

INTERNATIONAL NUCLEAR DATA COMMITTEE

REPORT OF THE NUCLEAR DATA SECTION TO THE INTERNATIONAL DATA COMMITTEE MARCH 1989 - JUNE 1990

D.W. Muir, Editor

September 1990

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

<u>Abstract</u>

This progress report of the IAEA Nuclear Data Section covers the 16-months period March 1989 to June 1990. It describes past, current and planned activities of the Section and presents the status of its nuclear and atomic data centre activities, services and technology transfer.

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List of Abbreviations

A+M Atomic and molecular

ADABAS Data base management system in use at IAEA

- CAJaD Centre for Data on the Structure of the Atomic Nucleus and Nuclear Reactions of the USSR State Committee on the Utilization of Atomic Energy, located at the Kurchatov Institute
- CBNM Central Bureau for Nuclear Measurements, located at Geel, Belgium
- CCDN Centre de Compilation de Donnees Neutroniques, same as NDCC Neutron Data Compilation Centre of the OECD Nuclear Energy Agency at Saclay near Paris; now part of NEA Data Bank
- CDFE Centre for Photonuclear Experiments Data, Institute of Nuclear Physics of the Moscow State University
- CIAMDA Computerized Index to Literature on Atomic and Molecular Collision Data Relevant to Fusion Research
- CINDA Computerized Index of Neutron Data, a specialized bibliography and data index on neutron nuclear data compiled jointly by NNCSC, NDCC, NDS and CJD
- CINDU A Catalogue of Numerical Nuclear Data Libraries available from NDS
- CJD Centr po Jadernym Dannym, the USSR Nuclear Data Centre at F.E.I. Obninsk
- CODATA Committee on Data for Science and Technology
- CODEN International code for the abbreviation of periodical titles used by ASTM, INIS and Chemical Abstracts
- CPL Computer Programme Library operated by NEA, and located at Ispra, Italy; now part of NEA Data Bank
- CPND Charged Particle Nuclear Reaction Data
- CRP Coordinated Research Programme
- CSISRS NNCSC' internal system for handling experimental data; the previous system was known as SCISRS
- DASTAR Data Storage and Retrieval System used originally at IAEA/NDS
- DBMS Data Base Management System
- EBCDIC Extended Binary-Coded Decimal Interchange Code
- EGAS European Group for Atomic Spectroscopy

ENSDF Computer-based <u>Evaluated Nuclear Structure Data File developed</u> by US/NDP

EWGRD European Working Group on Reactor Dosimetry

- ESCAMPIG Europhysics Study Conference on Atomic and Molecular Physics in Ionized Gases
- EXFOR Exchange Format, initially developed for the international exchange of neutron nuclear data, now being extended to charged particle nuclear data
- FIZ Fachinformationszentrum Energie, Physik, Mathematik GesmbH located at the Kernforschungszentrum Karlsruhe in the Federal Republic of Germany
- FPND Fission Product Nuclear Data
- IAEA/NDS Nuclear Data Section of the International Atomic Energy Agency, also NDS
- ICPEAC International Conference on the Physics of Electronic and Atomic Collisions
- ICTP International Centre for Theoretical Physics
- IFRC International Fusion Research Council
- INDC International Nuclear Data Committee
- INDL/A IAEA Nuclear Data Library for Evaluated Neutron Reaction Data of Actinides
- INIS International Nuclear Information System, a bibliographic system operated by the IAEA
- IRDF International Reactor Dosimetry File
- IWGRRM International Working Group on Reactor Radiation Measurements
- JILA Joint Institute for Laboratory Astrophysics
- JINR Joint Institute for Nuclear Research in Dubna, USSR
- KACHAPAG Karlsruhe Charged Particle Group
- KEDAK Karlsruhe Evaluated Neutron Data File
- LIYAF Leningrad Institut Yadernoy Fiziki: Leningrad Nuclear Physics Institute of the USSR Academy of Sciences
- NDCC Neutron Data Compilation Centre (Centre de Compilation de Donnees Neutroniques - CCDN) of the OECD Nuclear Energy Agency at Saclay near Paris; now part of NEA Data Bank

NDP Nuclear Data Project located at the Oak Ridge National Laboratory (also referred to as US/NDP)

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- NDS IAEA Nuclear Data Section, Vienna
- NEA Nuclear Energy Agency of the OECD
- NEA/DB Nuclear Energy Agency of the OECD Data Bank (previously NDCC)
- NEACRP Committee on Reactor Physics of the Nuclear Energy Agency of the OECD
- NEANDC Nuclear Data Committee of the Nuclear Energy Agency of the OECD
- NNCSC US National Neutron Cross Section Centre at the Brookhaven National Laboratory, Upton, N.Y. (now NNDC)
- NND Neutron Nuclear Reaction Data

NNDC National Nuclear Data Centre of the United States

- NRDC Nuclear Reaction Data Centres
- NSDD NSD data = Nuclear Structure and Decay Data
- OECD Organization for Economic Cooperation and Development
- RCN Now ECN = Energy Research Foundation at Petten in the Netherlands
- REAL Reaction Rate Estimates, Evaluated by Adjustment Analysis in Leading Laboratories
- RIKEN Institute of Physical and Chemical Research, Saitama, near Tokyo, Japan
- SCISRS Sigma Centre Information Storage and Retrieval System
- SOKRATOR Soviet Evaluated Neutron Data File Format
- TND Transactinium Isotope Nuclear Data
- UKNDL UK Nuclear Data Library
- WRENDA World Request List for Nuclear Data published by the IAEA
- ZAED Zentralstelle fuer Atomkernenergie-Dokumentation: Nuclear documentation and information centre for the Federal Republic of Germany; now FIZ

Programme Summary

J.J. Schmidt Head, IAEA Nuclear Data Section (NDS)

This progress report on the activities and services of the IAEA Nuclear Data Section covers the sixteen months period from March 1989 to June 1990.

This period is marked by a large turnover of NDS professional staff. Alex Lorenz and Koichi Okamoto, long-term senior staff members of NDS, have both reached retirement age and have left the Agency at the end of May 1989 and the end of March 1990, respectively. As successors in their posts Douglas Muir from Los Alamos National Laboratory and Ganesan Srinivasan from the Indira Gandhi Centre for Atomic Research, Kalpakkam, India, were selected and joined NDS in July 1989 and January 1990, respectively. Douglas Muir has assumed major responsibilities in NDS data centre operations including in particular the establishment of on line connections to several US laboratories, the US NNDC and the NEADB for remote use of their computers, the development of plans for the acquisition by NDS of a MicroVAX computer in the 1991/92 programme period, and the coordination and supervision of the production of the Fusion Evaluated Nuclear Data File (FENDL) and associated FENDL data processing and Koichi Okamoto's major responsibilities for the two Co-ordinated testing. Research Programmes (CRPs) on Nuclear Data needed for Neutron Therapy and on Atomic and Molecular Data for Radiotherapy, and in the field of nuclear data for medical radioisotope production were transferred to Nikolai Kocherov. Ganesan Srinivasan took over responsibilities for the intercomparison and processing of evaluated neutron cross section files for FENDL, implementation of the second stage of the project for verification of nuclear data processing for temperature dependent self-shielded neutron resonance cross codes sections, nuclear data for neutron emission in fission, and for nuclear data processing related interlaboratory exercises and technical co-operation (TC) projects in developing countries. Valery Goulo left NDS at the end of December 1989 and returned to the Institute of Nuclear Power of the Byelorussian Academy of Science, Minsk. He was replaced by Anatoly Pashchenko from the Power and Engineering Institute (FEI), Obninsk, USSR, who is actively involved in the development of the FENDL file, including the collection, intercomparison and consolidation of the FENDL activation data subfile and the testing of FENDL data in integral and benchmark experiments. He is also involved in the CRP on Methods and Calculation of Fast Neutron Cross Sections and several individual research contracts dealing with the improvement of nuclear model predictions of fast neutron cross sections for FENDL.

Madhu Mehta completed his contract as resident technical co-operation expert at the end of April 1989 and returned to India to become Director of the Vikram A. Sarabhai Community Science Centre in Ahmedabad. He was responsible for the implementation of the Interregional Technical Co-operation Project INT/1/039 on Nuclear Measurement Techniques and assisted NDS in the implementation of several CRPs for the improvement of fast neutron experimental and theoretical data and in the organization and direction of the joint IAEA/ICTP Workshops on Nuclear Data and Reactor Physics; in this latter activity he continues to be fully engaged. Monica Seits has left NDS in February 1990 to assume a higher level position in the Agency's Division of Safeguards Information Treatment. Kevin McLaughlin has been appointed to fill the NDS post vacated by Ms. Seits. Among his other duties, Mr. McLaughlin will supervise the work of the NDS Data Centre Operations Unit.

Finally, Marisa de Moraes-Cunha left NDS at the end of March 1990 and returned to the Brazilian Nuclear Data Centre at Sao José dos Campos near Sao Paulo. The responsibilities for NDS data service coordination entailed in her post were distributed to other mostly clerical NDS staff and converted to those of a development programmer, in order to cope with the shortage of NDS programming manpower.

Among the highlights of the Section's activities and accomplishments during the reporting period were significant progress in the development of FENDL and supporting CRPs, a strong increase in evaluated and recommended atomic and molecular (A+M) data for fusion. expansion of the A+M data activity in the field of plasma-material interaction data, and a first review of the thermal response of plasma-facing materials and components, establishment of close links to the ITER design requirements for both A+M data and FENDL, the successful completion of the two CRPs on X-ray and gamma-ray standards for detector efficiency calibration and on the measurement and analysis of neutron emission spectra in (p,n) and (alpha,n) reactions and of the Interregional Project TC/INT/1/039 on Nuclear Measurement Techniques, the start of on line connections for remote computing, and, last but not least, the publication of a complete archival issue of CINDA. Another main event strongly affecting the NDS future data centre activities and services to developing countries was the release of major evaluated nuclear data files (ENDF/B-VI, JENDL-3, JEF-1 and BROND) in 1990.

A Consultants' Meeting held at Argonne National Laboratory in September 1989 revealed considerable progress in the measurement of activation cross sections for the generation of long-lived radionuclides and pointed to the need to improve the accuracy of associated half life data. The importance of activation data was also stressed at the Advisory Group Meeting on Nuclear Data for Radiation Damage and Related Safety Aspects convened in Vienna in September 1989 as well as the requirement for improved nuclear data for radiation damage studies with intense d-Li and spallation neutron sources. The Consultants' Meeting on Fission Yield Nuclear Data held in Vienna in September 1989 reviewed the current compilation, evaluation and modelling efforts and methods as well as the deficiencies and gaps in the available data and developed a detailed work programme for a forthcoming CRP for the evaluation of improved fission yield data for the important actinides. Α Specialists' Meeting held in Vienna in November 1989 reviewed the accuracy status and requirements of transactinium isotope decay data and decided on a number of tasks for the publication of a revised edition of the IAEA handbook on "Decay Data of the Transactinium Nuclides" published as IAEA Technical Report No. 261 in 1986. The Consultants' Meeting on Measurement, Calculation and Evaluation of Photon-Production Cross Sections held at Smolenice, Czech and Slovak Federal Republic, in February 1990 emphasized the positive role and stronger exploitation of nuclear theory (exciton models, multistep theories) for the computation of gamma-ray production cross sections and spectra needed nuclear fusion, accelerator shielding and other applications and for recommended to establish a CRP for the improvement of gamma-production cross section data.

Two meetings convened in the reporting period (a Specialists' Meeting in May 1989 and a Consultants' Meeting in June 1990, both in Vienna) brought significant progress in the critical assessment, intercomparison, selection and testing of neutron cross section files for major fusion reactor materials to be incorporated in the first verion of FENDL, FENDL-1. An ITER Specialists' Meeting on ITER Shielding Calculations held at Garching, Federal Republic of Germany, in February 1990, with invited NDS participation (D. Muir) agreed on the usefulness of the FENDL project for future ITER design calculations and stressed the priority need of preparing processed data libraries for neutron and photon transport codes and the development of a comprehensive activation cross section library. Following the meeting, a data communication link was established between Garching and IAEA/NDS giving NDS the possibility of remote computing on the Garching VAX computers and, through them, access to the international MFENET network.

Under the CRP on Measurement and Analysis of 14 MeV Neutron-induced Double-differential Neutron Emission Cross Sections (DDCS) previously proposed 14 MeV measurements have now been performed for the elements V, Cr, Fe, Nb, Ta, W and Bi and a new double time-of-flight method been developed for DDCS measurements below 14 MeV. This progress was reported at the Second Research Co-ordination Meeting (RCM) under this CRP held in Vienna in June 1990 which also stressed the high priority need to include new 14 MeV DDCS measurements and evaluations for ⁶Li, ⁷Li and ⁹Be in the final work programme of this The third (and last) RCM on Methods for the Calculation of Fast Neutron CRP. Cross Sections for Structural Materials held also in Vienna in June 1990, adjacent to the DDCS RCM, highlighted recent development and applications of, for example, the unified optical potential based on dispersion relations, multistep theories and nuclear level densities with the inclusion of collective effects, stressed the need for an improved alpha-particle optical potential for more reliable predictions of (n,alpha) cross sections, and established a work plan for the preparation of standardized input data bases for selected nuclear model codes for use on PCs in developing countries. The final results of both CRPs will be used in future FENDL-related nuclear data evaluation work.

The CRP on X-ray and Gamma-ray Standards for Detector Efficiency Calibration was completed in 1989. CRP members from leading radionuclide metrology institutes of eight countries and two international organizations performed experiments and theoretical data analysis and agreed upon a common set of radionuclides and their radiation characteristics. This information will be published in an IAEA Technical Report and recommended as the international reference standard for the calibration of semiconductor detectors used in various fields of applied radionuclide metrology.

Also completed in 1989 was the CRP on Measurement and Analysis of Neutron Emission Cross Sections in (p,n) and (alpha,n) reactions, in which participants measured the emitted neutron angle-energy distributions resulting from the bombardment of 18 different target nuclides with 5-13 MeV protons and 9-13 MeV alpha particles. The experimental data were compiled by the Agency and re-distributed to other participants in the CRP, who used the data to extract improved information on nuclear level-density parameters. A consistent set of such parameters was obtained for 15 of the 18 nuclides, and these results will appear in a forthcoming INDC report. These improved parameters should improve the reliability of current nuclear-model codes which are especially useful in estimating specific nuclear data that, for practical reasons, cannot be measured directly.

The status of cross section data for 19 important charged particle-induced monitor reactions required for optimization of cyclotron production of medical thoroughly reviewed and documented radioisotopes was in the report. INDC(NDS)-218/GZ. Work on the handbook of nuclear data for well logging and mineral analysis is progressing with the inclusion of more recently released evaluated data and the preparation of a data base in the 640-group SAND II format. The 1990 update version of the International Reactor Dosimetry File, IRDF-90, was completed and released in September 1990; it contains 50 reactions, 14 of them represent new evaluations performed at the Institut für Radiumforschung unđ Kernphysik, Vienna, 36 reactions originate from INDC report documenting the file is in preparation. ENDF/B-VI. An Compilation of reports for the last edition of the joint INDC/NEANDC Discrepancy File was completed, its publication as report INDC(NDS)-235/U is currently in preparation.

