

INDC International Nuclear Data Committee

Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee for the period January 2004 – December 2005

Edited by

Alan L. Nichols IAEA Nuclear Data Section Vienna, Austria

May 2006

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Abstract

This report contains details of the main activities of the IAEA Nuclear Data Section (NDS) in 2004 and 2005, as information to the International Nuclear Data Committee (INDC). Work of NDS staff and their consultants has focused on the continued data development and ensuring adequate, trouble-free services to all users in Member States. This information is complemented with descriptions of other related activities in the reporting period, including meetings and publications. The atomic and molecular data programmes are presented to the INDC for their information only, since these specific activities are reviewed in depth by the A+M Subcommittee of the International Fusion Research Council.

Table of Contents

	Glossary of Abbreviations Preface NDS Organization Chart	
1.	Nuclear Data Section: Overview	11
2.	Nuclear Data Compilations	12
2.1.	EXFOR and dictionaries	12
2.2.	CINDA	12
3.	Nuclear Services	13
3.1.	Web-based services	13
3.2.	NDS electronic document project, CD-ROM and hardcopy services	14
3.3.	Statistics	15
4.	Network Coordination	17
4.1.	Network of Nuclear Reaction Data Centres (NRDC)	17
4.2.	Network of Nuclear Structure and Decay Data Evaluators (NSDD)	17
5.	Atomic and Molecular Data	18
5.1.	Establishment of A&M databases	18
5.2.	Coordination of A&M Data Centre Network (DCN)	20
5.3.	Other A&M activities	20
6.	Nuclear Data Development	21
6.1.	Coordinated Research Projects (CRP)	21
6.1.1.	Improvement of the Standard Cross Sections for Light Elements	23
6.1.2.	Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle	24
6.1.3.	Reference Input Parameter Library for Nuclear Reactions of Relevance to	
	Non-Energy Applications (RIPL-III)	24
6.1.4.	Nuclear Data for the Production of Therapeutic Radionuclides	25
6.1.5.	Development of a Reference Database for Ion Beam Analysis	25
6.1.6.	Reference Database for Neutron Activation Analysis	26
6.1.7.	Update of Decay Data Library for Actinides	26
6.2.	Data Development Projects (DDP)	27
6.2.1.	FENDL-2.1 library	27
6.2.2.	IRDF-2002 dosimetry library	27
6.2.3.	Application library for accelerator driven systems	27
6.2.4.	Updates to the WIMS-D library package	27
6.2.5.	Thermal scattering law library	27
6.2.6.	Resonance parameters for ⁵⁸ Fe	28
6.2.7.	Nuclear model parameter sets for the RIPL-2 database	28
6.2.8.	Ion Beam Analysis Nuclear Data Library (IBANDL)	28
6.2.9.	Nuclear data for the International Fusion Material Irradiation Facility (IFMIF)	28
6.2.10.	Phase-space database for external beam radiotherapy	28
6.2.11.	Beta decay and decay heat	29
(0 10	Lamost to 11/17/2 magazant	- 20

7.	Technology Transfer	29
7.1.	Technical cooperation: regional centre for nuclear data services	29
7.2.	Workshops	30
7.2.1.	Nuclear Reaction Data and Nuclear Reactors – Physics, Design and Safety, ICTP, Trieste, Italy, 16 February-12 March 2004	30
7.2.2.	Nuclear Data for Activation Analysis, ICTP Trieste, Italy, 7-18 March 2005	.31
7.2.3.	Nuclear Structure and Decay Data: Theory and Evaluation, ICTP Trieste, Italy, 4-15 April 2005	31
7.2.4.	Processing of Applications Libraries for Monte-Carlo Transport Calculations,	
	IAEA Vienna, Austria, 12-16 September 2005	33
8.	Computer Support	33
8.1.	Computer networks	33
8.2.	Data servers	34
8.2.1.	VMS systems	34
8.2.2.	Linux systems	34
8.2.3.	Microsoft systems	35
8.3.	Software and applications	35
8.4.	Equipment acquisition	36
8.5.	Software acquisition	36
9.	Concluding Remarks	37
	Appendices	
	Appendix 1 Meetings and Scientific Visits	41
	Appendix 2: Scientific Papers and Publications, 2004 and 2005	. 53

