develop the Agency's ALADDIN database system, which serves for storage, processing and exchange of all recommended or evaluated A+M, PMI and MATPROP data for fusion. The ALADDIN structure and interface developments in the reporting period include:

(i) Definition of ALADDIN hierarchical and Boolean labelling schemes and dictionaries for formatting and introducing the material properties data in the system (in co-operation with several IAEA consultants).

(ii) Initiation of the work on definition of ALADDIN hierarchical and labelling schemes for ALADDIN formatting of the spectroscopic data and their incorporation in the system (in collaboration with NIST, Gaithersburg and ORNL, Oak Ridge), including development of a conversion subroutine to convert the NIST recommended spectroscopic (now in ORACLE) into the ALADDIN format.

(iii) Development of a new interface (written in C) for ALADDIN to enhance its search (menue driven interactive programme), processing (multiple access to files), graphics and editing capabilities. This effort was undertaken jointly with the Efremov Institute for Radio-Physical Aparatus, St. Petersburg (Dr. G. Yushko) and the staff of the Agency's Physics Section (Dr. V. Osorio). A new, C-version of ALADDIN is now under preparation, and this work is expected to be finished in the next few months. Although the present C-ALADDIN interface is written for PC's (DOS), the transition to UNIX workstations will also be possible.

6.3. Maintenance, Updating, and Development of A+M and PMI Databases

The maintenance and the continuing updating and development of the A+M and PMI recommended numerical databases is a further major responsiblity of the A+M Data Unit. In the reporting period, extensive work has been done on updating the recommended database on carbon and oxygen plasma impurities, including generation of new analytic fits for all the reactions (more than hundred) in the database.

A similar work is now in progress on the A+M data for hydrogen-helium plasmas.

Apart from this activity, the staff of the Unit is also heavily involved in different joint projects with other experts' groups on the establishment of new evaluated and/or recommended numerical A+M/PMI databases (see Section 5), or in the further development of the existing ones (e.g. by adding new reactions, providing new, physically more acceptable parametrizations, etc.).

6.4. A+M and PMI Data Exchange

A+M and PMI data exchange between the IAEA A+M Data Unit and the A+M/PMI national data centres is a continuous process going both ways. The exchange of recommended and/or evaluated data uses all available means of information transfer, and most frequently is done by electronic mail. Bibliographic reference data are usually exchanged on diskettes. The data exchange process is not confined only to the members of the A+M/PMI Data Centre Network, but includes also a number of active data generating or data collecting groups (e.g. the Plasma Spectroscopy Group at Cadarache, the Radiation Transport Group at the Los Alamos National Lab., the Lebedev Physical Institute of the Russian Academy of Sciences in Moscow, etc.). This intense data exchange process provides the national data centres with the entire body of recommended/evaluated data information, so that they can act as data dissemination points for the major data users in their own countries (NIST and ORNL for USA, Kurchatov Institute for Russia, JAERI and NIFS for Japan, GAPHYOR for France, Belfast University for UK and CRAAMD for China).

7. A+M AND PMI DATA PUBLICATION AND DISSEMINATION

7.1. The IAEA Series on "Atomic and Plasma-Material Interaction Data for Fusion"

This IAEA Series has been established in 1990 to provide a medium for publication of large sets of generated or evaluated A+M and PMI data relevant to fusion research and their rapid communication to the entire fusion community. This journal-level publication also serves for publishing reviews on the A+M and PMI data needs for specific research areas in fusion, data status assessments for specific classes of atomic or plasma-material interaction processes, and reviews on the wider A+M and PMI apsects of fusion energy research development. The series is programmatically supervised by an International Editorial Board, and technically produced by the "Nuclear Fusion" journal editorial staff.

Three volumes of this series have sofar been published, containing a large body of evaluated A+M and PMI data, detailed data assessment and data status and needs reviews, and sets of original data calculations and measurements.