Cooperation of the nuclear reaction (NRD) and nuclear structure and decay data (NSDD) centre networks was continued with two meetings, one held in Vienna in October 1989 (NRD) and the other in Kuwait in March 1990 (NSDD). The NRDC meeting concentrated on technical aspects of the EXFOR and CINDA systems and on updating of compilation rules for the inclusion of fission product nuclear data. By the end of 1989 the NNDC CINDA compilation effort regrettably had to be considerably reduced due to a reduction of manpower and has not yet been re-instated. The NSDD meeting reiterated the need for an evaluation cycle time of 5-6 years, though only an average cycle period of 8-9 years could be achieved so far. The main problem in the continuous updating of the Evaluated Nuclear Structure Data File (ENSDF) is the lack of sufficient skilled evaluation manpower aggravated by the recent discontinuation of the German and UK contributions to the file.

Due to an exceptional favourable situation in the publication budget, it was possible, despite of the discontinuation of NNDC and NEADB bulk orders for the CINDA handbook, to publish in 1990 the complete archival issue of CINDA in five volumes.

A major event in the reporting period strongly affecting the future NDS data centre activities and services to developing countries was the previously mentioned release of the evaluated neutron data files ENDF/B-VI, JENDL-3, BROND and JEF-1 during 1990. It is planned to make extensive use of these files and modern data processing codes such as NJOY in training of nuclear data specialists and reactor physicists in many developing countries in nuclear data processing and updating of obsolete multigroup cross sections for neutron transport and other reactor physics calculations.

The use of PCs within NDS continues to grow, for both data input and processing activities. The ENDF "pre-processing" codes are used to process and plot data files, the NNDC ENDF utility codes are being converted for PC use, a PC evaluated data indexing system is being developed, nuclear model codes developed for PC use are compiled and tested for use in the joint NDS/ICTP Workshops. For EXFOR a PC system for data input and checking is being developed and will be available for use by compilers in data centres in developing Member States. A highlight of the current reporting period was the establishment of communication links to NEADB, NNDC and other US laboratories for remote computing.

The number of requests for data, codes and documents received and fulfilled by NDS during the reporting period remained high, amounting for the year 1989 to 773 requests received from altogether 63 countries, comprised of 44 developing and 19 advanced countries.

A technical evaluation was performed of the results of the TC Interregional Project INT/1/039 on Nuclear Measurement Techniques which was terminated at the end of 1989. Under this project 23 nuclear analytical laboratories from 14 developing countries performed elemental analyses of material samples provided by the Agency's Seibersdorf Laboratory with the most common nuclear analytical techniques introduced by the Agency in developing countries, i.e., X-ray fluorescence, fast neutron activation, low-level counting and protoninduced X-ray emission. Comparison of the results of these analyses with the known reference values for the sample composition revealed large discrepancies and inconsistencies in the reported measurements reflecting deficiencies in instrumentation as well as in the proper utilization of the measurement techniques in most of the participating laboratories. As a consequence, intensified training of scientists and technicians in nuclear instrumentation and measurement techniques is planned, with an emphasis on nuclear analytical laboratories in the region of Africa and on X-ray fluorescence and neutron activation techniques. This project will form part of a larger African Regional Project (AFRA) currently under development for the strengthening of nuclear programmes in African countries.

In 1989 two Interregional Training Courses were organized, one on Nuclear Measurements and Methods in Reactor and Personal Neutron Dosimetry at the Riga University from 15 May to 9 June 1989, and another one on Technology and Application of Neutron Generators at the Efremov Research Institute in Leningrad from 25 September to 27 October 1989; both were organized in co-operation with the USSR State Committee on the Utilization of Atomic Energy. They combined series of lectures with practical exercises and facility demonstrations.

As part of the established biennial series of Workshops on Nuclear Physics Applications and Nuclear Technology, a Workshop on Reactor Physics Calculations for Applications in Nuclear Technology was organized jointly by the IAEA Nuclear Data and Physics Sections and the International Centre for Theoretical Physics (ICTP) Trieste and held from 12 February to 16 March 1990. In lectures and computer exercises this Workshop covered various thermal reactor physics areas and most commonly used nuclear data processing (NJOY) and reactor physics codes (WIMS, ANISN, LEOPARD, MCRAC, HEATHYD, and KINIK). Compared to previous Workshops, this Workshop was particularly successful, since the 51 participants from 24 developing and two advanced countries formed a more homogeneous group of well qualified young scientists who actively participated in the Workshop programme and communicated with each other. Immediate results of this Workshop are a project for the updating of the multigroup constant library of the WIMS code with ENDF/B-VI and other recently released evaluated nuclear data files and a group fellowship training in nuclear data processing which NDS plans to conduct for the first time in 1991, with participation from several young scientists from developing countries selected during the Workshop.

In line with the advice and recommendations of the International Fusion Research Council (IFRC) Subcommittee on Atomic and Molecular (A+M) Data for Fusion, the main emphasis of the current NDS A+M Data Unit activities is on the establishment of adequate data bases required for understanding the behaviour and properties of tokamak edge plasma, for metallic impurities and for plasma wall interaction processes. All these data are urgently required for solving the critical problems of plasma impurity control and power exhaust systems in the design of next step experimental fusion reactor devices, such International Thermonuclear Experimental Reactor as the (ITER). The successful execution of these programmes, and their natural extension in the area of fusion material properties data, would provide a very important input for the design of such fusion devices.

Five scientific meetings were convened by the A+M Data Unit in the reporting period on these important issues for fusion reactor development. A Specialists' Meeting held in Vienna in April 1989 reviewed the requirements for an atomic data base for hydrogen neutral beam penetration in large tokamaks and concluded that in the energy region of interest to fusion test reactors the data base for all relevant electron impact processes is firmly established, and that the data base for atomic hydrogen collision processes with electrons, protons and impurity ions is adequate for use in neutral beam penetration codes. For ion-atom interaction energies of interest to the beam penetration calculations in present large tokamak devices the data base is still not fully established, with main gaps showing up in impact excitation data of impurity ions.

The excellent working relationship established between the NDS A+M Data Unit and the ITER project is illustrated by the invitation extended to Dr. R. Janev, Head of the A+M Data Unit, to participate in the ITER Workshop on Current Drive and Heating Physics held in Garching in June 1989, to present the recommended atomic physics data base resulting from the above mentioned Agency Specialists' Meeting and to help setting the optimal range of neutral beam injection energies.

An Advisory Group Meeting held in Vienna in April 1989 reviewed the data status and needs for plasma-surface interaction (PSI) processes. The demand has considerably expanded since the first review and data collections and publications in the beginning of the 80ies, and the existing data base was found to be far from satisfactory to meet the needs of current fusion research and design work. Following the meeting's recommendation a new CRP was initiated in 1990 on the characterization of plasma-induced errosion rates of fusion reactor candidate materials for coordinated experimental and theoretical research on all plasma-wall interaction processes contributing to material erosion and deposition and preparation of an evaluated data base for these In parallel to the CRP the A+M Data Unit, with the temporary processes. support of an outside expert (Prof. E. Thomas from the Georgia Institute of Technology, Atlanta, USA) and two IAEA scientist fellows from Beijing, China, started to compile, evaluate and model available backscattering and sputtering yield coefficients for inclusion in the PSI data base. For this purpose the format of the ALADDIN system has been extended to contain PSI data.

A Specialists' Meeting held in Vienna in September 1989 reviewed the status of data for A+M processes in fusion edge plasmas which have a strong influence on the overall plasma performance and are critical for the modelling and diagnostics of edge plasmas and the prediction of overall plasma behaviour and properties. The collisional A+M and spectroscopic data bases particularly for high-Z impurities were found to be fragmentary and it was recommended to adjust the activities of the ongoing CRP on A+M Data for Fusion Edge Plasmas so as to satisfy the increased interest particularly in Be, B and metallic impurities and in all A+M processes of hydrocarbons and metallic carbides. Also for main fusion plasmas the A+M data base for metallic impurities is still unsatisfactory, as stated by an Advisory Group Meeting on A+M Data for Metallic Impurities for Fusion Plasmas held in Vienna in May 1990. In view of the importance of metallic impurities for inducing plasma radiation losses, the meeting recommended to initiate a CRP for the generation of the required data base allowing reliable estimation of plasma radiation losses and, related to this CRP, to systematically compile and evaluate metallic impurity data in co-operation with the A+M Data Centre Network.

The development of appropriate plasma facing materials and components and computation and testing of their thermophysical the measurement, and mechanical properties are crucial issues in the current development of next generation experimental fusion reactor devices and subject of extensive national and international research (e.g., for ITER). A Consultants' Meeting on Thermal Response of Plasma Facing Materials (PFM) and Components (PCM) held in Vienna in June 1990 stated that a large but scattered body of data is available in this area, but that there are still important gaps in PFM and PCM property data for high temperature operation regimes and for extensive neutron damage conditions. It concluded that an involvement of the Agency in the co-ordination of material property research, in addition to the already ongoing multilaterally organized efforts, would not enhance the effects at the present stage, but that an Agency co-ordinated activity in compilation, critical analysis, consolidation and dissemination of the available material property data would be urgent and of immediate benefit to the current fusion reactor material development. These findings and recommendations will be one of the major issues in the deliberations on the future programme of the A+M Data Unit by the IFRC Subcommittee on A+M Data for Fusion at its forthcoming meeting in September 1990.

In September 1989 the 8th Meeting of the A+M Data Centre Network was This network is now comprised of fourteen co-operating A+M data convened. centres and groups in eight countries, to review the current status and the nearand long-term priorities in the compilation and evaluation of spectroscopic, collision and plasma surface interaction data and to discuss future developments of the ALADDIN data base, software and manual. Despite of manpower and funding problems in most national A+M data centres, a considerable growth in A+M data evaluation activities was noted, evidenced particularly by the number of evaluated spectroscopic and collisional data sets and publications produced during the past two years; growth in the near future is expected in PSI data evaluation activities. Regarding ALADDIN highest priority is given to the conversion of all existing A+M data sets which are used in plasma modelling codes into ALADDIN format.

Other major accomplishments of the A+M Data Unit in the reporting period not mentioned above are the completion and updating of atomic data bases for C, O and Fe impurity ions and the preparation of recommended data handbooks and computerized libraries for these ions as well as the preparation of a data compendium for the most important edge plasma A+M processes which will be published in 1991.

A. INDC SECRETARIAT

A.1. Liaison Officers of the INDC

The current list of INDC Liaison Officers, including scientists from 41 Member States, is given in <u>Appendix A</u>.

A.2. List of INDC Correspondents and National Nuclear Data Committees

The current list of INDC correspondents for the exchange of nuclear data information is to be issued in September 1990. The report also contains the information on National Nuclear Data Committees. This combined report will be published as INDC(SEC)-100.

A.3. List of INDC Documents

The current list of INDC Documents received and distributed by the INDC Secretariat is to be published in September 1990 as report INDC(SEC)-099. In an effort to help reduce the publication load of the Nuclear Data Section, the content of the List of INDC Documents includes only reports which have been published during the preceeding two years. A full list of INDC Documents is available from the Nuclear Data Section on request.

A.4. <u>Translation of Documents</u>

Subject to available funds, the IAEA translates a limited number of INDC reports. Between March 1989 and June 1990 twelve nuclear data reports were translated from Russian into English and distributed as INDC reports. Their full titles are given in the List of INDC Documents, INDC(SEC)-099.

B. DATA ASSESSMENT AND RESEARCH COORDINATION

B.1. Data Status and Requirements

B.1.1. <u>Required Atomic Database for Beam Penetration in Large Tokamaks (ITER)</u> (SPM, Vienna, 10-12 April 1989)

On suggestion from ITER Physics Group, a small Specialists' Meeting was organized to evaluate the available database for collision processes related to the penetration of energetic neutral hydrogen beams in fusion reactor plasmas. Based on extensive work and preparation prior to the meeting, as well as thorough discussions, data intercomparison and data evaluation during the meeting, the participants of the meeting were able to set up a coherent set of recommended data for the most important atomic processes influencing a neutral hydrogen beam penetrating a fusion plasma. This set of data was afterwards used by the ITER Team to optimize the neutral beam energy for heating and current drive of the ITER core plasma. B.1.2. <u>Particle-Surface Interaction Data for Fusion</u> (AGM, Vienna, 19-21 April 1989)

> The meeting was organized on the recommendation by the IFRC Subcommittee on Atomic and Molecular Data for Fusion to identify the status and needs for data on particle-surface interaction processes in the current fusion research and reactor design work (particularly ITER). Thirty world leading experts, covering different aspects of this research and data area, participated in this Advisory Group Meeting. A thorough analysis of the existing database and the needs for plasma-surface interaction data in ITER design was performed. Clear conclusions about the data status and needs were formulated by the Advisory Group, as well as appropriate recommendations for actions to be taken by the Agency in this area to improve the data situation and meet ITER design requirements.

B.1.3. <u>Second Meeting on the Fusion Evaluated Nuclear Data Library (FENDL)</u> and <u>Benchmark Calculation</u> (SPM, Vienna, 8-11 May 1989)

Following the recommendations of the 16th INDC Meeting and the scientific programme for the development of a nuclear data base for fusion reactor technology agreed at the IAEA Advisory Group Meeting on Nuclear Data for Fusion Reactor Technology, 1-5 December, 1986, Gaussig, German Democratic Republic, IAEA/NDS has convened a series of Specialists' Meetings and Consultants' Meetings on the Fusion Evaluated Nuclear Data Library (FENDL).

As a part of this continuing programme, on 8-11 May 1989 the IAEA convened the second Specialists' Meeting on FENDL and Benchmark Calculations. At this meeting, it was agreed that FENDL will serve as a reference library for use in national and international fusion activities. FENDL-1, the first version of the library, was planned to be finished by the end of 1990. It consisted initially of neutron and gamma-ray transport files selected from five national evaluated nuclear data libraries.

FENDL-1 includes evaluated data for the main elements and isotopes of the following fuel, blanket, structural and shielding materials:

H, D, T, Li-6, Li-7, Be-9, B-10, B-11, C-12, N, O, F, Si, Al, Ti, V, Cr-50, Cr-52, Cr-53, Cr-54, Mn-55, Fe-54, Fe-56, Fe-57, Fe-58, Co-59, Ni-58, Ni-60, Ni-61, Ni-62, Ni-64, Cu-63, Cu-65, Zr, Nb-93, Mo-92, Mo-94, Mo-95, Mo-96, Mo-97, Mo-98, Mo-100, Sn, Ba-134, Ba-135, Ba-136, Ba-137, W, and Pb. This list was later expanded, at the request of ITER designers, to include Na, Mg, P, S, Cl, K, Ca and Ta. It is intended that FENDL will also contain the following updated special-purpose libraries:

- the International Reactor Dosimetry File for use in neutron dosimetry maintained by the Nuclear Data Section with the support of the Institute für Radiumforschung und Kernphysik, Vienna;
- the Charged Particle Data Library DATLIB maintained by the Technical University Graz;

 a large comprehensive activation data library covering several thousand activation reactions selected and compiled from various national files, and

- a library of gamma-ray interaction data.