Glossary of Abbreviations

A+M	Atomic and Molecular
ACE	A Compact ENDF library for MCNP Monte Carlo particle transport codes
ADLIST	Address List Database, IAEA Nuclear Data Section
ADS	Accelerator Driven Systems
AMDC	Atomic Mass Data Centre
APID	Atomic and Plasma-material Interaction Data for fusion
ATOMKI	AtomMagKutató Intézete (Institute of Nuclear Research, Debrecen, Hungary)
BARC	Bhabha Atomic Research Centre
BrICC	Band-Raman Internal Conversion Coefficient
CCN	Code Centre Network
CINDA	Computer Index on Neutron Data (bibliographic database)
CD-ROM	Compact disk with read-only memory
СМ	Consultants' Meeting of the IAEA
CPND	Charged-particle nuclear data
CRP	Coordinated Research Project of the IAEA (compare RCM)
CV	Consultancy Visit
DBMS	Data Base Management System
DCN	Data Centre Network
DDP	Data Development Project
DMZ	De-Militarized Zone
EMPIRE	Nuclear model code package for calculating cross sections
ENDF	Evaluated Nuclear Data File
ENDVER	ENDF Verification software package
ENEA	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, Italy
ENSDF	Evaluated Nuclear Structure Data File
EU	European Union
EXFOR	Computer-based system for the compilation and international exchange of
	experimental nuclear reaction data (EXchange FORmat)
FEI	Fiziko-Energeticheskij Institut
FENDL	Fusion Evaluated Nuclear Data Library
ftp	fire transfer protocol
GENIE	General Internet Search Engine for atomic data
GUI	Graphics user - interface
HINDAS	High and Intermediate energy Nuclear Data for Accelerator-driven Systems
HP	Hewlett Packard
IAEA	International Atomic Energy Agency, Vienna, Austria
IBA	Ion Beam Analysis
IBANDL	Ion Beam Analysis Nuclear Data Library
ICC	Internal Conversion Coefficient
	International Centre for Theoretical Physics, Trieste, Italy
	International Fusion Materials Irradiation Facility
IFKC	International Fusion Research Council
INDU	International Nuclear Data Committee
INDL	IAEA Nuclear Data Library
INIS IDENI	Institute de Desquises Energetiens e Nucleares
	Instituto de resquisas Elieigeneas e indéleares
IT	Information Technology
ITEP	International Thermonuclear Experimental Reactor
IILK	memanonal incinionucical experimental reactor

JEFF	Joint Evaluated Fusion and Fission Files (from OECD/NEA-DB)
LANL	Los Alamos National Laboratory
MATXS	Material Cross Section Library
MCNP	Monte Carlo N-Particle code
MCNPX	Monte Carlo N-Particle eXtended code
MIRD	Medical Internal Radiation Dose format
n TOF	neutron Time-Of-Flight (CERN experimental facility)
NAPC	Division of Physical and Chemical Sciences (of the IAEA)
NDS	IAEA Nuclear Data Section, Vienna, Austria
NDS	IAEA Nuclear Data Service
NEA	Nuclear Energy Agency of the OECD, Paris, France
NEA-DB	Nuclear Energy Agency – Data Bank
NENP	Division of Nuclear Power (of the IAEA)
NGAtlas	Atlas of Neutron Capture cross sections
NIST	National Institute of Science and Technology
NJOY	NJOY nuclear data processing system
NNDC	National Nuclear Data Center, Brookhaven Naitonal Laboratory, USA
NRA	Nuclear Reaction database
NRDC	Network of Nuclear Reaction Data Centres
NSDD	Nuclear Structure and Decay Data
NSR	Nuclear Science References, a bibliographic file related to ENSDF
NUCLEUS	Nuclear Information and Knowledge Portal (IAEA)
NuDat	Nuclear Data (code for decay scheme data)
OASIS	Agency Intranet
OECD	Organization for Economic Cooperation and Development
PC	Personal Computer
PGAA	Prompt Gamma Activation Analysis (CRP of the IAEA)
POINT	Temperature Dependent ENDF/B-VI Release 8 Cross Section Library
PPP	Peelle's Pertinent Puzzle
PREPRO	ENDF/B Pre-processing code
RAM	Random Access Memory
RCM	Research Coordination Meeting
RIPL	Reference Input Parameter Library
RNAL	Reference Neutron Activation Library
SAMMY	Resonance analysis code
SSA	Special Service Agreement
SSH	Secure Shell
TAGS	Total Absorption Gamma-ray Spectroscopy
TECDOC	Technical Document published by the IAEA
TM	Technical Meeting
TRANS	Collection of some EXFOR entries
TRIPOLI	Monte Carlo particle transport code from CEA France
TSL	Thermal Scattering Law
UkrNDC	Ukranian Nuclear Data Centre
VMS	Operating system of the Compag Alpha Server
WIMS	Winfrith Improved Multigroup Scheme of reactor lattic codes
WINENDE	Package for storage/retrieval of ENDE files
WPEC	Working Party on International Nuclear Data Evaluation Cooperation
WS	Workshop
XML	Extensible Markup Language
XNWLUP	Graphical user interface to plot WIMS-D library multigroup cross sections
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Preface

The IAEA Nuclear Data Section is one of four Sections within the Division of Physical and Chemical Sciences, which in turn is one of five Divisions of the Department of Nuclear Sciences and Applications. A primary aim of the Section is the provision of good quality atomic and nuclear data to Member States of the International Atomic Energy Agency, covering both energy- and non-energy-related applications. The Nuclear Data Section is internally organized into four Units as shown in the organizational chart. All material in this document has been prepared by the Unit Heads. Progress reports for all projects within the Atomic and Nuclear Data Sub-programme are combined, along with other related support activities during 2004 and 2005. The focus of this report involves the nuclear data aspects of the Sub-programme, constituting about 80% of both staff efforts and the budget of the Section.

The International Nuclear Data Committee (INDC) along with the A+M Data for Fusion Subcommittee of the International Fusion Research Council are two standing committees that advise the Department of Nuclear Sciences and Applications at the individual Section and Unit levels. Both of these bodies provide extremely useful services to the Agency in their advice and guidance.