Vol. 1 of the series (September 1991) represents a data compendium for particle-surface and plasma-material interaction processes;

Vol. 2 of the series (June 1992) contains a number of comprehensive data assessment reviews on the A+M collision processes in the fusion edge plasmas;

Vol. 3 of the series (November 1992) contains recommended and/or evaluated data sets and data status reviews on the A+M collison processes involving He, Be and B atoms and ions;

Vol. 4 of the series is planned to appear in 1993. It will contain evaluated/recommended sets of data for the thermo-physical and thermo-mechanical properties of fusion reactor plasma facing candidate materials, and a number of reviews on PMI data related issues of the fusion reactor design.

7.2. Data Compendia, Reviews and Journal Publications

The work on the establishment of evaluated/recommended A+M and PMI data bases has resulted in the publication (or preparation) of the following data compendia, reviews and journal publications:

(i) *Compendia*

(1) Collision Processes of Metallic Ions in Fusion Plasmas (Ed. R.K. Janev), Physica Scr. T37 (1991)

(2) Atomic and Molecular Processes in Magnetic Fusion Edge Plasmas (Ed. R.K. Janev) (in preparation for Plenum Press)

(3) R.K. Janev, J.J. Smith
"Recommended Cross Sections for Collision Processes of Hydrogen Ground-State and Excited Atoms with Electrons, Protons and Multiply Charged Ions" (in preparation for At. Data Nuc. Data Tables, and as an IAEA publication)

(4) Atomic and Plasma-Material Interaction Processes in Controlled Thermonuclear Fusion (Eds. R.K. Janev and H.W. Drawin), Elsevier Publ. Co., Amsterdam, 1993 (in preparation)

(ii) *Reviews*

(1) R.K. Janev
Atomic physics issues in fusion reactor design
Comments At. Mol. Phys. 25, 83 (1991)

(2) R.K. Janev, A. Miyahara
Plasma-material interaction issues in fusion reactor design and status of the database
At. Plasma-Mat. Int. Data Fusion, 1, 123 (1991)

(3) R.K. Janev
Atomic processes in thermonuclear fusion plasmas.

Chapter in: "Progress in Atomic and Molecular Physics", (Ed. C.D. Lin) World Scientific Publ. Co., Singapore 1993 (in press)

(iii) *Journal publications*

In the reporting period, the IAEA A+M Data Unit's staff has published more than 15 publications in international scientific journals containing A+M or PMI data relevant for fusion. Five of these publications contain recommended A+M/PMI data.

7.3. International Bulletin on Atomic and Molecular Data for Fusion

The International Bulletin on Atomic and Molecular Data for Fusion publishes semi-annually selected bibliographic information on references containing A+M and particle-surface interaction data of interest to fusion research. References on spectroscopic A+M data are also included. The input for the Bulletin, prepared and edited by the A+M Data Unit, is provided by the NIST, ORNL, NIFS, Kurchatov Institute, and GAPHYOR data centres. The Bulletin is being distributed to over one thousand institutions, laboratories and individuals. Five issues of the Bulletin (Nos. 42 - 45) have been published and distributed in the reporting period.

7.4. IAEA-NDS Publications of Recommended Data

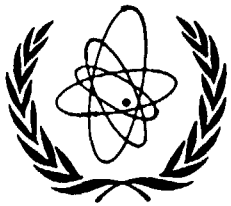
Expanded versions of certain A+M/PMI data bases, supplemented by appropriate background physics comments, are sometimes also published as IAEA-NDS publications. In the reporting period, two such publications appeared:

(1) "Particle Reflection from Surfaces: A Recommended Database" (by E.W. Thomas, R.K. Janev and J.J. Smith)
IAEA Report INDC(NDS)-249 (1992)

(2) "Radiative Losses and Electron Cooling Rates for Carbon and Oxygen Plasma Impurities" (by R. Marchand, R.K. Janev and X. Bonnin)
IAEA report INDC(NDS)-255 (1992)

7.5. Numerical Data Dissemination

The dissemination of evaluated or recommended numerical A+M and PMI data to fusion laboratories and research groups, as well as to the most active A+M/PMI physics groups, is done on a continuous basis. The recommended/evaluated A+M/PMI databases available at the IAEA are being announced in each of the issues of the international bibliographic A+M data Bulletin, where the procedure for requesting and obtaining the data is explained.