The processing of the microscopic data files into forms usable in neutronic and safety calculations is underway at the IAEA/NDS with the support of the laboratories which contribute to the FENDL project. In particular, FENDL is being converted into a fine-mesh point data library and from this a multigroup data library for use in discrete ordinate codes and a library for use in Monte-Carlo code calculations will be prepared.

B.1.4. <u>Activation Cross Sections for the Generation of Long-lived</u> Radionuclides (CM, Argonne, 11-12 September 1989)

A Consultants' Meeting on activation cross sections for the generation of long-lived radionuclides of importance in fusion reactor technology was held at the Argonne National Laboratory, Argonne, Illinois, USA. The meeting was, in effect, the first of the Research Coordination Meetings of the Coordinated Research Programme (CRP). It was attended by six participants of the CRP and twenty observers from eight Member States.

The objectives of the meeting were to review the first results of the CRP and the status of activation cross section data for the generation of long-lived radionuclides, exchange of experience in the measurement and evaluation, and to fix the future working programme for the CRP.

The proceedings of the meeting, published as INDC(NDS)-232/L in January 1990, contain all presented papers and the summary of the conclusions and recommendations.

B.1.5. <u>Review of the Status of A+M Data for Plasma Edge Studies</u> (SPM, Vienna, 11-13 September, 1989)

About twenty meeting participants, from both atomic physics and fusion-research communities, addressed the most urgent needs and the availability and quality of the data for the atomic and molecular processes taking place in the boundary layers of tokamak fusion plasmas. Most of the participants in this meeting reported on significant sets of newly evaluation and/or generated A+M data. The meeting formulated actions for further generation and evaluation of A+M data needed in fusion-plasma edge studies and in the design of ITER.

B.1.6. <u>Status and Requirements of Nuclear Data for Radiation Damage and</u> <u>Related Safety Aspects</u> (AGM, Vienna, 27-29 September 1989)

The previous AGM on Nuclear Data for Radiation Damage Assessment was convened by NDS eight years ago in 1981. The present meeting was the second one on this topic and it was intended to summarize the progress and status of nuclear data for radiation damage assessment since the first meeting.

The participants discussed the progress in the experimental facilities used for radiation damage studies. It was noted that during the period of the last meeting construction of intense 14 MeV D-T sources, d-lithium and spallation sources was planned. Of these three only spallation sources became a reality and five of them are now working in the world. The attention of the group then was concentrated on different properties of neutron fields with largely extended neutron energies. Therefore reliable evaluated data for proton and neutron monitor reactions are needed.

In addition to the damage due to helium released in nuclear reactions, further damage is produced by nuclear recoils. The basic data needed for a theoretical calculation of this type of damage are the recoil energy spectra. It appears desirable to develop a simple model of damage energy partitioning for the components of alloys and compounds (for example, steel). It is recommended that IAEA provides the users with information on available methods (computer codes) for the calculation of these quantities and, as far as possible, to collect the above mentioned data and to create a compilation in a standard form (e.g., ENDF-6 format).

The importance for fusion reactor materials of data for activation reactions of nuclides with long half-lives was considered and a list of reactions of basic interest was compiled.

A separate workshop was devoted to discussion of results of REAL-88 exercise. The contents and quality of the reference file produced in the result of this exercise was discussed.

It was recommended to test the new IAEA IRDF-90 library in a similar way and to present the results at the 7th ASTM-EURATOM Symposium.

A short summary of the meeting was published in the report by N. Kocherov INDC(NDS)-231/L+R; the full proceedings will be issued in 1990 as IAEA-TECDOC-572.

B.1.7. <u>Compilation and Evaluation of Fission Yield Nuclear Data</u> (CM, Vienna, 27-29 September 1989)

This meeting was attended by the main evaluators in the field. The objectives were to:

- discuss problems in fission yield measurements, compilation and evaluation, and propose improvements;
- establish means of communication and co-operation;
- prepare a Co-ordinated Research Programme (CRP) on the same subject in detail.

Within the frame of these objectives, the meeting participants reviewed existing compilation and evaluation efforts and methods, discrepancies and gaps in measurements, and semiempirical models and their prediction capabilities. They issued several recommendations on the topics listed above, including some of the compilation of and format for fission yield data in EXFOR, and lists of fission yield data that need improvement. The participants defined the tasks of the CRP following the proposals of a previous meeting (see INDC(NDS)-208, page 9), proposed the names of CRP participants and assigned special tasks to them. A summary report of the meeting's discussions, conclusions and recommendations will be published as an INDC-report.

B.1.8. <u>Status and Requirements of Transactinium Isotope Decay Data</u> (SPM, Vienna, 7-9 November 1989)

This meeting was attended by 6 participants from 4 countries and one international organization, all attending at no cost to the Agency.

The participants reviewed half-life data and gamma-emission probabilities of selected actinides and assessed the data accuracy status in view of the requirements for applications such as non-destructive assay, decay heat calculations, environmental studies and others.

Various actions and recommendations were reached which will result in a revised edition of the IAEA handbook on "Decay Data of the Transactinium Nuclides" (Tech. Rept. 261 of 1986).

The earlier version of this handbook was published in 1986 as the result of a CRP from 1978 to 1985. This handbook has found a wide distribution of 1250 copies, which are now out of stock.

Meanwhile, some of these data must be updated, due to the new experiments with improved accuracy. In some other cases, disturbing data inaccuracies or discrepancies that were stated in the 1986 book continue to exist. Some additional data, in particular for the nuclides of the U-238 decay chain, were now found to be important so that their inclusion in the handbook appears desirable.

The minutes of the meeting will be available as report INDC(NDS)-229.

B.1.9. <u>Measurement</u>, <u>Calculation</u> and <u>Evaluation</u> of <u>Photon-Production</u> <u>Cross-Sections</u> (SPM, Smolenice, CSFR, 5-7 February 1990)

> The ways of production of more accurate and more complete data on photon production in neutron and proton interactions with nuclei were considered by the participants.

The following experimental techniques were considered: continuous energy spallation "white" neutron sources, in-beam gamma-ray measurements with a pulsed 14-MeV neutron source together with neutron TOF spectroscopy, in-beam gamma-ray measurements at 14 MeV using continuous beams with the associated particle techniques. The conclusion of the participants was that these techniques produce data which are reliable and sufficiently accurate, but the measurements are time consuming and costly. So the idea was to obtain the majority of gamma-ray data by calculation and to have a complete and precise set of experimental data only for several nuclei to verify different models and codes.

Two approaches to calculate gamma-ray spectra were discussed: the exciton and the statistical multistep models. It was concluded that the exciton model describes continuous gamma rays, multiple cascades, correlational properties and gamma emission in the giant dipole resonance (GDR) region. The statistical multistep theory was successfully used for the calculation of the 14 MeV spectrum and can account for 20-50% of the data in the GDR region.

It was also noted that the precision of the calculation depends on the knowledge of nuclear level densities, decay schemes and branching ratios.

The participants felt that a concentrated effort was needed to address the problems existing in this field. It was proposed to the IAEA to organize a CRP related to this field.

A short summary of the meeting was published in a report by N. Kocherov in INDC(NDS)-233/L, 1990, the complete proceedings will be published in 1990 as INDC(NDS)-238/L.

B.1.10. <u>A+M Data for Metallic Impurities in Fusion Plasmas</u> (AGM, Vienna, 16-18 May, 1990)

> About twenty world leading experts evaluated the current status of the spectroscopic and collisional database for the most common metallic impurities in current fusion devices and anticipated reactors (Ti, Cr, Fe, Ni, Cu, Mo, W). An evaluation of the existing body data of data for these impurity ions has also been performed at the meeting. The Advisory Group formulated a strong recommendation to the IAEA for initiating a three year Co-ordinated Research Programme to improve the data situation in this area and meet the most urgent needs in fusion plasma diagnostics and modelling.

B.1.11. <u>Thermal Response of Plasma-Facing Materials and Components</u> (CM, Vienna, 11-13 June, 1990)

> A small group of ten experts from the world's leading fusion laboratories and national fusion programmes discussed the status, required research developments and the possibility for establishment of an international (IAEA) database for thermophysical, mechanical and irradiation properties of plasma facing materials and components

for the next generation of fusion devices (engineering fusion reactors). The group identified the data status and the main areas of material-property data needs and formulated recommendations regarding future IAEA activities in this field.

B.1.12. <u>Results of FENDL-1 Testing and Start of FENDL-2</u> (CM, Vienna, 25-28 June, 1990)

Following the recommendations of the 17th INDC Meeting and the IAEA scientific programme for the development of a nuclear data base for fusion reactor technology (see items B.1.3. and C.2.2.c.), the IAEA/NDS convened a Consultants' Meeting on First Results of FENDL-1 Testing and Start of FENDL-2 at the IAEA Headquarters in Vienna, Austria, from 25 to 28 June 1990. It was attended by nineteen specialists from eleven Member States.

The main objectives and specific tasks of the meeting were the following:

- (1) to finalize the review of FENDL-1, especially:
 - to discuss the problems encountered in FENDL-1 files,
 - to review gamma production and DDCS data in FENDL-1 for ${}^{52}Cr$, ${}^{56}Fe$, 58 , ${}^{60}Ni$, and Pb,
 - to review and approve activation cross sections for incorporation into FENDL-1, and
 - to review and approve dosimetry neutron cross sections (IRDF update) for incorporation into FENDL-1,
 - to review and approve charged particle nuclear data for incorporation into FENDL-1,
 - to review user requirements for processed data;
- (2) to start preparation of FENDL-2, especially:
 - to identify new evaluations to replace FENDL-1 files in developing FENDL-2.

Also discussed were the fusion-related nuclear data needs and required activities after the completion of FENDL-2 (scheduled for the end of 1992). The following topics were considered:

- nuclear data needs after FENDL-2
- future of FENDL
- need for FENDL-2 benchmark testing
- activation libraries and general purpose files activities after FENDL-2.

The question of an appropriate date for the next meeting to select evaluations for FENDL-2 was discussed. With the currently known plans an appropriate time appears to be late in 1991.

The conclusions and recommendations of this meeting will be published as an INDC(NDS)-report.

B.1.13. Fission Product Newsletter

Work continues on the biennially published report series "Progress in Fission Product Nuclear Data". Contributions to the 13th issue, which will be published as INDC(NDS)-222, were collected up to early 1990. Presently, these contributions are being edited and the subject index and text pages are under preparation. The actual publication had to be delayed due to heavy workload in connection with the preparation and publication of CINDA 90 and the new archival issue CINDA-A.

B.1.14. INDC/NEANDC Discrepancy File

Most of the reports from the contributors were received by B.H. Patrick and forwarded to the Nuclear Data Section for further compilation and editorial work. The compilation was completed here in NDS with the exception of two items:

- Pu-239 fission above the resolved resonances;

- U-238 and Pu-239 delayed neutron fractions.

It was decided to publish the discrepancy file without these items and the manuscript prepared for publication in the NDS was submitted for publication in June 1990 as report INDC(NDS)-235/U.

B.2. <u>Coordinated Research Programmes</u>

B.2.1. <u>Nuclear Data Needed for Neutron Therapy</u> (RCM, Vienna, 24-27 January, 1989)

The aim of the CRP is to consider the present status of accuracy of the estimations of dose delivery and physical selectivity of dose distribution in different human (or biological) tissues and to increase this accuracy by means of selecting the most reliable data, most reliable techniques and suggesting new experiments which would provide needed data with higher accuracy.

The following aspects were considered:

- 1. Evaluation of kerma and absorbed dose in different tissues
- 2. Determination of the response of different detectors (kerma and absorbed dose in the detector material)
- 3. Optimization of the collimation and shielding systems and improvement of the physical selectivity.

The meeting considered the scope of the final report which is to be issued after the 3rd Research Co-ordination Meeting. It was decided to emphasize in this report the provision of up-to-date information on the status and needs of nuclear data for neutron therapy. It was decided that the future report will have the following structure:

- 1. provide the driving force for data improvement by demonstrating the success of neutron therapy;
- 2. provide an overview of the current protocols, and
- 3. to demonstrate how the dose delivery to patients can be improved by on-going and new experimental measurements and theoretical calculations of nuclear data, and individual contributions of participants to this report were agreed upon.

More details about the meeting can be found in the report INDC(NDS)-216/GZ by K. Okamoto.

B.2.2. <u>A+M Data Needed in Radiotherapy</u> (RCM, Vienna, 30 January - 2 February, 1989)

The CRP on Atomic and Molecular Data for Radiotherapy was established with the aim of generating, collecting and evaluating the physical data required for radiation therapy. The principal purpose of the first meeting was to exchange views on the CRP and discuss future contributions to the project. The topics of the discussions included all areas of research pertinent to the goal of the CRP. It was decided to cover the following areas of research in the handbook:

- 1. Ionization cross-sections
- 2. Double differential cross-sections
- 3. Charge transfer cross-sections and total ionization cross-sections.
- 4. Ion-induced excitation and dissociation
- 5. Electron collision processes
- 6. Photo-absorption and photo-ionization cross-sections
- 7. Process of conversion of initial ions and excited

B.2.3. <u>X-ray and Gamma-ray Standards for Detector Efficiency Calibration</u> (RCM, Braunschweig, 31 May - 2 June 1989)

The last Research Co-ordination Meeting of the CRP under above topic was held from 31 May to 2 June 1989 at the Physikalisch-Technische Bundesanstalt in Braunschweig, FRG. There were 13 participants from 8 countries and 2 international organizations.

Based on a many-year programme of precision measurements and data evaluation, the CRP members will produce a handbook (IAEA Technical Report) on "X-ray and Gamma-ray Standards for Efficiency Calibration". The manuscript with contributions from the CRP members is almost ready, but the final work on the manuscript is seriously delayed due to lack of manpower at the Nuclear Data Section. B.2.4. <u>Measurement and Analysis of Neutron Emission Spectra in (p,n) and</u> (alpha,n) Reactions (RCM, Bologna, Italy, 13-15 November 1989)

> This was the third and final meeting of this Coordinated Research Programme. The main objective of the programme was to extract systematic information about level densities as a function of excitation energy by means of analysis of neutron emission spectra from (p,n) and (alpha,n) reactions on properly selected targets and within proper bombarding-energy ranges.

> Measurements of double differential neutron spectra have required a considerable experimental effort and a lot of accelerator time. All participants have agreed that in the result of this effort a new reliable data set with an up-to-date accuracy was produced and the volume of the data was sufficient for an unambiguous analysis. The data were received for 18 nuclides for 5-25 MeV for protons and 9-12 MeV for alpha-particles.