The main text of the report is complemented by Appendices that provide additional information on the work of the Section. Appendix 1 is a list of meetings and workshops organized and sponsored by the Section, while Appendix 2 summarizes all of the various publications during 2004-2005.

Alan L. Nichols IAEA Vienna, Austria May 2006

Nuclear Data Section

Organization Chart (31 March 2006)

Section Office (and INDC Secretariat)

Section Head: A. Nichols Nuclear Data Physicist (21709/21710) Deputy Section Head: **A. Trkov** Nuclear Data Physicist (21712/21711)

Section Secretary: J. Roberts (21710)

Nuclear Data Services Unit	Nuclear Data Development Unit	Systems Development Unit	Atomic & Molecular Data Unit
<u>A. Mengoni</u> (Head) Nuclear Data Physicist (21717)	<u>A. Trkov</u> (Head) Nuclear Data Physicist (21712)	<u>W. Costello</u> (Head) Systems Analyst (21724)	<u>R. Clark</u> (Head) Atomic Physicist (21731)
V. Zerkin Nuclear Physicist/ Programmer (21714)	<u>R. Capote Nov</u> Nuclear Physicist (21713)	M. Verpelli Systems Analyst (21723)	D. Humbert Atomic Physicist (21729)
<u>S. Dunaeva</u> Nuclear Physicist (21727)	M.A. Kellett Nuclear Physicist (21708)	M. O'Connell Applications Programmer (21722)	<u>K. Sheikh</u> Database Clerk (21730)
O. Schwerer Asst. Nuclear Data Physicist (21715)	R. Bojdo Secretary (on TAP) J. Roberts Clerk	<u>R. Bojdo</u> Secretary (on TAP)	
<u>G. Bush</u> Production Programmer (21725)			
M. Wirtz Office Clerk (21716)			

1. NUCLEAR DATA SECTION: OVERVIEW

Both the budget and staffing level of the Nuclear Data Section (NDS) have been stable, albeit zero budget growth that constitutes a small annual decrease due to inflation effects. The authorized staff level of the Nuclear Data Section (NDS) for 2004-2005 remained at a total of 18, consisting of 11 professionals (P-staff) and 7 support staff (G-staff).

Alan Nichols has continued as Section Head during 2004-2005, and the Unit Heads during this same period have been:

Robert Clark, Atomic and Molecular Data Unit,

Liam Costello, Systems Development Unit,

Vladimir Pronyaev, Nuclear Data Services Unit (until November 2004),

Alberto Mengoni, Nuclear Data Services Unit (from 1 July 2005), and

Andrej Trkov, Nuclear Data Development Unit,

of which those in residence at the end of 2005 have contributed to this report.

Three new staff members joined the Section during the reporting period:

Mark Kellett (effective from 1 March 2005), succeeding Racquel Paviotti-Corcuera who accepted employment at the Instituto Nacional de Pesquisas, São José dos Campos, near São Paulo, Brazil,

Alberto Mengoni (effective from 1 July 2005), succeeding Vladimir Pronyaev who returned to IPPE, Obninsk;

Janet Roberts (effective from 1 June 2005) succeeding Andrea Scherbaum who transferred to IAEA Research Contracts Section on promotion in December 2004.

A nuclear physicist is being sought to replace Andrej Trkov as Deputy Section Head, who resigned with effect from mid-April 2006

The budget and costs of NDS are outlined in Table 1, and also show a switch from US\$ to Euros at the beginning of 2006. Comparisons can only be made by adopting a constant exchange rate (set at 0.82 Euros \cong \$1 US). Staff costs have undergone analysis on the basis of individual NDS-staff time dedicated to the various technical projects as opposed to purely administrative duties and the Agency-support overhead. Staff resignations and the ensuing replacement exercises in 2004 and 2005 also caused minor fluctuations in the administrative and sub-programme costs. There has been a modest increase in overall funding in 2004-05 through the regular budget, based on the increased credibility and reputation of Agency work.

	2004 (US\$)	2005 (US\$)	2006 (C)	2007 (C)
Authorized Staff Level	18	18	18	18
Actual Staff Level	17	17	18	18
Admin + Agency O/H Support Costs	889022	911260	773000	811000*
Technical Programme	1722478	1867340	1500000	1573000*
Total Budget – 2005 Prices	2611500	2778600	2273000	2384000*

Table 1. Staff and budget - summary for 2004-2007.

*uncertain figures

2. NUCLEAR DATA COMPILATIONS

2.1. EXFOR and dictionaries

With effect from 1 July 2005, NDS offers a "common EXFOR master file" for use with retrieval software through web interfaces, as well as for stand-alone programs distributed with CD-ROMs. The use of a unique file for common applications facilitates the updates of the database, which needs to be done on a single file only. The first version of the master file resulted from a detailed comparison of the NDS and NNDC master files.

Over the previous two years, NDS staff has distributed 19 CPND TRANS files (D025 - D043), containing 320 new entries (266 compiled at NDS, 51 at ATOMKI, and 3 at UkrNDC) and 10 revised entries, and 3 neutron TRANS files (3115 - 3117) containing 21 new and 42 revised entries. The compilations consist of new literature as well as important old references for ion beam analysis, medical applications, and proton-induced data. A collection of EXFOR-relevant articles in pdf. format has been initiated for internal use - includes about 2000 articles found on-line or scanned from hard copies.