IAEA PROGRAMMES

ON

ATOMIC AND PLASMA - MATERIAL INTERACTION

DATA FOR FUSION

IAEA A+M DATA UNIT

NUCLEAR DATA SECTION
DIVISION OF PHYSICAL AND
CHEMICAL SCIENCES

OBJECTIVES AND RELEVANCE

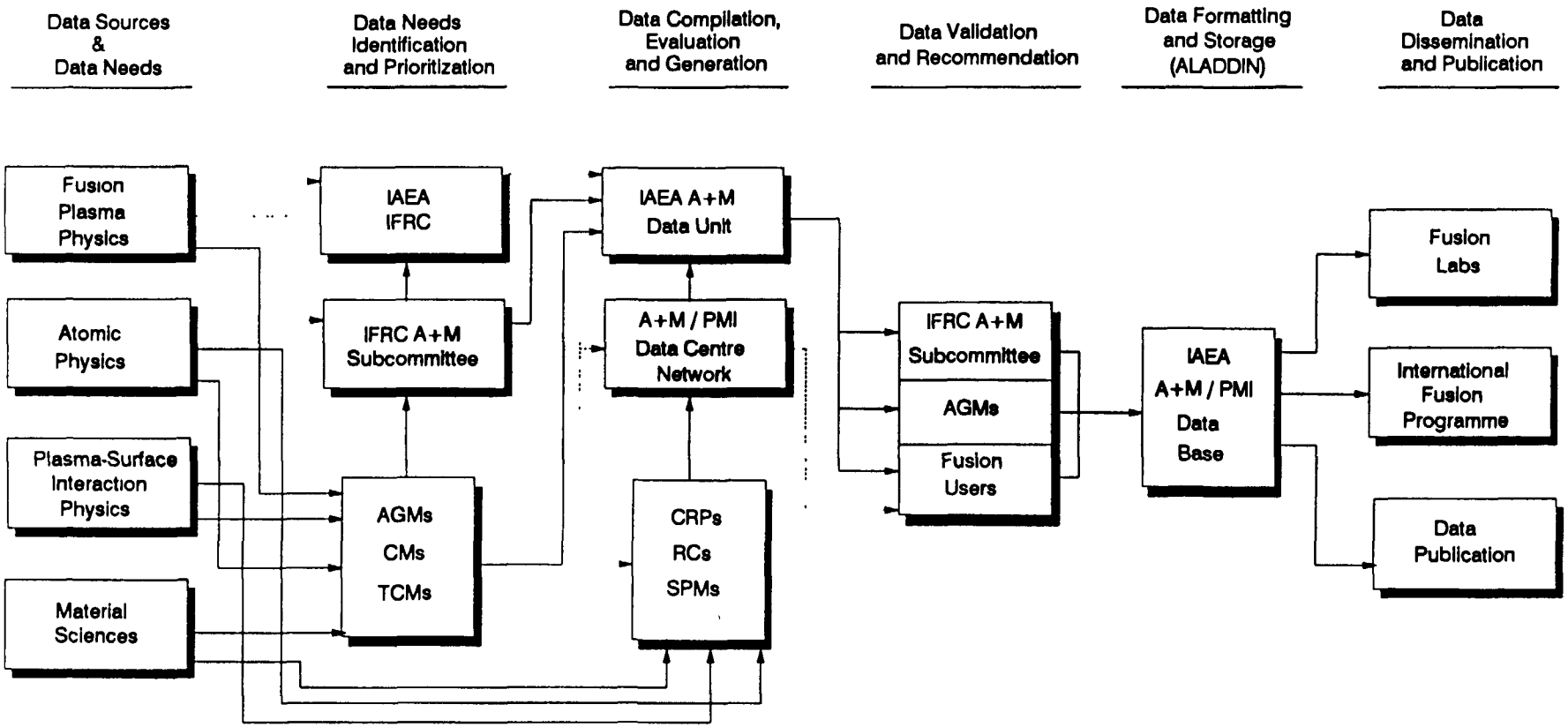
PROGRAMME OBJECTIVES

* ESTABLISH AN INTERNATIONAL BANK OF RECOMMENDED ATOMIC, PLASMA-WALL INTERACTION AND MATERIAL PROPERTIES DATA FOR FUSION ENERGY RESEARCH AND REACTOR DESIGN;
* CO-ORDINATE AND INTEGRATE THE WORLD'S EFFORTS IN PROVIDING THE FUSION PROGRAMME WITH EVALUATED DATA;
* DISSEMINATE THE DATA INFORMATION TO NATIONAL FUSION LABORATORIES, INTERNATIONAL FUSION PROJECTS AND OTHER USERS IN THE AGENCY'S MEMBER STATES.

FUSION RELEVANCE

* SELECTION OF PLASMA FACING REACTOR MATERIALS;
* OPTIMIZATION OF REACTOR IMPURITY CONTROL SYSTEM;
* OPTIMIZATION OF REACTOR POWER AND PARTICLE EXHAUST SYSTEM;
* PLASMA ENERGY BALANCE AND RADIATION LOSSES;