The analysis was performed by five participants independently and each of them used his own procedures to extract the level density information. The results were compared at the meeting.

The analysis of the data showed the importance of the contribution from non-equilibrium processes in a number of cases.

It was concluded that the "nuclide specific" or "regional" (with respect to atomic mass) parameters are preferred to "global" parameters. It was possible to extract level density information in the range of 0-10 MeV of excitation energy for the corresponding residual nuclei from the measured data. The participants also recommended that work to extend the determination of level densities based on discrete-level counting to higher energies should be encouraged by the IAEA. They have also recommended to IAEA to convene a Consultants' Meeting in 2-3 years to review further progress and prepare a recommended level density data set for use in calculations related to nuclear data for nuclear technology applications.

A short summary was published in a report by N. Kocherov as INDC(NDS)-230/L, 1989. Full texts of presented papers were published in report INDC(NDS)-234/L, 1990.

B.2.5. <u>14 MeV Neutron Induced Double-Differential Neutron Emission Cross</u> Section (DDCS) Measurement and Analysis (RCM, Vienna, 18-20 June 1990)

The second Research Co-ordination Meeting of this CRP was held at the IAEA Headquarters. The main objectives of the meeting were to review the status and progress of the CRP, to discuss the experimental techniques and to decide on the programme for the next year for each of the laboratories. This meeting mainly concluded that:

(1) most of the DDCS proposed at the previous RCM in 1988 have been measured at about 14 MeV for the elements V, Cr, Fe, Nb, Ta, W and Bi.

- (2) A new double time-of-flight method to measure DDCS at 10 MeV has been developed. It is desirable to provide more reliable data for the elements ²³⁸U and Bi at 10 MeV.
- (3) Measurements and evaluation of DDCS at 14 MeV for the elements 6 Li, 7 Li, 9 Be, Mg and S will be included in the CRP.
- (4) All final experimental results and data evaluations will be presented at the third (and final) RCM, which is planned to be held at the beginning of 1992.

B.2.6. <u>Methods of Calculation of Fast Neutron Nuclear Data for Structural</u> <u>Materials of Fast and Fusion Reactors</u> (RCM, Vienna, 20-22 June 1990)

The third (and final) Research Co-ordination Meeting of this CRP was held at the IAEA Headquarters. The objectives of the meeting were to exchange information and to discuss the progress achieved by the participants over the course of the CRP. Twenty speakers reviewed developments in their institutes on the subject of methods of calculation of fast-neutron data for structural materials. Also, working groups met to review progress on the following specific topics

- global optical potentials
- level-density developments
- pre-equilibrium and multistep theories
- standard codes and input parameters.

In the presented papers and in the written summaries of the workshops, important conclusions were presented concerning the application of the unified optical model based on dispersion relations, the implications of collective processes for both multistep statistical and level-density theories, the need for an improved alpha-particle optical potential for more reliable (n,alpha) cross sections calculations, and the establishment of a work plan for the development of a standard set of nuclear model codes and input data bases for PC applications.

- C. <u>DATA PROCESSING AND EXCHANGE</u>
- C.1. Data Centre Network Co-ordination
- C.1.1. Nuclear Reaction Data (NRD)
- C.1.1.a) Nuclear Reaction Data Centre Network

The co-ordination meetings of the network of data centers for nuclear reaction data ("NRDC Meetings") take place annually, in two cycles. Each "odd" year (1987, 1989, ...) there is a "full" NRDC Meeting hosted in turn by one of the centers, attended by technical staff and the center heads. Each "even" year (1988, 1990, ...) there is a "technical" NRDC Meeting hosted by the Agency and convened at no cost to the Agency; it is attended by technical staff only.

The tenth "full" NRDC Meeting was hosted by the IAEA in Vienna, 2-4 October, 1989. The Conclusions and Actions have been issued as Memo CP-D/200; the proceedings are being issued as an INDC(NDS)-report.

The fourth "technical" NRDC Meeting will take place in Vienna, 13-15 November 1990.

Nine data centers participate in the network:

- CAJaD, Center for Nuclear Structure and Reaction Data, Moscow: charged-particle data;
- ODFE, Photonuclear Data Center, Moscow (represented through CAJaD): photonuclear data;
- CJD, Nuclear Data Center, Obninsk: neutron data;
- CNDC, Chinese Nuclear Data Center, Beijing: neutron and charged-particle data;
- Hokkaido University, Japan: charged-particle data;
- NEA Data Bank: neutron data
- NNDC, National Nuclear Data Center, Brookhaven: all nuclear reaction data;
- RIKEN Nuclear Data Group, Japan: charged-particle data
- IAEA/NDS: all nuclear reaction data.

The discussions at the NRDC Meeting concentrated on technical details of the EXFOR and CINDA systems and on compilation rules which must be updated continuously to take into account new or more detailed data types to be compiled, such as fission product nuclear data.

Special emphasis was given to the EXFOR compilation of experimental fission-product yield data, including the conversion into EXFOR of old non-EXFOR data files, where essential information on experimental method and on error analysis must be added so that covariance matrices can be produced.

Another topic worthwhile mentioning was the start of compiling evaluated charged-particle reaction data in ENDF-6 format and the increasing availability of ENDF-6 data processing codes in PC versions.

C.1.1.b) The CINDA Network

CINDA 89 and CINDA 90 have been published in the traditional way, however, without the Supplements, which were previously published towards the end of the year.

The CINDA file is now accessible on-line to most scientists in OECD countries. Nevertheless, the CINDA books will continue to have a significant value as a handy tool for nuclear physicists. Despite of the discontinuation of the CINDA bulk orders from NNDC and the NEA Data Bank, it was possible to continue the publication of CINDA books. The print run was reduced from 1150 to 950 copies.

Due to an exceptional budgetary situation it was possible to print in 1990 a complete Archival Issue of CINDA in 5 volumes. By the end of 1989 NNDC had another reduction in staff which had the effect that the systematic coverage for CINDA of US and Canadian literature was discontinued. A reduced CINDA activity will continue at NNDC. It is hoped that this reduction in US CINDA activities is a temporary measure. However, it must be realized that strong efforts by the US nuclear physics community will be required to restore an adequate staffing at the NNDC. It is somewhat ironic that the US CINDA activities were reduced at a time when the use of the CINDA file in the US was significantly increased due to the completion of the on-line CINDA service.

C.1.1.c) Neutron Data

The neutron data EXFOR operation is routine, requiring a constant level of manpower for compilation, exchange, file maintenance, and correctness and completeness checking. Due to the limited number of staff, certain data categories, such as neutron-induced gamma spectra, though considered to be important, are not compiled however, completeness systematically. In general, the of experimental neutron reaction data in EXFOR is satisfactory. EXFOR retrievals are prepared mainly for experimentalists, who want to compare their own data with data from other experiments, and for data evaluators. For evaluators, simultaneous graphical plots of EXFOR data and ENDF-formatted data can be made.

The main event during the past months was the release of the evaluated neutron data files BROND, ENDF/B-VI, JEF-1, and JENDL-3. Documentation has been prepared for each of these files, i.e.,

- IAEA-NDS-90 for BROND (released in several stages between 1988 and 1990)
- IAEA-NDS-100 for ENDF/B-VI
- IAEA-NDS-110 for JENDL-3
- (IAEA-NDS-120 for JEF-1, in preparation)

A simultaneous index to all of these files has been prepared in the document IAEA-NDS-107.

C.1.1.d) Charged-particle Nuclear Data

The main EXFOR compilation of charged-particle nuclear data continues to be done by CAJaD. This centre also co-ordinates the charged-particle data compilation in the RIKEN, CNDC, NNDC, and NDS centres. The main emphasis is on the compilation of reaction data needed for the production of radioisotopes, in particular for medical applications.

The experimental database for these reactions must be completed before evaluated data files for medical radioisotope production can be established. Progress in this work is extremely slow due to lack of manpower at the data centers. Another problem is the lack of generally recognized standard reference data for a set of 19 monitor reactions used for the normalization of the nuclear reaction data for radioisotope production. In a concentrated effort, NDS has produced an atlas of experimental data for these monitor reactions: INDC(NDS)-218, December 1989, by O. Schwerer and K. Okamoto. It is hoped that this database will be used for producing evaluated data sets for the 19 monitor reactions.

C.1.1.e) Photonuclear Data

CDFE (Moscow) is the only active center which compiles photonuclear data in EXFOR format, and publishes CINDA-type bibliographies of these data.

C.1.2. Nuclear Structure and Decay Data (NSDD)

The international NSDD Network, consisting presently of 16 evaluation groups in 11 Member States, and 2 international data service centres, aims at a complete and continuous nuclear structure data evaluation of all isobaric mass chains on a six-year cycle, the continuous publication of these evaluated data in the journals Nuclear Data Sheets and Nuclear Physics A, and their dissemination to the scientific community. This international cooperative effort is coordinated by the NNDC in the USA and the IAEA/NDS.

The ninth meeting of the International Network of Nuclear Structure and Decay Data (NSDD) Evaluators was convened by the NDS in Kuwait, 10-14 March 1990, generously co-sponsored by the Kuwaiti authorities hosting the meeting. The meeting was attended by 19 scientists from 15 institutes in 9 countries and from 2 international organizations, representing centres and groups concerned with the compilation, evaluation and dissemination of nuclear structure and decay (NSD) data.

The Summary Report of this meeting is being prepared as an INDC(NDS) report.

The main achievements of this meeting were as follows:

- As the nuclear structure data evaluation activities originated from two roots, in the Netherlands for the light nuclei (A < 45) and in the USA for the heavy nuclei, a common data base for all nuclei was still missing. There is now good progress towards a uniform file for all data.
- The need for an evaluation cycle time of 5 to 6 years was reiterated though only an average cycle period of 8 to 9 years could be achieved so far.
- Progress was reported in the programming of user-friendly access to the ENSDF system on the VAX computer at the NNDC (USA). A copy of the same system is used at the NEA Data Bank.

- A PC version of a gamma-ray catalog extracted from ENSDF had been produced by P. Ekström et al., Lund University, Sweden. This is now also available at the IAEA/NDS for distribution to Member States.
- Various details on the ENSDF system and on the publication format in Nuclear Data Sheets were discussed and agreed.
- The Lawrence Berkeley Laboratory and the Brookhaven National Laboratory intend to publish handbooks from the ENSDF database aimed a defined user groups.

The main problem is the lack of a sufficient number of skilled nuclear structure data evaluators to contribute to ENSDF. The UK group having left the network a couple of years ago, now the German group (FIZ Karlsruhe) has discontinued their evaluation work. All efforts must be made to convince financing bodies of the necessity of numerical nuclear databases and of the necessity to provide funding for their updating and maintenance.

C.1.3. Atomic and Molecular (A+M) Data

C.1.3.a) <u>Eighth Meeting of the A+M Data Centre Network</u> (CM, Vienna, 14-15 September 1989)

> The representatives of 12 (of the 14) A+M data centres discussed the results of the A+M data compilation and evaluation work carried out within the Network during the previous year and the implementation of newly established and adopted ALADDIN system for A+M data storage, exchange and management in the data centre practices. The meeting was attended also by ALADDIN users outside the Data Centre Network. The data centre representatives co-ordinated their activity programmes for the next year so as to achieve an optimum overall output in the data compilation and evaluation work.

C.2. Data Processing

C.2.1. Data Compilation, Evaluation and Exchange

C.2.1.a) <u>CINDA</u>

The compilation of CINDA entries from the literature published outside the OECD countries and the USSR, is part of a continuing effort at NDS. After the recent revision of the structure of the CINDA network, the computer programs (input checking, file maintenance, exchange with other data centers) have been revised, so that input can be prepared in batch mode for new entries, and on-line for revisions and updates. CINDA input is intimately linked with EXFOR compilation. The processing of the CINDA file for book publication must be revised. CINDA 90 and CINDA-A were produced on an old phototypesetting machine which has been phased out. Programmes must be revised for input to a laser-printer for both, book production and retrievals for customers on request.

C.2.1.b) EXFOR

Experimental neutron reaction data

During the last few years compilation of experimental neutron reaction data produced in the NDS service area was fairly complete and up-to-date. In addition, many of the data compiled earlier were updated in close co-operation with the authors who receive proof copies of their data as compiled in EXFOR. Special attention is given to error analysis and standard reference data.

Charged-particle and photonuclear data

The EXFOR compilation of charged-particle reaction data and photonuclear data by NDS continues at a low rate with emphasis on neutron production reactions.

C.2.1.c) Evaluated Neutron Nuclear Data

In the first half of 1990 most important evaluated data libraries have been received for distribution to customers in Member States:

- ENDF/B-VI in ENDF-6 format
- JENDL-3 in ENDF-5 format
- BROND supplements, partly in ENDF-5, partly in ENDF-6 format.

These data libraries were summarized in the following documents for the information of customers:

- IAEA-NDS-90 Rev. 3 BROND
- IAEA-NDS-100 Rev. 3 ENDF/B-VI
- IAEA-NDS-110 Rev. 1 JENDL-3
- IAEA-NDS-107 Rev. 3 A simultaneous index to BROND, ENDF/B-VI and JENDL-3
- IAEA-NDS-113 ENDF/B-VI High Energy Data File.

The large size of the libraries ENDF/B-VI and JENDL-3 required a restructuring into four tapes each for light elements, structural materials, medium range, and actinides.

For the new BROND data, which supplement and update the file released two years ago, time consuming checking and reformatting procedures had to be done, which are not yet quite finished.

C.2.1.d) Nuclear Structure and Decay Data

The ENSDF data file and programme package is <u>not</u> in operation at NDS. Retrievals for, e.g., half-lives are done with ad-hoc programmes when required.

Plans are being developed for the NDS to obtain a dedicated MicroVAX computer. Among other objectives, this move will permit the NDS to operate the entire Brookhaven programme package (in the same way as the NEA Data Bank operates it offering on line service to their customers).

A PC data file with a catalog of gamma-rays and half-lives has been extracted from ENSDF by P. Ekström at the Lund University, Sweden. It is available on a set of PC diskettes together with supporting programmes.

C.2.1.e) A+M Data Compilation, Evaluation and Exchange

The A+M data libraries of evaluated and recommended data currently compiled are listed in Item C.2.2.f. below. These data files, along with the ALADDIN system are available on request. Updates to the available data bases listed are regularly published in the International Bulletin on Atomic and Molecular Data for Fusion. It is expected that by the end of 1990 approximately 200 requests for evaluated A+M data will have been received.