Altogether, 132 TRANS files were received from network centres, checked (with feedback to the originating centres) and processed. These transmissions contained 919 neutron entries (353 new and 566 revised), 2318 CPND entries (1824 new and 494 revised) and 111 photonuclear entries (79 new and 32 revised).

NDS staff have produced and distributed 5 regular transmissions of the EXFOR/CINDA dictionaries (TRANS 9085-9089). A revised structure was implemented for several of the main dictionaries and several related software programs were upgraded accordingly and distributed to network centres. Three separate lists of papers have been maintained for the completeness of compilation (mostly "old" literature): literature on ion beam analysis, references related to the CRP on "Reference Input Parameter Library (RIPL)", and references related to the CRP on "Nuclear Data for the Production of Therapeutic Radioisotopes".

2.2 CINDA

A new version of the CINDA database has been produced that contains old CINDA data and data imported automatically from the latest version of the common EXFOR database. Algorithms and procedures were implemented on the basis of the common EXFOR master file and dictionaries 9089. The software also allows the import of the latest update(s) from EXFOR to CINDA. The first version of a CINDA editor has been developed for an efficient compilation of entries, and is available along with database maintenance tools. With this system, the NDS staff are able to scan over 71 journal titles (mainly through the Internet) for the purpose of compilation coverage control. Over 1300 journal issues from 1995 to 2005 were added to the database for CINDA coverage control in late 2005. Journal references that should be compiled elsewhere were also dispatched to the relevant centres (in Japan, Russia, Hungary and NEA-DB). All relevant references absent from EXFOR were sent to the responsible centres for compilation, along with and necessary hard copies of the papers.

A meeting to discuss "EXFOR-CINDA: revision of contents, compilation and plans" was held at IAEA Vienna, on 26-28 April 2005. Debate focused on the algorithm for the import of information from EXFOR to new CINDA (extended to include charged particles, photonuclear and missing neutron reaction data), and definition of the steps that should be taken by nuclear data centres to produce the new common CINDA database. Other important tasks and problems were discussed concerning the contents of CINDA and EXFOR databases, compilation process, and the on-going project to merge NNDC and IAEA versions of the EXFOR database. A major result was that all details for assembly of the final new CINDA file were agreed, and a plan of migration has been fixed.

3. NUCLEAR SERVICES

3.1. Web-based services

The migration of all the Web-services from VMS to Linux-based systems has been completed, and has operated reliably during 2004-2005. Further improvements have been implemented in the EXFOR/CINDA/ENDF retrieval systems with direct links to Web-journals and NSR, and inclusion of the data retrieval in the new computational format (T4). The ENDF retrieval system has been extended to include the IRDF-2002 and JEFF-3.1 libraries. A self-configuration of the entire retrieval system has been developed, so that installation in the various cloned servers has became trivial. Further developments of the system were also based on analyses of retrieval statistics, user feed back and regular discussions with NNDC staff.

A full copy of the EXFOR/CINDA/ENDF system including database management tools and the Web-based retrieval system was installed and operated on the NNDC Website at Brookhaven from 2004. Software source codes, their updates, regular maintenance and technical consultation have also been provided during 2004-2005. Mirror sites of the Web-retrieval system are also operating on the Websites of the Bhabha Atomic Research Centre (India) and at the Instituto de Pesquisas Energéticas e Nucleares (Brazil) –see Section 7.1.

Various new evaluated data libraries, files and programs for data checking, processing and graphical presentation have been added to the NDS Website and distributed on CD-ROM. The most important extensions and/or updates include:

- ENDF retrieval interface extended to include IRDF-2002 and JEFF-3.1 libraries,
- ENDF-WINENDF (updates of July 2005),
- ADS-applications library for accelerator driven systems, including ADS-ENDF, ADS-ACE and ADS-MATXS,
- XNWLUP (August 2005 version),
- EXFOR CINDA database and retrieval system, version 1.80 data updated in June 2005 (CD-ROM),
- AMDC (Atomic Mass Data Center) by Audi *et al.*, including 2003 Atomic Mass Evaluation and NUBASE 2003,
- EMPIRE Nuclear Reaction Model Code, version 2.19 Beta (Lodi), April 2005,
- FENDL-2.1, Fusion Evaluated Nuclear Data Library package, December 2004, including FENDL/E-2.1, FENDL/MC-2, FENDL/MG-2.1 (MATXS), and FENDL/MG-2.1 (GENDF),
- IRDF-2002 International Reactor Dosimetry File, March 2005,
- Minsk Actinide Library updates of April 2005,
- POINT2004, temperature-dependent version of the ENDF/B-VI library, release 8, available on one DVD data at eight temperatures between 0 and 2100K, and

reconstructed with 0.1% accuracy,

- PREPRO2004. ENDF/B pre-processing codes, November 2004; updated June 2005,
- charged-particle cross-section database for medical radioisotope production, update January 2004 (with links to ENDF-formatted data),
- NuDat-2.1 for interactive searching and plotting of nuclear structure and decay data,
- INDL/TSL Thermal Neutron Scattering Library,
- IBANDL Ion Beam Analysis Nuclear Data Library, updated CD (April 2005).