* OPTIMIZATION OF PLASMA HEATING NEUTRAL BEAM SYSTEM;
* PLASMA MODELLING;
* PLASMA DIAGNOSTICS.

FUSION A+M / PMI DATABASE ESTABLISHMENT: INTERACTIVE ELEMENTS AND INFORMATION FLOW



Legend

A+M : Atomic and Molecular

PMI : Plasma-Material Interaction (Including : Particle-Surface Interactions and Material Properties)

IFRC : International Fusion Research Council

AGM : Advisory Group Meeting

CM : Consultants' Meeting

TCM : Technical Committee Meeting

CRP : Co-ordinated Research Programme

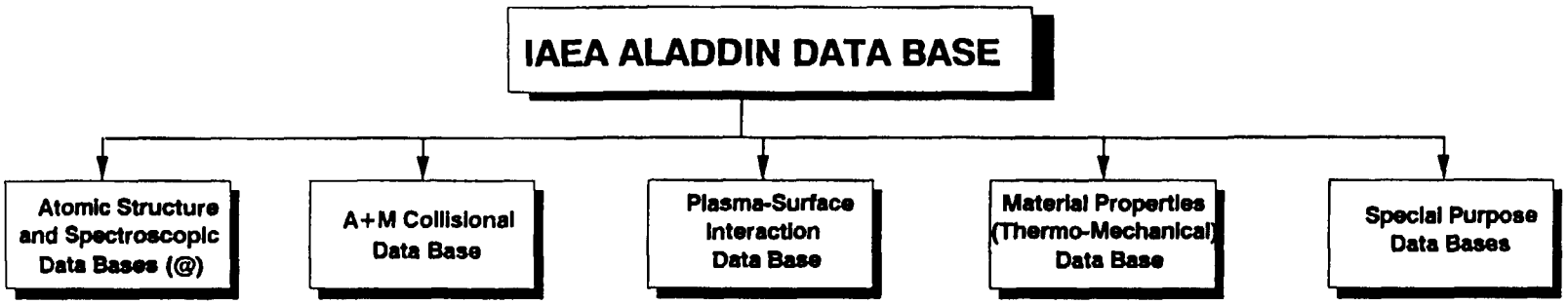
RC : Research Contract

SPM : Specialists' Meeting

ALADDIN : IAEA Data Base System

IAEA A+M DATA UNIT ACTIVITIES

IAEA A+M / PMI NUMERICAL DATA BASES



1. Energy levels
   - One-electron systems
   - Two-electron systems
   - Ti, Cr, Fe, Ni
2. Transition Probabilities
   - Two-electron systems
   - Ti, Cr, Fe, Ni
3. Spectral Wavelengths
   - (pending @)