C.2.2. Generation of Special Data Bases and Handbooks

C.2.2.a) Nuclear Data for Applied Geophysics

The work on the Handbook on Nuclear Data for Well Logging and Mineral Analysis is continuing. The recent release of BROND and ENDFB-6 files has made it possible to collect the evaluated data for all the elements of interest. The formats of data presentation in the Handbook were discussed at the Nuclear Well Logging Session of the IEEE Meeting in San Francisco in January this year. The presentation on "The Status of the IAEA Handbook on Nuclear Data for Well Logging and Mineral Analysis" was made by N. Kocherov of NDS; the plan and formats of the handbook were agreed upon with participants of a special discussion. A magnetic tape with the data in the 640-group SAND-II format is also in preparation. The Handbook and the tape will contain data for 20 elements and the necessary information on interfering reactions. The completion of this compilation is scheduled for the end of this year.

The above mentioned paper will be published in the June/July issue of the IEEE Transactions.

C.2.2.b) Nuclear Data for Radioisotope Production for Medical Applications

Following the recommendations of the IAEA/NDS Consultants' Meeting on Data Requirements for Medical Radioisotope Production held in Tokyo in April 1987, the status of data on cross sections of 19 charged particle induced monitor reactions, required for optimization of cyclotron operation in the production of radioisotopes, was thoroughly reviewed by O. Schwerer and K. Okamoto and summarized and published as report INDC(NDS)-218/GZ+. Most of the experimental data were extracted from the EXFOR library and were supplemented by a number of additional data sets found in the literature.

C.2.2.c) Nuclear Data for Fusion Neutronics Calculations (FENDL)

Participants in the world-wide FENDL project (see Items B.1.3. and B.1.12.) warmly welcomed the timely and complete release of both the ENDF/B-VI JENDL-3 libraries early in 1990. anđ Previous FENDL-related meetings (1986, 1987, 1989) had focussed on the difficulties caused by restrictions previously placed on the international distribution of the major national and regional files. By early 1990, work was essentially complete on assembling a FENDL working file, consisting of preliminary versions of evaluations to be submitted to ENDF/B-VI and JENDL-3, supplemented with material from the BROND library, EFF-1 and ENDL-84.

With the mentioned releases of the ENDF and JENDL libraries, the emphasis of the FENDL project now has turned from the selection of candidate evaluations to (a) the processing and integral testing of cross sections for neutron and gamma-ray transport and (b) the assembling and testing of auxiliary files needed to supplement the large ENDF/B-VI and JENDL-3 files, especially in the fields of activation/decay data and in data for fusion-relevant neutron metrology.

It is expected that an extensive 175-group (neutrons) by 42-group (gamma-rays) multigroup set, based mainly on ENDF/B-VI, can be completed in the NDS using NJOY 89 by the end of 1990, in conformance with the original schedule set for FENDL-1. A library for input to MCNP will follow in the first half of 1991. Covariance processing is now planned for the second half of 1991. At the suggestion of the FENDL Consultants' Meeting of 25-28 June 1990, the NDS is examining ways of combining the isotopic multigroup sets that will be produced by NJOY into more compact natural-element sets, prior to external distribution. The separate isotopic sets will, in any case, be retained to service special needs.

Plans and early results from the integral data testing of the FENDL data will be a major topic at the forthcoming AGM in Chengdu, China, to be held 19-21 November 1990. It is expected that many additional integral testing results will be presented at the next "combined" FENDL meeting (both evaluators and data-testing specialists) now planned in late 1991.

C.2.2.d) Nuclear Data for Safeguards

Some more tables have been compiled for the handbook of "Nuclear Data for Safeguards". The new tables will be distributed to safeguards users. Unfortunately, the finalization of the handbook has been further delayed due to the additional heavy workload in connection with the preparation and publication of CINDA 90 and the new archival issue CINDA-A.

C.2.2.e) International Reactor Dosimetry File IRDF-90

The IAEA International Reactor Dosimetry File IRDF-90 was assembled here in NDS. It contains 50 reactions, 14 of them are new evaluations made at IRK, Vienna, 36 reactions come from the ENDF/B-VI file. Ten of the ENDF/B-VI evaluations are old and were changed into ENDF-6 format from the previous dosimetry file. Four of the new American evaluations still have no covariance information. It was decided not to wait till we get the lacking information, but to release the assembled file as version 1 in September 1990. The status of the assembled file was presented at an oral session of the 7th ASTM-EURATOM Symposium and the paper will be published in the proceedings.

The INDC report documenting the file is in preparation.

C.2.2.f) A+M Databases for Fusion

The IAEA A+M Data Unit is conducting an independent activity on updating and/or establishing the following numerical databases:

- (1) Database for modelling the neutral hydrogen beam penetration in fusion plasmas.
- (2) Databases for carbon, oxygen and iron impurities in fusion plasmas.
- (3) Database for particle-exchange reactions in the fusion plasma edge.
- (4) Database for Li-beam plasma diagnostics.
- (5) Database for physical sputtering of fusion reactor materials.
- (6) Database for light-ion backscattering from first-wall fusion reactor materials.

Details of these databases are supplied in the documents listed in Table 1.

C.2.3. Data Base Management

C.2.3.a) Systems Development

The CINDA and EXFOR systems have been stable throughout the last years; however, modifications and new features continue to be programmed to improve the relevant data checking programs. For CINDA the transferring of responsibility for Area-4 data to CJD has been initiated, the testing period for this will continue through the first half of 1990. An exercise to compare the CINDA master files from NNDC, NEA-DB and NDS was performed. It was decided, in order to resolve discrepancies, that each centre would transmit to the other 2 centres the latest version of their respective area subfiles which would replace the existing area subfiles.

The Request and Dissemination Log System is used to monitor NDS processing of all incoming requests, in order to ensure that each request is answered on a timely basis. This log is also used to record detailed information of what has been requested, and subsequently sent out, in order to obtain current request and dissemination statistics. The online screens for data entry have been enhanced, completely superseding the existing data entry process that used a data entry package. The NDS continues to use a PC-based system for logging all information on the work performed by the Data Centre which is not in direct response to incoming requests (see D.1.3.). This system is used to log outgoing tapes, including all CINDA exchange tapes and EXFOR transmission tapes, as well as outgoing documents sent as a result of PROFILE (see below) retrievals.

The NDS PROFILE system consists of a data file of names, addresses and interest indicators of approximately 6900 scientists who are maintained on any of the Section's distribution lists. The PROFILE is kept current by a continuous updating effort with information provided by the Member States. It is used for producing address lables for participants of NDS-organized meetings, and maintaining current lists of committee members or other special interest groups. This system has been stable for a number of years, however a comprehensive set of online screens has been implemented for all data entry updating uses, superceding the existing data entry package.

C.2.3.b) Use of Personal Computers

The use of PCs within the NDS continues to grow, both for data input and processing activities. The ENDF/B pre-processing codes are used to process and plot data files, the NNDC ENDF/B utility codes are being converted for PC use, nuclear model codes developed for PC use are compiled and tested for NDS workshop purposes, a PC evaluated data indexing system is being developed. For EXFOR a PC system for data input and checking is being developed and will be available for use by compilers in Member States.

C.2.3.c) ALADDIN system development

Version 1.0 of ALADDIN was finalized in June 1989. Improvements to the ALADDIN system and extending the ALADDIN data formats were discussed at the A+M data centre meeting in June 1989. A new version of ALADDIN, Version 1.7, has now been developed. It incorporates all the suggested improvements and the data labelling formats for surface interactions and spectroscopic data have been finalized.

Table 1: References to Evaluated Atomic Databases

A. <u>A+M Collisional Databases</u>

- "Atomic and Molecular Data for Fusion, Part I Recommended Cross Sections and Rates for Electron Ionisation of Light Atoms and Ions," K.L. Bell, H.B. Gilbody, J.G. Hughes, A.E. Kingston and F.J. Smith. J. Phys. Chem. Ref. Data 12, 891 (1983).
- "Recommended Data on Excitation of Carbon and Oxygen Ions by Electron Collisions," Y. Itikawa, S. Hara, T. Kato, S. Nakazaki, M.S. Pindzola, D.H. Crandall. At. Data Nucl. Data Tables (ADNDT) <u>33</u>, 149 (1985).
- 3. "Recommended Data on Atomic Collision Processes Involving Iron and its Ions," C. Bottcher, D.C. Griffin, H.T. Hunter, R.K. Janev, A.E. Kingston, M.A. Lennon, R.A. Phaneuf, M.S. Pindzola, S.M. Younger. Nucl. Fusion, Special Supplement, (1987).
- 4. "Collisions of Carbon and Oxygen Ions with Electrons, H, H₂ and He". Atomic Data for Controlled Fusion Research, Vol. V. R.A. Phaneuf, R.K. Janev, M.S. Pindzola (Editors). Report ORNL-6090/V5, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA (1987).
- 5. "Atomic and Molecular Data for Fusion, Part II Recommended Cross Sections and Rates for Electron Ionisation of Light Atoms and Ions: Fluorine to Nickel," M.A. Lennon, K.L. Bell, H.B. Gilbody, J.G. Hughes, A.E. Kingston, M.J. Murray, F.J. Smith. J. Phys. Chem. Ref. Data <u>17</u>, 1285 (1988).
- 6. "Recommended Data for Excitation Rate Coefficients of Helim Atoms and Helim-like Ions by Electron Impact," T. Kato and S. Nakazaki. At. Data. Nucl. Data Tables (ADNDT), <u>42</u>, 313 (1989).
- 7. "Elementary Processes in Hydrogen-Helium Plasmas", R.K. Janev, W.D. Langer, K. Evans Jr., D.E. Post Jr., Springer-Verlag, (1987).
- "Collisions of H, H₂, He and Li Atoms and Ions with Atoms and Molecules, Vol. 1. C.F. Barnett, (Editor). Report ORNL-6086/V1, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, USA (1990).

B. <u>Particle-Surface Interaction Databases</u>

- "Energy dependence of Ion-Induced Sputtering Yields of Monatomic Solids in the Low Energy Region", N. Matsunami, Y. Yamamura, N. Itoh, H. Tawara, T. Kawamura. Report IPPJ-AM-52, Institute of Plasma Physics, Nagoya, Japan (1987).
- "Energy Dependence of the Yields of Ion-Induced Sputtering of Montatomic Solids", N. Maksunami, Y. Yamaura, Y. Itikawa, N. Itoh, Y. Kazumata, S. Miyagawer, K. Morita, R. Strimizu, H. Tawara. Report IPPJ-AM-32, Institute of Plasma Physics, Nagoya, Japan (1988).

C.2.4. Intercomparison of data processing codes

IAEA cross-section processing-code verification project is The designed to ensure that the complicated computer codes used to process nuclear data can produce results which accurately reflect the improved quality of recent nuclear data. The first round of this verification exercise graphically demonstrated that because of the complexity of these computer codes this is an extremely difficult task and yet also an extremely important one, since these codes are used by many Member States of the IAEA. The importance of this project was recognized at the previous meeting of the INDC. The present round of this project will be led by S. Ganesan of the NDS and will emphasize the calculation of Doppler broadening of resolved resonances. "Benchmark" results for use in the project are now being established by D.E. Cullen, Livermore, in collaboration with R.E. McFarlane, Los Alamos.

It was decided that unresolved resonance parameters will not be included in this round. The processing of unresolved resonance parameters would be an excellent topic for a Consultants' Meeting in an attempt to bring together experts on this subject with the ultimate objective on establishing a unique set of mathematical conventions which should be used by all codes to process these data.

We have selected the following data from ENDF/B-VI for inclusion in the project,

- H-1 no resonance parameters, only tabulated data this will check the ability of codes to handle simple tabulated data.
- 2) Mo-nat single level Breit-Wigner, 7 isotopes
- 3) W-nat multi-level Breit-Wigner, 4 isotopes
- 4) U-233 Adler-Adler
- 5) U-235 Reich-Moore, multiple resolved resonance energy ranges

Of the ENDF/B-VI evaluations distributed to date, none include Hybrid R-function or General R-Matrix resolved resonance parameters, so the processing of these two formalisms cannot currently be tested.

Participants in this project will be asked to produce results at 0 (only reconstruct cross sections, no Doppler broadening, 300 (room temperature) and 2100 (reactor operating temperature) Kelvin. Participants will send to the NDS energy dependent cross sections at The NDS will group-average the data to a fine each temperature. group structure and graphically compare the results. If significant differences are found in the group-averaged data, the corresponding energy dependent data will then be examined in detail. The results of the comparisons will be reported back only to the participant who submitted data, and if differences are found he will be asked to submit improved results. Only over a longer period of time will the results of this project be made public (in the form of an IAEA report describing the initial and final status of each participating code).

C.2.5. WIMS Library Update Project

The International Atomic Energy Agency is initiating a project to update the multigroup nuclear data input library of the WIMS reactor physics code (in short: WIMS Library Update Project). The WIMS code is one of the most widely used thermal reactor physics codes and is of interest especially to reactor physics groups in developing countries.

The idea for a project to update the multigroup nuclear data input library of the WIMS code grew out of discussions between the participants, lecturers and directors of the Joint IAEA/ICTP Workshop on Reactor Physics Calculations for Applications in Nuclear Technology held at the ICTP from 12 February to 16 March 1990 and organized in co-operation with the Nuclear Data and Physics Sections of the Department of Research and Isotopes of IAEA. The planned project is in line with the relevant conclusions and recommendations of the Technical Committee Meeting on In-core Fuel Management held by the IAEA in Vienna, 4-7 December 1989. The project is thus being organized by the Nuclear Data and Physics Sections of the IAEA, with the co-operation of the IAEA Nuclear Power Technology Development Section.

After a development period of 10-15 years, improved evaluated nuclear data libraries such as ENDF/B-VI from the USA and JENDL-3 from Japan have recently been released to the Agency. There are many reactor physicists around the world who are interested in updating and improving the multigroup nuclear data input to the WIMS code.

The "WIMS Library Update" (WLU) project is principally conceived to proceed through a series of thermal reactor benchmark calculations using the evaluated nuclear data libraries, nuclear data processing codes and the WIMS code, with a gradual replacement of old by new nuclear data, and, including at each step, a checking of the reliability of the calculational results. Deviations between calculated and experimental benchmark data will be used to remedy inaccuracies in the calculations and/or nuclear data input and will also be fed back to the originators of the codes and/or evaluated nuclear data for review and improvement.

The final outcome of this project will thus be a reliable up-to-date nuclear data base for the WIMS code. Project participants will simultaneously acquire a detailed knowledge of nuclear data relevant to thermal reactor physics as well as a capability for reliable use of an important reactor physics computer code and associated nuclear data processing codes.

The project will be carried out primarily through correspondence and at no cost to the Agency.

M. Ravnik and A. Trkov of the Jozef Stefan Institute in Ljubljana, Yugoslavia, will be responsible for the co-ordination of the Project, and S. Ganesan will be the contact person at the IAEA.

D. DATA SERVICES AND TECHNOLOGY TRANSFER

D.1. Data Centre Services

D.1.1. Documentation and User Services

The availability of existing and new data files and reports from NDS is advertised to its customers by the "IAEA Nuclear Data Newsletter" (see D.2.2.). Most of the incoming requests refer to this Newletter.

Each data library sent out and each selective retrieval from a data library prepared on request is accompanied by "documentation" describing the contents and format of the file and related data processing computer codes. Such documentation is included in the IAEA Nuclear Data Services report series (IAEA-NDS-). For details see below under D.2.5.