As a consequence of the improvements in the Web interfaces, Telnet access to the nuclear data bases is no longer supported - users are encouraged to switch to the Web services.

Country Scanned Pending

3.2. NDS electronic document project, CD-ROM and hardcopy services

Table 2. Electronic documents.

(a) INDC reports

Country	Scanned	Pending
ARG	0	13
AUL	10	34
AUS	3	15
BLR	20	0
BOL	1	0
BUL	2	14
CCP	379	199
CPR	4	56
CSR	0	16
CUB	0	7
CZR	1	0
DEN	0	4
EAN	0	3
EGY	0	7
ENE	0	20
EUR	0	31
FR	0	72
GDR	0	50
GER	0	50
GRC	0	3

HUN	4	32
IAE	0	41
IBW	0	1
IND	1	45
IRN	0	4
IRQ	0	1
ISL	0	5
ITY	1	11
JAP	0	83
JPN	0	194
KOR	0	5
KWT	0	2
MOR	0	3
NDS	449	0
NEA	0	10
NED	0	10
NOCODE	1	23
NOR	0	3
PAK	0	13
POL	0	14

Country	Scanned	Pending
PRT	0	3
ROM	0	22
SAF	0	11
SEC	2	103
SLK	0	2
SLN	0	2
SPN	0	5
SUD	0	4
SWD	0	23
SWT	0	16
TAI	0	4
TUK	0	6
UK	1	89
UKR	1	7
UNI	0	7
USA	1	106
VN	1	10
YUG	0	11
Total	882	1525
	37% cc	omplete

(b) Technical documents

Series	Scanned	Pending
IAEA	12	0
IAEA-	23	0
TECDOC		
Technical	6	0
Reports Series	0	0
Total	41	0
		100% complete

(c) IAEA-NDS reports

Scanned	Pending
72	0
72	0
	100% complete

Good progress has been made in scanning relevant nuclear data documents, and converting them to a useable format for electronic distribution from the main Web server. This work is being undertaken in cooperation with INIS who have suitable equipment and expertise to handle microfiche and original texts. Work has begun in the Section on extracting suitable text from these documents to facilitate automatic searching and retrieval. At the time of writing this report, the numbers of documents defined in Table 2 had been scanned and placed on the Web server.

The following sets of CD-ROMs have been produced:

- EXFOR/CINDA for Windows (four versions issued) EXFOR contains common contents,
- Linux and Windows versions of EXFOR/CINDA for Applications were issued four times (also distributed as part of ENDVER/GUI-CD and EMPIRE-II package),
- ENDVER/GUI for Linux and Windows integrated tools for ENDF evaluators, version 1.3, June 2005.

NDS distributed 958 hardcopy documents (INDC reports, Charts of Nuclides, Nuclear Wallet Cards) and 2506 PC media (CD-ROMs and DVDs) in 2004-2005.

3.3. Statistics

Full statistics of the usage of the Web retrieval system are presented in Fig. 1, and show various representations of user access to the NDS Web server and the mirror servers in Brazil and India. Although the Web system was significantly changed and analyses are not always possible for all Web products, comparison of statistics can help understand general trends and interest for different parts of the system. The total number of data retrievals has increased by 25% in 2004-2005 when compared with 2002-2003. This increased demand arises mainly from customers requiring and requesting data from EXFOR, IBANDL, CINDA and NSR databases, and documents. A noteworthy feature is that the number of queries from developing countries exhibits substantial growth, and now represents 30% of the total number of NDS retrievals.

NDS+IPEN+BARC Nuclear Data Services: Web Statistics

Total per Year (Number of accesses + retrievals)



Fig.1. Access and retrievals from IAEA-NDS, IPEN (Brazil) and BARC (India), 2000-2005.

4. NETWORK COORDINATION

4.1 Network of Nuclear Reaction Data Centres (NRDC)

NDS assists the network of Nuclear Reaction Data Centres by organising the annual coordination meetings. This network includes four core nuclear data centres, and nine national and specialised data centres. Biennial meetings of the data centre heads are designed to generate administrative recommendations on nuclear reaction data exchange and the development of shared databases and services. Technical matters associated with data exchange are also considered, and a dedicated biennial technical meeting in alternative years is primarily devoted to this topic. Bilateral visits and consultancies are also used to identify and solve problems associated with data exchange and database development.

An IAEA Technical Meeting of the International Network of Nuclear Reaction Data Centres (NRDC) was held at the National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY, USA, on the 4–7 October 2004 (see INDC(NDS)-464). The meeting focused on a revised protocol of cooperation between network centres, revisions of the EXFOR/CINDA dictionary structure, EXFOR manual, a reformulation of the scope of compilations, and technical questions on EXFOR compilation. Thirty-one conclusions and twenty-seven actions were formulated and agreed.

An IAEA Technical Meeting on the Coordination of the International Network of Nuclear Reaction Data Centres was held at the IAEA Headquarters, Vienna, Austria on 12–14 October 2005 (see INDC(NDS)-480). This meeting focused on the coordination of compilation coverage, the common EXFOR master file, and technical issues, with twenty-three conclusions and thirty-three actions.