1. H, H_2, He
2. Li (*)
3. Be, B (*)
4. C, O
5. Ti, Cr, Ni (*)
6. Fe
7. Mo, W (*)
8. Electron-impact ionization (all elements and ions)

1. Particle and energy reflection
2. Physical sputtering
3. Erosion rates (*)
4. Particle-impact electron emission (#)
5. Trapping/detrapping (#) (Tritium)

1. Graphites (*)
2. Carbon-composites (#)
3. Be (#)
4. W (#)

1. H-beam penetration
2. He-beams (*)
3. Li-beams (*)
4. Cooling rates (#)
5. H-recycling (#)
6. A+M data for edge plasmas (#)

Legend :

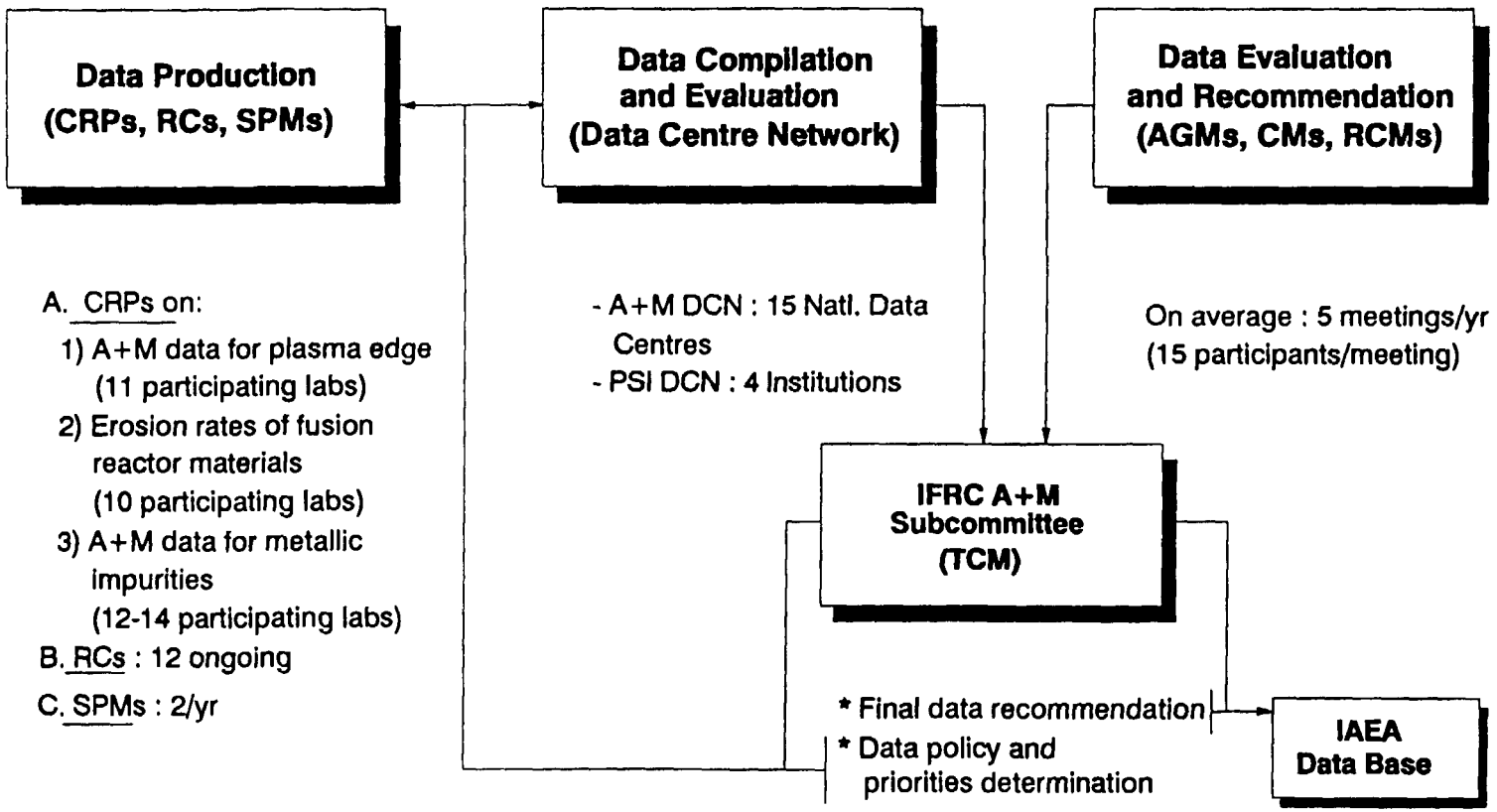
@ Most of these databases are maintained at NIST (Washington) and VNIIFTRI (Mendeleevo)