Each data tape sent out is also accompanied by a return sheet on which recipients are requested to report back any type of difficulty encountered.

Over 120 data users in the NDS service area have expressed a need for online services, and this customer base can be expected to grow rapidly. For this reason, efforts are now being made to develop on line user services.

Most data retrievals are currently sent out on magnetic tapes. Distribution of data on PC diskettes is increasing, but because of the size of most data libraries, distribution on diskettes is limited to small files or data for individual ENDF materials. An essential prerequisite for providing such an on line user service would be the availability of a MicroVAX to the Nuclear Data Section. The current IBM-3081 mainframe computer of the IAEA cannot be used for this purpose, because

- there are technical compatibility problems;
- it is too busy and therefore has slow response;
- the software available for on line services has been developed for VAXs.

D.1.2. Data Requests

As part of its function as a data centre, NDS processes and fulfills requests received from users in countries within its service area (Eastern Europe - except USSR, Africa, Asia - except Japan, Latin America, Australia and New Zealand) as well as from users in other countries.

For the statistics compiled by NDS, a "request" is defined as any query received by NDS for any one of the following specific categories: experimental data, evaluated data, bibliographic retrievals (e.g., from the CINDA master file), documents, and computer programs. For example: one letter asking for experimental and evaluated data counts as two requests, one letter asking for ten EXFOR data sets counts as one request. Request statistics for each of the considered categories, and statistics showing the total number of requests handled by NDS for each year since 1965 are given in <u>Table 2</u>. The request statistics since 1966 in terms of number of requests per year averaged over three-year periods (e.g., the value for 1989 is the average over the years 1987, 1988 and 1989) is shown in Fig. 1.

D.1.3. Data Dissemination

In addition to data, computer codes and reports sent out on request, NDS sends out data and reports without having received a specific request. This dissemination activity includes:

- the regular transmission and exchange of EXFOR and CINDA data between the co-operating data centres;
- the data sent out to previous recipients of particular data libraries when updates or new versions of these libraries have been received at NDS;
- INDC documents that are regularly disseminated by NDS on behalf of Member States; and
- distribution of other documents such as the NDS Newsletter.

Data dissemination statistics are designed to show the quantity of data and reports that have been sent, the number of tapes or diskettes sent out and also which countries they have been sent to. Numerical data are normally quantified in terms of "data sets". A "data set" is defined as a set of numerical data of a given type for a given energy range which resulted from a specific data measurement or evaluation. For experimental data (EXFOR) a data set comprises all data combined in an EXFOR sub-entry excluding the first BIB (bibliographic) subentry. For evaluated data, a data set comprises all data given under one "MAT" number in a given evaluated data library. As the definition of "data set" is meaningless for bibliographic retrievals (e.g., from CINDA), the values given in Table 3 are the numbers of actual retrievals performed and not data sets retrieved.

Dissemination statistics also include "items" sent out. An "item" is defined as any combination of document or data library sent to a recipient. Each document sent to a requestor counts as one "item", even if multiple copies are sent. However, each bulk distribution counts as one "item" even though a document may be sent to hundreds of people. Each complete library sent out counts as one "item" and each retrieval from a library counts as one "item" even if hundreds of data sets are selected and copied.

Dissemination statistics for all years since 1983 are given for each of the data types in <u>Table 3</u>; and for documents, tapes, recipient countries and number of "items" sent out in <u>Table 4</u>. <u>Figure 2</u> shows the dissemination statistics since 1983 in graphical form; the number of megabytes of data disseminated for the different types of data libraries are averaged over a three-year period.

D.2. <u>Publications</u>

D.2.1. INDC reports

Between January 1989 and May 1990 a total of 95 INDC reports was produced and mostly distributed by NDS on behalf of the Member States. Included in these INDC reports are also those which originate at the NDS and which serve to document meetings and results of projects conducted by NDS. A list of INDC(NDS) and INDC(SEC) reports published during the reporting period is given in Appendix B.

D.2.2. The <u>IAEA Nuclear Data Newsletter</u> continues to be published once or twice a year whenever important new data files or documents are received. Its distribution exceeds 3000 in the NDS service area. Of the recipients in the NDS service area, more than the half (typically 1600) have responded either by sending in a request or at least by expressing the wish to be kept on the distribution list. Compared to other circulars this is a most impressive response rate. To OECD countries and the USSR it is distributed upon request only (around 550 copies), in order not to duplicate services of the other data centres. Attached to each copy of the Newsletter is a return postcard by which data, reports or other information can be requested.

D.2.3. IAEA-NDS Documents

This series of documents is produced to document contents and formats of data files sent out to customers (see D.1.1. above). An up-to-date list of these documents published during this reporting period is given in <u>Appendix C</u>.

Some of the more important ones are the following:

IAEA-NDS-7 Rev. 90/1:	Index of Nuclear Data Libraries and Related Computer Codes Available from the IAEA Nuclear Data Section
IAEA-NDS-51 Rev. 2 :	JENDL Fission-Product Nuclear Data Libraries
IAEA-NDS-76 Rev. 2 :	ENDF-6 Formats Manual
IAEA-NDS-90 Rev. 3 :	BROND, including the 1990 updates
IAEA-NDS-100 Rev. 3 :	ENDF/B-VI
IAEA-NDS-107 Rev. 3 :	Index to BROND, ENDF/B-VI, JENDL-3 (to be expanded to include JEF-2)
IAEA-NDS-110 Rev. 1 :	JENDL-3
IAEA-NDS-113 :	ENDF/B-VI high-energy data
IAEA-NDS-114 :	Neutron Activation Data from the Hanford REAC*2 Data Library

Table 2

lear	Experimental Data	Evaluated Data	Experimental and Evaluated	Documents + Bibliogr.	Computer [*] Codes	Totals per year	Totals (Averaged	Totals Cumulative
			Data	Data			over 3 years)	
1965	3		3			3		3
1966	40	_	40	_	5	45	16	48
1967	118	_	118	_ 0	8	135	61	183
1968	110	_	110	16	9	144	108	327
1969	48	15	63	25	5	03	124	420
1970	45	20	115	34	8	157	131	577
1971	76	23	109	63 63	8	160	131	737
1972	48	23	71	60	8	139	152	876
1973	43	22	65	54	6	125	141	1 001
1974	49	24	73	61	6	140	135	1 141
1975	43	49	92	114	3	209	158	1 350
1976	34	43	77	153	9	239	196	1 589
1977	45	49	94	232	3	329	259	1 918
1978	62	71	133	193	17	343	304	2 261
1979	63	93	156	95	18	269	314	2 530
1980	40	86	128	239	42	407	339	2 937
1981	59	185	244	369	31	644	440	3 581
1982	76	174	250	403	60	713	588	4 294
1983	52	115	167	508	45	713	690	5 007
1984	54	113	167	462	38	667	698	5 674
1985	24	221	245	587	12	844	741	6 518
1986	37	93	130	407	32	569	693	7 087
1987	18	72	90	667	136	893	769	7 980
1988	34	108	142	684	67	893	785	8 873
1989	32	100	132	579	62	773	853	9 646

Data Request Statistics 1965 - 1989

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



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TABLE 3

Data Dissemination Statistics 1983 - 1989

	(1)	(2)	(3)	(4)	(5)	(6)		
(ear	Total Experi- mental=EXFOR data sets (incl. TRANS) (x 1000)	EXFOR TRANS only (x 1000)	Total Evaluated Data Sets (x 1000)	Total Bibl. retrievals (incl. CINDA Exchange)	CINDA Exchange only	Total # Computer Codes	Total Mbytes for columns 1,3,4, and 6	Total Mbytes for columns 2 and 5
L983	10.5	not available	15.1	8	0	56	1 840	not available
984	60.7	13.6	8.8	37	0	56	3 312	72
.985	48.1	41.3	24.7	14	4	19	1 928	200
986	71.5	29.9	10.7	101	91	28	2 560	200
~ ~ -	18.3	12.4	5.9	46	36	132	1 480	208
.987					E 2	120	1 502	329
L987 L988	51.3	27.6	8.4	10/	23	130	I J72	520





TABLE 4

Documents and Miscellaneous "Item" Dissemination Statistics 1983 - 1989

Year	Documents sent out on Request	Documents sent out on PROFILE distribution	Total # Tapes	Total # PC Diskettes	<pre># of "items" sent out to countries in NDS service area (number of countries in parentheses)</pre>	<pre># of "items" sent out to countries outside NDS service area (number of countries in parentheses)</pre>
1983	1252	not available	156	0	1245 (48)	287 (16)
1984	1233	not available	271	0	1182 (41)	429 (21)
1985	1484	not available	206	0	1540 (46)	380 (17)
1986	1669	not available	246	0	1533 (43)	447 (17)
1987	1716	not available	240	155	1509 (45)	613 (16)
1988	2008	6228*	168	220	1741 (54)	638 (17)
1989	1508	9735	165	146	1269 (47)	579 (16)

* value for 1988 corrected since last report due to retroactive entries into database

IAEA-NDS-115	:	Prompt Gamma-ray Data from Thermal Neutron Capture, by M.A. Lone
IAEA-NDS-116	:	Thermal Neutron Capture Gamma-rays, by J.K. Tuli
IAEA-NDS-118	:	The ENSDF Radioactivity Database for IBM-PC, by P. Ekström

D.2.4. International Bulletin on Atomic and Molecular Data for Fusion

In the last year the volumes 39 and 40 of the Bulletin have been published and over 1000 copies distributed.

D.3. <u>Technology Transfer to Developing Countries.</u>

D.3.1. Interregional Technical Co-operation Project TC/INT/1/039 on Nuclear Measurement Techniques

The project was initiated in July 1987 with the objectives to improve the capability of nuclear scientists in developing countries to carry out accurate, reliable and reproducible nuclear measurements required for applications and applied research and to strengthen and promote collaboration between nuclear laboratories in developing countries. It was intended to contribute, over the long term, to the development of self-supporting nuclear infrastructure in developing countries, especially to the development of trained manpower needed for the national science and technology programmes.

The scope of the project set out a programme of nuclear measurements of successively higher complexity, with a first phase programme of intercomparison exercises emphasizing equipment utilization. Two sets of intercomparison exercises were carried out under the programme in which 41 laboratories volunteered to participate. Intercomparison Exercise-I was aimed at nuclear analytical techniques and consisted of the determination of major, minor and trace elements in samples supplied by the IAEA Seibersdorf Laboratory, using X-ray fluorescence analysis (XRF), fast-neutron activation analysis (FNAA) and proton-induced X-ray emission (PIXE) techniques, and of the determination of low level activities in milk powder samples using Low Level Counting (LLC) techniques. Intercomparison Exercise-II was aimed at laboratories equipped with neutron generators and consisted of measurements to determine the angular distribution of neutron flux and energy.

Out of 54 originally invited laboratories, 41 sent in participation programmes; to these laboratories samples for analysis were sent. Out of these 41, 23 laboratories reported measurement results. The measurements for the second set of exercises were carried out by only 3 laboratories out of a possible 14. One of the striking results that emerged from the results of Intercomparison Exercise-I was that discrepant results were reported by almost all laboratories (except for one or two cases). The major factors contributing to the discrepancies were inappropriate sample preparation techniques, improper calculations of correction factors for the "matrix effect" and use of improper reference materials. The main factor contributing to poor FNAA results was improper operation of the neutron generator, while incorrect efficiency calibration for weak gamma activity seemed to be the main source of discrepancy for LLC measurements.

Due to the decision to terminate the project at the end of 1989, only the first step of the originally foreseen programme could Ъe implemented. However, this first step of implementation has already revealed the need for continuing the activity aimed at improving the capability of nuclear laboratories in developing countries to carry out accurate, reliable and reproducible nuclear measurements for activities should applications. Follow-up include appropriate training measures to remedy the situation wherever necessary. These training measures should be designed to carry out "integral" training for each type of analysis, i.e., it should include all steps of the experiment involved starting from sample preparation, use of reference material, operation of equipment and collecting data, processing and analysing the data, calculation and application of correction factors and reducing the measured data to final values including the errors. It is necessary to carry out such training in small homogeneous groups and thus it is best to continue this activity on a regional basis.

Considering the present status of interest, the best prospects for regional activities along these lines are in Africa. A proposal for a regional TC project on an XRF laboratory network has been prepared (see Section D.3.2.).

The full final report on this Interregional Project is contained in report INDC/P(90)-2.

D.3.2. Proposed African Project on XRF Laboratory Network

A proposal is presented to organize a network among the African laboratories dealing with XRF for a period of three years 1991-1993. It aims to establish appropriate ways for continuing training of scientists and service technicians, provision of spare parts and technical advice, to start collaboration between the member laboratories through exchange of scientists and senior technicians, to assure continuing exchange of information and experiences, and to develop programmes for the use of the XRF technique in solving various analytical problems.

Background:

In the area of nuclear sciences and their applications, there are 15 national TC-projects in 11 African countries dealing with X-ray fluorescence analysis, which are carried out in a number of university departments, research institutions and analytical control units. Under these projects, the Agency has provided both isotopic and tube-excited XRF systems and various additional equipment including detectors with related nuclear electronics, computers, analysis software, liquid nitrogen plants, laboratory chemicals and a wide range of reference standards. The Agency has already utilized about US \$5 million to set up and operate different types of XRF systems under the above TC-projects. This represents the costs of equipment, completed expert services and completed fellowship training and scientific visits.

Among the 15 TC-projects dealing with XRF in Africa, only about 50% of the isotope-excited systems and 20% of the tube systems are properly used and the rest are not efficiently used or even not functioning, due to a number of common problems including:

- (i) lack of sufficient experience to operate nuclear measuring instruments, computers and software, and to set up long-germ programmes for several nuclear applications;
- (ii) unsatisfactory quality of the analytical results presented by most laboratories regarding reliability, accuracy and sensitivity measurements of various elements in different matrix materials.
- (iii) Several technical problems are also common due to lack of trained technicians able to repair different types of defected instruments, lack of necessary spare parts whenever needed, and absence of service manuals and specialized service stations in most cases.

Detailed Objectives:

The network of laboratories dealing with XRF activities in Africa is planned to achieve the following detailed objectives:

- to establish appropriate means of co-operation between the different research institutes, university departments and analytical service units dealing with XRF in different African countries through exchange of information, scientists and senior technicians;
- (2) to assist in setting up programmes for the use of XRF in several research investigations and analytical services related to geological studies and mineral properties, environmental pollution control, analysis of biological, nutrition and medical samples, and to quality control of industrial products;
- (3) to facilitate national programme implementation, to assess the results obtained and their reliability, and to widen the scope of XRF applications according to the different national needs;
- (4) to establish regional co-operation in the training of scientists and senior technicians and in research in application areas of common interest;

- (5) to define the means and training effort needed to enhance the technical capability of service technicians to assure successful running of simple repair services;
- (6) to ensure timely response to the various needs of the different counterparts, to provide sufficient information to assist in the repair of defected instruments, and to ensure provision of spare parts which are urgently needed.