Bilateral visits:

- V. Zerkin (IAEA NDS) to NNDC, Brookhaven Software development for management and Web-retrieval of ENDF and EXFOR Relational Databases.
 15 March - 2 April 2004,
 23 February - 16 March 2005,
 4 November - 2 December 2005.
- M. Verpelli (IAEA NDS) to NNDC, Brookhaven Explore ways for closer integration of NNDC and NDS information systems. 17-21 October 2005.
- V. McLane (NNDC) to IAEA NDS CINDA and EXFOR – procedures and manual(s) 28 November – 14 December 2005.

4.2 Network of Nuclear Structure and Decay Data Evaluators (NSDD)

Biennial meetings of the international network of Nuclear Structure and Decay Data (NSDD) Evaluators are funded and organized under the auspices of the NDS. A meeting of the NSDD network was held at McMaster University, Hamilton, Canada, on 6–10 June 2005 (see INDC(NDS)-0476). This meeting was attended by 33 scientists from 12 Member States concerned with the compilation, evaluation and dissemination of nuclear structure and decay

data. The Indian Institute of Technology, Roorkee (representative: Ashok Jain) was welcomed as a member of the central team of mass chain evaluators, and various mass number responsibilities were adjusted accordingly. IAEA-NDS sponsorship of the two-week NSDD evaluators' workshops at ICTP, Trieste (2003 and 2005) was warmly praised, with new evaluation work being encouraged from this source by means of a network mentoring process. A significant technical development during the course of the network meeting was the agreed adoption of the BrICC program for ICC calculations using the Band and Raman prescription, and modelling the hole by the frozen orbital approximation. NDS staff were asked to seek further support for mass chain evaluations by organising a 1-day meeting of Directors/Heads from appropriate institutes to discuss NSDD and develop a coherent approach to possible EU funding, invite relevant specialists/managers to the next NSDD Evaluators' Network meeting (May/June 2007), and write to the Director of iThemba Labs, South Africa, to seek their involvement in NSDD activities.

Agreement was reached with NNDC staff for NDS to assist in the preparation of Nuclear Science References (NSR). Articles in specific journals are scanned manually, and key words are compiled and transmitted to NNDC for inclusion in NSR. This work began in September 2005, and will be reviewed at regular intervals over an agreed trial period.

Bilateral visits:

 M. A. Kellett (IAEA NDS) to NNDC, Brookhaven New collaboration to compile keyword abstracts for Nuclear Science References (NSR bibliographic database).
 10-15 July 2005,
 5-9 December 2005.

5. ATOMIC AND MOLECULAR DATA

The primary role of the Atomic and Molecular (A+M) Data Unit is to provide data relevant to fusion energy and other research-based activities. A number of different activities are undertaken to achieve this goal, enhance the content and quality of the databases, and ensure that the databases are readily accessible to users in the fusion energy and nuclear physics communities. The databases maintained by staff of the A+M Data Unit include interactions of isolated atoms and molecules and their ions with other particles, particle-surface interactions, and materials property data. These last two sets of data type are combined under the term "plasma-material interaction".

A+M Data Unit staff supervise Coordinated Research Projects (CRPs) under the guidance and control of a series of Research Coordination Meetings (RCMs), as well as coordinating the work of an A+M Data Centre Network (DCN). Data gathered from these sources and from Consultants' Meetings (CMs) are evaluated and added to the databases maintained by the A+M Data Unit. All of the various activities are supervised and reviewed by the Atomic and Molecular Data for Fusion Subcommittee of the International Fusion Research Council (IFRC), which meets biennially.

5.1. Establishment of A+M databases

Over the previous two years, two CRPs came to a close, and two new CRPs were initiated; thus, three CRPs are currently operational within the Unit.

The second RCM on "Tritium Inventory in Fusion Reactors" was held in 2004. Participants reviewed their progress with respect to the initial agreed work plan. All completed and ongoing research was discussed and reviewed, and used to update the various studies. Specific experiments on a number of fusion devices were planned in a series of collaborations between experimentalists and theorists to further develop methods of modelling the interactions of hydrogen isotopes with wall materials. A third and final RCM is planned for September 2006.

A final RCM on "Molecular Processes in Edge Plasmas" was also held in 2004. All participants have submitted comprehensive review articles for publication in *Atomic and Plasma-Material Interaction Data for Fusion* (APID). Participants in this CRP addressed the most pressing needs to identify and quantify the molecular processes in the plasma edge region. The resulting studies have had a significant impact on the chosen field, and generated significant new databases that define the relevant molecular processes. These data are now being used to model the edge regions, and will have significant impacts on design considerations for future devices.

The CRP on "Atomic and Molecular Data for Fusion Diagnostics" held a third and final RCM in 2004, whereby all participants submitted review articles for publication in APID. This CRP has contributed greatly to the provision of data for plasma diagnostics that are needed in the modelling of plasma in different regimes in order to determine such fundamental parameters as density and temperature. Since many of these data were not known for many plasma conditions, these studies have had a significant impact on the ability to model the behaviour of neutral beam injection as well as interactions of the plasma with cool particles sputtered from the plasma-facing components.