* Work in progress

\# Initiated or planned

CO-ORDINATION OF DATA PRODUCTION, COMPILATION AND EVALUATION

(current activity level)



Legend :

DCN - Data Centre Network
PSI - Particle Surface Interaction
CRP - Co-ordinated Research Programme
RC - Research Contract
SPM - Specialists' Meeting
AGM - Advisory Group Meeting
CM - Consultants' Meeting
RCM - Research Co-ordination Meeting
TCM - Technical Committee Meeting

DATA PUBLICATION AND DISSEMINATION

Data Handbooks and Compendia

@ Compendium on PSI data for Fusion (Nucl. Fus. Spec. Issue, 1984)
@ Compendium on A+M Data for Iron Ions (Nucl. Fus. Spec. Issue, 1988)
@ Compendium on A+M Data for C and O Ions (Physica Scr. Topic. Issue, 1989)
* Compendium on A+M Data for Metallic Impurities (Physica Scr. Topic. Issue, 1991)
* Handbook on A+M Data for H-beams in plasmas (IAEA, 1991)
# Handbook on A+M data for He-beams in plasmas (IAEA, 1992)
# Compendium on A+M data for LI-beam diagnostic (IAEA TecDoc, 1992)

Nucl. Fusion A+M/PMI Supplement

(Regular journal-level publication, issued once per year)
* Vol. 1 : PMI data (1990)
* Vol. 2 : A+M data for plasma edge (1991)
# Vol. 3 : He,Be,B-data (1992)

Data Dissemination and Services

@ Dissemination of numerical data in computer-readable form and in book format on a regular basis
@ Dissemination of data and publications on request

Legend :

@ Work already performed	A+M - Atomic and Molecular
* Work in progress	PSI - Particle Surface Interaction
# Work initiated or planned	PMI - Plasma Material Interaction

MAINTENANCE AND DEVELOPMENT OF ALADDIN* SYSTEM

ALADDIN SOFTWARE	ALADDIN DATA FILES	ALADDIN MANUAL
- Continuous development of ALADDIN software (structure & functionality)	- Creation of numerical data files - Maintenance and up-dating of existing data files - Creation of evaluation functions	- Regular up-grading - Preparation of new Manual Versions - Dissemination to users

* **ALADDIN** is the IAEA computerized system for storage, management and exchange of all numerical data bases for fusion, maintained by the A+M Data Unit

IAEA A+M BIBLIOGRAPHIC DATA BASE FOR FUSION

International Bulletin on A+M Data for Fusion

Publication, Preparation and Dissemination
- Semi-anually (40 issues as of 1991)
- Distribution to over 1200 recipients
- Input from ORNL, Orsay, Kurchatov Inst.

CIAMDA *

Publication, Preparation
- Periodic publication
  - CIAMDA - 1 (1980)
  - CIAMDA - 2 (1986)

Data Base Maintenance and Development

- Data Base up-dating
- Completeness check-ups

* Computerized Index of Atomic and Molecular Data for Fusion

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DOCUMENT: a:\letter.rkj (Pg.7)

APPENDIX 3

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