Project activities and Implementation

The different activities necessary to run the network need to be organized through close collaboration between the XRF laboratories. It is foreseen to fulfill the principal objectives of the network within three years during 1991/1993 in the following sequence:

<u>1991</u>

Workshop to intitiate the network.

1992

First seminar and training course in XRF techniques for Western and Northern African countries.

1992

Second seminar and training course for Eastern African countries, similar to the first one for 1992.

D.3.3. <u>Training Courses and Workshops</u>

D.3.3.a) Interregional Training Course on Nuclear Measurements and Methods in Reactor and Personnel Dosimetry

The Interregional Training Course on Nuclear Measurements and Methods in Reactor and Personal Neutron Dosimetry was jointly organized by the IAEA and the USSR State Committee on the Utilization of Atomic Energy. The Training Course was convened at the P. Stucka Latvian State University in Riga, 15 May-9 June 1989.

The Training Course was recommended by the 16th Meeting (in October 1987) of the INDC. The objectives of the Training Course were to train scientists from developing countries in the field of nuclear measurements 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, and neutron personal dosimetry.

Twenty scientists from nineteen developing countries (Argentina, Bangladesh, Brazil, China, Cuba, Czechoslovakia, Egypt, India, Indonesia, Iran, Iraq, Libya, Malaysia, Poland, Romania, Sudan, Thailand, Zaire and Zambia) participated in the Training Course. During the Training Course, thirty lectures were given on neutron spectra measurements in reactors, unfolding programs of neutron spectra, detectors for the monitoring and spectroscopy of neutron fluxes, personal reactor dosimetry problems, methods and results in personal dosimetry, neutron dosimetry in pressure vessels of VVER nuclear power stations, neutron transport and neutron dosimetry problems, and application of theoretical models for the evaluation of neutron activation cross section for reactor dosimetry. The practical exercises covered unfolding programs of neutron spectra (SAIPS, IBM/PC version, developed by Dr. Bondars, the P. Stucka Latvian State University in Riga, USSR) and were arranged in small groups. Visits to research reactor and dosimetry laboratories were also arranged.

D.3.3.b) <u>Interregional Training Course on Technology and Application of</u> Neutron <u>Generators</u>

This Training Course, jointly organized by the IAEA and the USSR State Committee on the Utilization of Atomic Energy, was held at the D.V. Efremov Scientific Research Institute of Electrophysical Apparatus in Leningrad, from 25 September to 27 October 1989.

The objectives of the Training Course were to train senior technicians and scientists from developing countries in technology and applications of neutron generators, with special attention to the practical understanding of all parts of neutron generator facilities and the fast neutron activation analysis.

Fifteen scientists from fourteen developing countries (Algeria, Bolivia, Bulgaria, China, Egypt, India, Iran, Libya, Morocco, Nigeria, Pakistan, Poland, Turkey and Vienam) participated in the Training Course.

During the Training Course, twenty-five lectures were given on ion source, high voltage generator, ion optical system, vacuum system, acceleration tube, control system and rotating tritium target device, and the main properties of the D-D, D-T reactions, cyclic activation analysis and typical applications of fast neutrons in elemental analysis for agriculture, geology/mining and industry. Practical demonstrations of neutron generators were arranged. Scientific visits were organized to the Institute of Nuclear Physics in Leningrad and the All-Union Scientific Research Institute of Radiation Techniques in Moscow.

D.3.3.c) <u>Workshop on Reactor Physics Calculations for Applications in Nuclear</u> <u>Technology, ICTP Trieste, 12 February-16 March 1990</u>

The Workshop on Reactor Physics Calculations for Applications in Nuclear Technology was organized jointly by the IAEA Nuclear Data and Physics Sections and the International Centre for Theoretical Physics (ICTP) Trieste and was held from 12 February to 16 March 1990. It was directed by J.J. Schmidt (Nuclear Data Section/IAEA), R.G. Muranaka (Physics Section/IAEA), M.K. Mehta (Vikram A. Sarabhai Community Science Centre, Ahmedabad, India) and D.E. Cullen (Lawrence Livermore National Laboratory, U.S.A.), with the assistance of Profs. H.R. Dalafi (ICTP) and L. Fonda (ICTP and University of Trieste) as local organizers.

This Workshop was held in continuation of the series of Winter Colleges and Workshops on Nuclear Physics Applications and Nuclear Technology organized biennially since 1978. It was designed to familiarize participants with evaluated nuclear data files and processing codes and with computer codes widely used in thermal reactor physics calculations and to provide them with "hands-on" experience by performing related computer exercises using a few selected computer codes.

The main thrust of the Workshop was the practical use by the participants of several selected nuclear data processing and thermal reactor physics computer codes in carrying out sets of well-defined computational exercises every afternoon, using the ICTP's CONVEX main frame and personal computer (Olivetti, IBM) facilities. A series of lectures in the morning (two to three per day) was held with the aims, (a) to provide a general review of the actual status of nuclear data files, nuclear data processing and thermal reactor physics and safety by leading researchers and practitioners in the field, and, (b) to introduce the participants in the specific physics and detailed structure of the codes used in the computer exercises by the authors of the codes or by persons well experienced in the use of the codes.

The Workshop covered the following main topics and computer codes: nuclear data processing (code NJOY), basic reactor physics, thermal reactor lattice cell and core calculations (code WIMS), multigroup diffusion theory (code ANISN), in-core fuel management (codes PSU-LEOPARD and MCRAC), fluid flow and heat transfer (code HEATHYD), inverse point kinetics (code KINIK), and reactor safety and safety analysis criteria. The exercises in the afternoon covered two mainframe computer codes (NJOY and WIMS/D4) and five codes for personal computers (ANISN, PSU-LEOPARD, MCRAC, HEATHYD and KINIK).

51 reactor physicists, reactor engineers and nuclear data scientists attended the Workshop, 49 from 24 developing countries and 2 from 2 advanced countries. They were carefully selected from over 140 applicants and, compared to previous Workshops, formed a more homogeneous, better qualified and more actively participating and interacting group of young scientists and engineers.

The number of lecturers in the main Workshop programme was 19, 2 from USA, 1 from the Federal Republic of Germany, 1 from the NEA Data Bank, 8 from Eastern Europe, 2 from Brazil and Greece, and 5 from IAEA. The main programme was supplemented by 6 special lectures on advanced reactor concepts, related safety and nuclear data aspects, and on the use of reactor neutrons in neutron optics and neutron interferometry, and by 6 special seminars given by 6 more advanced Workshop participants on their work. In feedback questionnaires and a general discussion session on the last day of the Workshop the participants were invited to comment on all aspects of the Workshop. The majority of the participants judged this Workshop to be the best planned and most efficient and effective one in this series of Workshops. Several factors have contributed to this success, including incorporation of the feedback from previous Workshops, long-term advance planning by the directors and strong back-up support provided by the NDS infrastructure, especially the NDS computer and data processing staff. One important criticism was concerned with the lack of interrelationship between the various codes and exercises during the Workshop. It was proposed in future Workshops to have the exercises more strongly interfaced so as to allow the treatment of a full set of realistic reactor physics calculations. This and several other constructive suggestions made by the participants will be incorporated in the programme and organization of future Workshops in this series. The next Workshop is scheduled for early 1992 on "Computation and Analysis of Nuclear Data Relevant to Nuclear Energy and Safety".

An important outcome of the Workshop was the initiation of a project for the updating of the nuclear data input library to the WIMS/D4 code (see Item C.2.5.). Workshop participants from 20 reactor physics groups of 15 developing countries expressed keen interest to participate in this project, and two of the lecturers, M. Ravnik and A. Trkov from the Institute "Jozef Stefan", Ljubljana, Yugoslavia, agreed to guide and tutor this project, in co-operation with the Agency's Nuclear Data and Physics Sections. Strong interest was also expressed by a number of participants in follow-up in-depth training in nuclear data processing for reactor physics applications. It is intended to implement such training in the form of a 3 months group fellowship training at the NDS with 5-6 selected trainees during the first half of 1991.

D.3.4. <u>Technical Co-operation Projects</u>

D.3.4.a) Nuclear Analytical Techniques and Nuclear Physics

NDS is currently technically responsible for 11 national TC projects dealing with the introduction of nuclear physics and nuclear analytical techniques in 8 African countries and 1 Asian country. In addition to the description of 8 TC projects given in the previous report INDC(NDS)-219/LNA, a short description of another three TC projects is given as follows.

Bangladesh - Utilization of the Neutron Generator (BGD/1/011)

Under a previous TC project (BGD/1/005), the Agency provided the Institute of Nuclear Science and Technology with a neutron generator, a microcomputer, a multichannel analyser and a high-purity germanium detector. A "rabbit" sample transfer system was supplied under project INT/1/018. Although the Institute has been encountering technical problems with the neutron generator (the detector was sent for factory repair after being damaged in transit), work on neutron nuclear data measurements at 14 MeV using the activation technique has continued. This follow-up footnote-a project was formulated on the basis of recommendations of an Agency review mission.

For 1989-90, the Agency has been requested to provide experts who will assist in investigating equipment malfunctions, will train counterparts in its operation, maintenance and servicing, and will help to develop a programme in neutron physics using the neutron generator. Provision of spare parts and materials is also foreseen.

The project will assist the Institute to carry out its research activities in applied nuclear physics.

Senegal - X-ray Fluorescence Laboratory (SEN/2/002)

This project is a follow-up project of the previous project SEN/1/003 "Nuclear Analytical Laboratory". The previous project was initiated in 1980 and closed in 1986. Under this project in the period 1980-1986, the X-ray fluorescence techniques have been introduced in the Institute of Applied Nuclear Technology (ITNA) of the University of Dakar, Senegal. All equipment is now housed in a new building, including the liquid nitrogen plant. The X-ray fluorescence equipment was not used for several years due to the delay in the construction of the building. Therefore ITNA has to re-start the programme for XRF analysis.

For 1990, the Agency has been requested to provide experts who will assist in investigating equipment malfunctions, will train counterparts in the operation, maintenance and servicing, and will help to develop a programme in XRF. Provision of spare parts and materials is also foreseen.

Zambia - Nuclear Sciences and Techniques (ZAM/1/006)

There are many activities in medicine, agriculture and industry in Zambia in which nuclear techniques are used but there is always a shortage of trained manpower to carry them out. To overcome this manpower problem, the University of Zambia would like to develop an advanced programme of studies in the nuclear sciences that would lead to an MSc degree. Qualified national staff and the basic facilities for undergraduate courses in nuclear physics and radiation, including adequate laboratory space and a small electronics laboratory, are available. However, the University lacks the foreign currency to equip the Physics Department with the necessary facilities for teaching and research at an advanced level.

To assist the University in introducing nuclear physics in the post-graduate curriculum, a two-year project has been formulated on the basis of the recommendations of an Agency mission undertaken in 1987. In the first year of the project in 1990, it is foreseen that an expert will design experiments in nuclear physics and radiation for post-graduate students and train them in the new techniques. The necessary equipment will be provided as well as some scientific textbooks. In the second year, 1991, the equipment will be augmented and research initiated under the guidance of the national staff. A scientific visit for the Head of the Department is foreseen and a fellowship in equipment maintenance for the electronics technician.

The project is expected to provide Zambia with the means to develop urgently needed manpower in nuclear sciences for national research and development.

D.3.4.b) Nuclear Data Processing

INDONESIA (INS/RP91-92/05)

The Agency has been requested to provide in 1991 and 1992 technical assistance for the purpose of further development of the nuclear data processing capability for reactor application calculations in the Centre for Nuclear Technology Assessment, National Atomic Energy Agency, Indonesia.

Expert services and the training of staff by fellowships have been requested under this programme.

It is expected that the project will strengthen the capability of the Centre to perform all reactor physics and safety related calculations starting from basic evaluated data files, such as ENDF/B-VI.

ALGERIA (AFRICA/RP91-92/ALG-9)

A pre-project mission to Algeria was performed in May 1990 with the objective of assessing the TC project proposal AFRICA/RP91-92/ALG-9. This proposal envisages the establishment of a computer-based nuclear data library and associated data processing capability for reactor physics calculations and the acquisition of a MicroVAX computer for this purpose by 1991 or 1992. Dr. S. Ganesan visited the Centre for the Development of Energy Systems, High Commission for Research, including its 1 MW open pool research and training reactor NUR, and met with the local VAX computer supplier in order to obtain quotations for a specific configuration suitable for nuclear data processing.

It is expected that this project will create a capability in the Centre to perform nuclear data processing for all applications connected with its 1-MW reactor and reactor physics design studies expected in the future.

MYANMAR (Burma) (BUR/RP91-92/06)

The Agency has been requested to provide computer equipment for enhancing the capability in computational nuclear physics in the Physics Department of Mawlamyine University of the Union of Myanmar (Burma). This project will help to establish infrastructure for local nuclear-physics related activities.

D.3.5. <u>Training Fellowships and Cost-free Interns</u>

During the reporting period, NDS has hosted three IAEA fellows, funded under the Agency's Technical Co-operation Fellowship Programme, Mr. Mohsen Tehrani Rad from Iran, and Messrs. Qiu Yu-Bo and Qiu Yanghui from China.

<u>Mr. M. Tehrani Rad</u> spent five months (September 1989 to February 1990) at NDS and received training in the processing of EXFOR and ENDF files using the IAEA IBM mainframe computer and NDS PCs.

<u>Mr. Qiu Yu-Bo</u> from the Institute of Applied Physics and Computational Mathematics in Beijing was hosted by the NDS Atomic and Molecular (A+M) Data Unit for three months from January to March 1990. His training programme included familiarization with the IAEA A+M numerical data base and the A+M data base management system ALADDIN as well as ALADDIN formatting of particle-surface interaction (PSI) data and assistance in the establishment of the IAEA PSI database.

<u>Mr. Qiu Yanghui</u> from the same Institute was also hosted by the NDS A+M Data Unit for six months from January to June 1990. During his training Mr. Qiu acquired knowledge in the handling of large atomic data bases using the ALADDIN data management system, and assisted the Unit in the parameterization of atomic and PSI data and to compile backscattering and sputtering yield coefficients into the PSI database.

<u>Mr. José Martinez Rico</u> from Mexico, who previously spent one year (from May 1987 to April 1988) as an IAEA-supported fellow with the NDS has in the meantime worked on his diploma thesis on "Evaluation of cross sections for the reactions 197Au(n,2n)196Au, 59Co(n,2n)58Co and 93Nb(n,2n)92mNb" at the University of Vienna under the tutorship of Prof. H. Vonach. He is currently hosted by NDS as a cost-free IAEA intern for completion of his thesis using NDS data files and computer facilities.