A new CRP on "Atomic and Molecular Data for Plasma Modelling" was initiated on 26-28 September 2005. The objectives are to collect and evaluate cross sections, rate coefficients, branching ratios and kinetic energies from various sources for hydrides and isotopes. Vibrational relaxation times in the hydride complexes need to be estimated, and gaps in the existing data need to be identified and addressed on the basis of existing knowledge. During the first RCM, participants reviewed the current status of worldwide research efforts. A detailed work plan was formulated in terms of two topics: plasma-surface interactions, and volume processes. Each participant indicated areas in which they could make contributions to the agreed work plan.

A new CRP was established on "Atomic Data for Heavy Element Impurities in Fusion Reactors", and the first RCM was held on 14-15 November 2005. The specific aim is to provide data relevant to the analysis of heavy element behaviour in a fusion reactor, categorized in terms of collisional and radiative processes. Collisional processes include excitation, ionization and charge transfer:

excitation and ionization can be initiated by electron as well as heavy-particle impact; excitation processes can lead to auto-ionization and di-electronic recombination; recombination of ions with electrons can occur as the inverse of ionization; charge transfer occurs in the collision of two heavy particles.

Radiative processes include bound-bound absorption as well as photoionization. The inverse processes of line emission and radiative recombination are vital in the modelling of the spectral features of the plasma impurities. A detailed work plan was formulated at the first RCM, with all participants indicating the relevance of their proposed contributions. Several

comparisons are planned between different theoretical methods and between theory and experiments.

5.2. Coordination of A+M Data Centre Network (DCN)

The Data Centre Network (DCN) consists of twelve members from the USA, Russian Federation, Japan, France, Germany, Italy, PRChina and Korea. DCN meets every two years to discuss data needs and to coordinate activities. A meeting took place in October 2005 at the IAEA Headquarters to report and assess recent and on-going activities. The list of data needs and priorities was reviewed and updated (available through the IAEA A+M home page *www-amdis.iaea.org*). Discussions focused on the changing nature of data generation and transmission. Recent developments on XML schema for A+M data were presented, along with plans for further work on the topic in collaboration with the astrophysics community.

5.3. Other A+M activities

Besides the normal data gathering activities of the Unit, several other significant activities have taken place during 2004-05, including improved access to the databases, preparation of various publications, presentations at scientific conferences, and the continued developments of an extra-budgetary project.

The Web interface to the bibliographic and numerical databases has undergone considerable revision over the past two-year period with the help of several consultants. A comprehensive index of processes, reactants and products was established in common with both databases, with the long-term goal of cross linking between the numerical and bibliographic data. The general search engine (GENIE) has continued to be developed - several additional databases can be searched by means of this tool, allowing users to retrieve data from as many as twelve databases through one command. A Web-based interface has been developed in collaboration with Abdallah, Jr. (Los Alamos National Laboratory (LANL)) to access several powerful atomic physics codes. These codes allow a user to calculate energy levels, oscillator strengths, excitation cross sections and data for several ionization processes. The interface has been developed for use with heavy-particle collisions in collaboration with Dubois and Hansen. Although this interface and computer code have been installed on the A+M server, use is restricted to registered users who are able to demonstrate a specific need due to the prohibitively extensive and lengthy nature of such calculations.

Most data for A+M processes are generated by means of calculation rather than experimental measurements. This situation arises from the difficulty of carrying out many of the measurements, as well as the development of highly accurate quantum theory. With the rapid increase of computational facilities, a number of institutes now have significant resources for generation of large amounts of detailed A+M data relevant to fusion research. Representatives from eleven research institutes participated in a Technical Meeting at IAEA Headquarters in May 2005 to discuss the need for and feasibility of establishing a code centre network (CCN) equivalent to the existing data centre network (DCN). The proposed CCN would function as an extra tool for the generation of new data when such data for a particular process are unavailable from the existing databases. CCN members can make a number of calculational tools available to generate data encompassing a wide variety of processes. The method for using these tools will depend on the complexity of the task. For processes associated with atomic structure and certain cross-section calculations, there are on-line computer codes that can be used directly. When more complex situations arise, the code authors will respond to

data needs by analyzing a problem and performing the necessary calculations in the most efficient manner. A Web page is under construction with links to CCN members, and descriptions of their capabilities to analysis the prescribed processes.

The A+M Unit continue to publish *Atomic and Plasma-Material Interaction Data for Fusion* (APID) series of technical reviews. Volumes 13 and 14 are undergoing final review prior to publication as issues dedicated to "A+M data for fusion plasma diagnostics" and "Molecular processes in edge plasma", respectively. Staff also prepare and publish the International Bulletin that contains bibliographical information for fusion-related A+M data (volume 63 is the latest issue). Furthermore, two professional staff of the A+M Unit attended and presented papers at several international scientific conferences in 2004-05. Staff also collaborate directly with several research institutes to generate data of interest to the fusion and nuclear physics research communities. Finally, the A+M Data Unit continues to maintain the "International Database on Irradiated Graphite Properties" – the Steering Committee for this project met in September 2004 and March 2005, and a schedule has been agreed to complete the current phase of data entry from existing reports.

6. NUCLEAR DATA DEVELOPMENT

Nuclear data development activities are primarily aimed at improving the quality and quantity of nuclear data accessible by all Member States through the following functions:

- coordinated research projects,
- individual research contracts, contractual and special service agreements with experts in specific fields,
- specialised technical meetings,
- work undertaken directly by NDS staff.