Finally, in conjunction with the IAEA/NDS Technical Co-operation Project CPR/1/004, through which the Agency provided the Chinese Nuclear Data Centre (CNDC) at the Institute of Atomic Energy, Beijing, with a MicroVAX computer, the Computer Centre of the Vienna University hosted <u>Mr. Yang Junxiao</u> from the CNDC for three months in 1989 for training in the installation and utilization of a MicroVAX computer. This training was arranged in co-operation between the Institut für Radiumphysik und Kernforschung (H. Vonach) and NDS.

List of Liaison Officers to the INDC as of March 1989

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Ricabarra, G. Vonach, H.K. Islam, Shafiqul Poortmans, F. Calderón, A.A. Martinez, R.D. Janeva, N. Morales-Peña, R. Director, Instituto de Asuntos Nucleares Salazar Matarrita, A. Gandarias-Cruz, D. Rocek, J. Christensen, C.J. Muñoz, R. Hammad, F.H. Wasastjerna, F. Dritsa, S. Kluge, G. Azimi-Garakani, D. Said, K.I. Yiftah, S. Gacii, P. Dzang, S.H. Cho, M. Shihab-Eldin, A. Aboughalya, E. Erradi, L. Gruppelaar, H. Salau, A.A.M. Andersen, E. Gul, K. Espinosa Garcia, R. Navarro, Q.O. Marcinkowski, A. de Carvalho, F.G. Rapeanu, S.N. Tang, Seung-Mun Mingay, D.W. Habbani, F.I. Boonkong, W. Gueltekin, E. Than Quoc Thuong

PAGE

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LIST 2. ORIGIN DESIGNATOR CODE SORT

- 43 -

INDC DOCUMENT Designator	DATE OF DISTRIB.	ORIGINAL Document 1D.	DOCUMENT TITLE, AUTHOR, OTHER Identification numbers, etc	ACC.NO
INOC(NDS)-212/G	APR 89	ECN-212	FINAL REPORT ON THE REAL-84 EXERCISE W.L. ZIPJ, E.M. ZSOLNAY, H.J. NOLTHENIUS AND E.J. SZONDI NOVEMBER 1988 99 PAGES	1676
INDC(NDS)-215/LJ	9 NUL		NUCLEAR DATA FOR STRUCTURAL MATERIALS OF FISSION AND FUSION REACTORS. JUNE 1989 27 PAGES SUMMARY OF THE SECOND RESEARCH COORDINATION MEETING ON METHODS FOR THE CALCULATION OF FAST NEUTRON DATA FOR STRUCTURAL MATERIALS HELD IN VIENNA, 15-17 FEBRUARY 1988	1698
I NDC (NDS) - 216/G2	MAR 89		NUCLEAR DATA NEEDED FOR NEUTRON THERAPY Summary Report Second Research Co-ordination meeting organized By The International Atomic Energy Agency Vienna, 24-27 January 1989 Prepared By K. Okamoto, IAEA/NOS March 1989 35 Pages	1680
1 NDC (NDS) - 2 17 / GZ+	MAR 89		ATOMIC AND MOLECULAR DATA FOR RADIOTHERAPY Summary Report First Research CD-Oroination Meeting Organized by the International Atomic Energy Agency, Vienna, 30 January - 2 February 1989 Prepared by K. Okamoto, IAEA/NDS March 1989 54 Pages	1681
INDC(NDS)-218/G2	DEC 89		STATUS REPORT ON CROSS-SECTIONS OF MONITOR Reactions for radioisotope production O. Schwerer and K. Okamoto December 1989 281 pages	1733
INDC(NDS)-219/LNA	MAY 89		REPORT OF THE NUCLEAR DATA SECTION TO THE INTERNATIONAL NUCLEAR DATA COMMITTEE SEPTEMBER 1987 TD FEBRUARY 1989 A. Lorenz, Editor 39 Pages	1688
1NDC{ND\$}-220/L	98 MUL		PHYSICS OF NEUTRON EMISSION IN FISSION PROCEEDINGS DF A CONSULTANTS MEETING ON PHYSICS OF NEUTRON EMISSION IN FISSION ORGANIZEO BY THE INTERNATIONAL ATOMIC ENERGY AGENCY AND HELO IN MITO CITY, JAPAN, 24-27 MAY 1988 H.D. LEMMEL (ED.) JUNE 1989 339 PAGES	1703
1 NDC (NDS) - 22 1	JUL 89		IAEA RESEARCH COORDINATION MEETING X- AND GAMMA-RAY STANOARDS FOR DETECTOR EFFICIENCY CALIBRATION BRAUNSCHWEIG, FRG. 31 May - 2 June 1989 Summary Report July 1989 31 PAGES	1702
INDC(NDS)-223/GF	AUG 89		FUSION EVALUATED NUCLEAR DATA LIBRARY (FENDL) PROCEEDINGS OF THE IAEA SPECIALISTS' MEETING ON FUSION EVALUATED NUCLEAR DATA LIBRARY (FENOL) IAEA, VIENNA, 8-11 MAY 1988 Summary Report EDITED BY V. GOULO AUGUST 1989 262 PAGES	1714
INDC (NDS) - 224/GF	AUG 89		TRANSLATION OF REPORTS FROM THE FIRST INTERNATIONAL CONFERENCE ON NEUTRON PHYSICS KIEV, USSR, 14-18 SEPTEMBER 1987 S. ANTONOV ET AL (NRPI, BULGARIAN ACADEMY OF SCIENCES, SOFIA, BULGARIA), V.A. ZAGRYADSKIJ ET AL (I.V. KURCHATOV INSTITUTE OF ATOMIC ENERGY, MOSCOW, USSR) TRANSLATED BY THE IAEA, AUGUST 1989 12 PAGES	1711
INDC (NDS) - 225/MS	JUL 89		IAEA SPECIALISTS' MEETING ON "REQUIRED ATOMIC DATABASE FOR NEUTRAL BEAM PENETRATION IN LARGE TOKAMAKS" VIENNA, 10-12 APRIL 1989 Summary Report PREPARED BY R.K. JANEV JULY 1989 40 PAGES	1721
INDC(NDS)-226/MA	AUG 89		IAEA ADVISORY GROUP MEETING ON "PARTICLE-SURFACE Interaction data for fusion" Vienna, 19-21 April 1889 Summary Report Prepared By R.K. Janev and A. Miyahara August 1989 37 Pages	1720
INDC(NDS)-227/MD	OCT 89		IAEA SPECIALISTS' MEETING ON "REVIEW OF THE STATUS OF ATOMIC AND MOLECULAR DATA FOR FUSION EDGE PLASMA STUDIES" VIENNA, 11-13 SEPTEMBER 1989 SUMMARY REPORT, PREPARED BY R.K. JANEV OCTOBER 1989 30 PAGES	1739

INDC DOCUMENT Designator	DATE OF DISTRIB.	ORIGINAL Document ID.	DOCUMENT TITLE, AUTHOR, OTHER Identification numbers, etc	ACC . NO
1 NDC { NDS } - 228/ME	NOV 89		IAEA CONSULTANTS' MEETING: &TH ATOMIC AND Molecular data centre network meeting Vienna, 14-15 September 1989 Summary Report, prepared by R.K. Janev November 1989 108 Pages	1740
1NDC(ND5)-230/L	DEC 89		MEASUREMENTS AND ANALYSIS OF OOUBLE DIFFERENTIAL NEUTRON SPECTRA IN (P.N) ANO (ALPHA,N) REACTIONS SUMMARY REPORT, THIRD RESEARCH CD-ORDINATION MEETING, ORGANIZED BY THE IAEA, BOLOGNA, ITALY 13-15 NOVEMBER 1989 N.P. KOCHEROY DECEMBER 1989 10 PAGES	
INDC{ND\$}-231	DEC 89		NUCLEAR DATA FOR RADIATION DAMAGE ASSESSMENT AND RELATED SAFETY ASPECTS SUMMARY REPORT ADVISORY GROUP MEETING, ORGANIZED BY THE IAEA VIENNA, 19-22 SEPTEMBER 1989 N.P. KOCHEROY DECEMBER 1989 25 PAGES	1736
INDC(NDS)-232/L	OF NAL		ACTIVATION CROSS SECTIONS FOR THE GENERATION OF LONG-LIVED RADIONUCLIDES OF IMPORTANCE IN FUSION REACTOR TECHNOLOGY PROCEEDINGS OF AN IAEA CONSULTANTS' MEETING HELD AT ARGONNE NATIONAL LABORATORY, ARGDNNE, ILLINDIS, USA, 11-12 SEPTEMBER 1989 EDITED BY WANG OAHAI JANUARY 1990 99 PAGES	1741
1NDC(NDS)-233/L	MAR 90		MEASUREMENT, CALCULATION AND EVALUATION OF PHOTON PRODUCTION CROSS-SECTIONS SUMMARY REPORT SPECIALISTS'S MEETING ORGANIZED BY THE IAEA AND CO-SPONSORED BY THE CZECHOSLOVAK ATOMIC ENERGY COMMISSION, SMOLENICE, CZECHOSLOVAKIA, S-7 FEBRUARY, 1990 PREPAREO BY N.P. KOCHEROV MARCH 1990 16 PAGES	1746
INDC(NDS}-234/L	APR 90		MEASUREMENTS AND ANALYSIS OF DOUBLE DIFFERENTIAL NEUTRON SPECTRA IN (P,N) AND (ALPHA,N) REACTIONS PROCEEDINGS OF THE FINAL MEETING OF A CO-ORDINATED RESEARCH PROGRAMME ORGANIZEO BY THE IAEA AND HELD IN BOLOGNA, ITALY, 13-15 NOVEMBER 1989 COMPLLED BY N.P. KOCHEROV APRIL 1990 14 PAGES	1753
INDC(NDS)+235	JUN 90		THE INDC/NEANDC JOINT DISCREPANCY FILE 1990 COMPILED BY B.H. PATRICK, HARWELL LABORATORY, DIDCOT, OXON, U.K. N.P. KOCHEROY, IAEA NUCLEAR DATA SECTION, VIENNA, AUSTRIA JUNE 1990 52 PAGES	1768

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LIST 2. ORIGIN DESIGNATOR CODE SORT

INDC DOCUMENT DESIGNATOR	DATE OF DISTRIB.	ORIGINAL Document ID,	DOCUMENT TITLE, AUTHOR, OTHER IDENTIFICATION NUMBERS, ETC	ACC. NO
INDC(SEC)-097/UN	P8 NUL		INDC LIST OF CORRESPONDENTS FOR THE Exchange of Nuclear data information and compilation of national nuclear data Committees {this list supersedes indc(sec)-93/UN} May 1989 125 pages	1689
INDC[SEC]-098/UN	MAY 89		LIST OF OOCUMENTS RECEIVED BY THE INDC SECRETARIAT (This list supersedes indc(sec)-094/un 30 pages	1687

<u>Appendix C</u>

<u>IAEA-NDS-Documents</u> March 1989 - September 1990

<u>#</u>	<u>Rev</u> .	<u>Date</u>	<u>Title</u> <u>Author or Editor</u>
0	90/9	90/9	Index to the IAEA-NDS Documentation Series H.D. Lemmel
7	90/9	90/9	Index of Nuclear Data Libraries available from the IAEA Nuclear Data Section H.D. Lemmel
11	5	90/9	ENDL-84, LLNL Evaluated Nuclear Data Library 1984 in ENDF-5 format Contents and Documentation D.E. Cullen
23	3	89/12	ENDF/B-4 General Purpose File 1974 Summary of contents and documentation O. Schwerer
39	5	89/12	The 1989 ENDF Pre-Processing Codes D.E. Cullen, P.K. McLaughlin (Rev.1, available as INIS microfiche) See IAEA-NDS-69 for implementation on a Personal Computer
51	2	89/6	JENDL Fission-Product Nuclear Data Libraries Contents and Documentation H.D. Lemmel
58	2	90/9	ENDF/B-6 Photo-Atomic Interaction Beta Library H.D. Lemmel This document also relates to the LLL RSIC Photon Interaction Library of 1983 which is included in ENDF/B-5 and JEF-1.
76	2	90/3	ENDF-6 Formats Manual. P.F. Rose, C.L. Dunford US National Nuclear Data Center
90	3	90/9	BROND. USSR evaluated neutron data library of 1987/88 in ENDF-5 format, with supplements of 1989/90, partly in ENDF-5, partly in ENDF-6 format. V.N. Manokhin et al. (H.D. Lemmel, ed.)
96	0	89/10	ACTIV87 - Fast neutron activation cross- section file by V.N. Manokhin et al., for 206 neutron-induced threshold reactions, in ENDF-5 format, up to 20 MeV. O. Schwerer (ed.) Graphical plots see IAEA Tech. Rep. 273 Handbook on Nuclear Activation Data (1987) pp. 305-411.

<u>#</u>	<u>Rev</u> .	<u>Date</u>	<u>Title</u> <u>Author or Editor</u>
97	1	90/9	ENDF/B-6 Thermal Neutron Scattering Law Library. V. Goulo, H.D. Lemmel
100	3	90/9	ENDF/B-6. The U.S. evaluated nuclear data library for neutron reaction data. Summary of contents. H.D. Lemmel
107	4	90/9	Index to BROND, ENDF/B-6, JEF-1, JENDL-3 H.D. Lemmel
109	90/2	90/2	CINDA Manual S. Webster, NEA Data Bank
110	1	90/6	JENDL-3. The Japanese evaluated neutron data library. Summary of contents. H.D. Lemmel
112	0	89/1	Decay data for detector efficiency calibration; documentation of the GAMDEC dBase-3 database. A. Lorenz
113	0	90/3	ENDF/B-6 high-energy data library. Summary. H.D. Lemmel
114	0	89/12	ACTV-F/H - Neutron activation cross-section library for fusion reactor design. Selected data from the Hanford REAC*2 data library. V. Goulo
115	0	89/4	Prompt gamma rays from thermal-neutron capture. M.A. Lone et al. (H.D. Lemmel, ed.).
116	0	89/4	Thermal-neutron capture gamma-rays. J.K. Tuli (H.D. Lemmel, ed.)
117	0	90/5	GAMCAT. Gamma and alpha rays from radioactive decay. Fachinformationszentrum Karlsruhe. <u>Note</u> : GAMCAT is for sale by FIZ; it is not available from IAEA.
118	0	89/8	ENSGAM89. The ENSDF Radioactivity Database for IBM-PC and Computer Network Access. P. Ekström, L. Spanier. Lund University
119	0	90/7	NJOY: A comprehensive system for the processing of ENDF formatted nuclear data. (A summary description of NJOY.) D.W. Muir

<u>#</u>	<u>Rev</u> .	Date	<u>Title</u> Author or Editor
120	0	90/9	JEF-1. The evaluated nuclear data library of the NEA Data Bank. Summary of contents. H.D. Lemmel
121	0	90/9	JEF-1 thermal neutron scattering law data. Brief of summary of contents. H.D. Lemmel
122	0	90/9	JEF-l radioactive decay data. Brief summary of contents. H.D. Lemmel
123	0	90/9	JEF-1 fission product yield data. Brief summary of contents. H.D. Lemmel