Immediate outputs of these data development projects include:

- creation of new data bases designed and dedicated to various energy and non-energy based applications,
- new contributions or improvements to existing databases,
- documents related to the database description, verification and validation,
- software tools for data manipulation including visualisation and verification,
- users' manuals when appropriate.

6.1. Coordinated Research Projects (CRP)

A somewhat historic perspective of CRPs within the Nuclear Data Section can be seen in Table 3 that covers the previous 16 years of such activities (1991-2006) as well as giving some consideration of the future. As can be seen from these data, CRP commitments are solid up to 2008, and plans concerning future years are already being made on the basis of the envisaged completion dates of various on-going CRPs and previous recommendations of the INDC and IFRC.

Four coordinated research projects on nuclear reaction data were active and continued during 2004 and 2005; one CRP on "Prompt-gamma activation analysis" was completed. Three new CRPs were approved during 2004 for which contracts/agreements were awarded, and their first RCMs were convened in 2005. The status of the various on-going nuclear data CRPs is summarised in Table 4. The total number of currently active CRPs in NDS is 11, including those identified with the A+M Data Unit.

CRPs - Technical reports	(5) 1991	(5) 1992	(5) 1993	8 1994	10 1995	9 1996	9 1997	10 1998	12 1999	10 2000	9 2001	11 2002	12 2003	9 2004	12 2005	11 2006	9 2007	8 2008	(8) 2009	(3) 2010	(1) 2011
TECDOC-0992 (Kocherov)																					Ì
APID, vol. 6 (Janev)																					
At. data medium- and high-Z impurities																					I
TECDOC-0799 (Kocherov)																					1
A+M radiotherapy & radiation research																					
Plasma-interaction induced erosion																					1
TECDOC-1168 (Lammer)																					
Fission yield nuclear data																					<u> </u>
TECDOC-1034 (Oblozinsky) RIPL-1																					ł
APID, vol. 11 (Janev)																					
Radiative cooling rates/fusion impurities																					l
INDC(NDS)-412 (ObioZinsky) Photon production data																					1
TECDOC-1285 (Herman)																					
Reference neutron activation library																					
Set aside (Janev) - see tritium CRP, below																					1
APID vol 12 (Clark)		<u> </u>	<u> </u>							<u> </u>			<u> </u>					<u> </u>			<u> </u>
At. + plasma-wall interaction data									L			1									ł
TECDOC-1211 (Oblozinsky)		1	İ 👘	1								1	1					1			1
Prod. cross sect diagnostic radioisot.		L	ļ	L									L					L			ļ
IECDUC-1178 (Oblozinsky)												1									l
Technical Reports Series (Lammer)																					
Fission yields for minor actinides																					1
APID, vol. 9 (Clark)																					
At. and plasma-material interaction data																					
Charge exchange cross-section data																					1
Tech Reports Series (Oblozinsky/Herman)																					
RIPL-2																					l
Lindate X and x-ray decay data standards																					1
Technical Reports Series (Paviotti)																					
Prompt y rays for elemental analysis																					1
Technical Reports Series (Trkov) WIMS-3D																					ł
Technical Reports Series (Paviotti)																					
IRDF-2002 (DDP - not CRP)																					
APID, vol. 13 (Clark)																					1
APID. vol. 14 (Clark)																					
Molecular processes in edge plasmas																					1
Technical Reports Series (Trkov)																					1
ND for Th-U fuel cycle																					
Standard cross sections																					1
APID, vol. 15 ? (Clark)																					
Tritium inventory nucl. fusion machines																					l
RIPL-3																					1
Technical Reports Series (Capote Noy)																					
Prod. cross sect therapeutic radioisot.																					1
Technical Reports Series (Trkov/Kellett)																					1
Technical Reports Series (Schwerer)																					
Ref. database for ion beam analysis																					1
Technical Reports Series (Kellett)																					
Update of actinide decay data																					
A+M data for plasma modelling												1									l
APID, vol. (Clark)		1	1	1	1	1			1	1		1	1								(
At. data for heavy element impurities		L	L		L	L				L		ļ	L								ļ
APID, vol. (Clark)												1									l
Technical Reports Series (Capote Nov?)																					
Evaluated ND files for medical therapy												1									l
Technical Reports Series (Mengoni?)																					
Minor actinide neutron reaction data											1	1									

Table 3. Past 16 years and the immediate future of NDS activities related to Coordinated Research Projects.

No.	Short title	Duration	Participants (contracts)	Project Officer	Status	Section
1	Cross-section standards	2002-2006	9 (4)	Pronyaev/Nichols	Completed – database/document in preparation	6.1.1
2	Nuclear data for Th- U fuel cycle	2002-2006	10 (6)	Trkov	On-going	6.1.2
3	RIPL-III	2003-2006	11 (5)	Capote Noy	On-going	6.1.3
4	Nuclear data for the production of therapeutic radionuclides	2003-2007	9 (4)	Capote Noy	On-going	6.1.4
5	Development of a reference database for ion beam analysis	2005-2009	9 (4)	Schwerer	Approved and on-going	6.1.5
6	Reference database for neutron activation analysis	2005-2009	6 (4)	Trkov/Kellett	Approved and on-going	6.1.6
7	Update of decay data library for actinides	2005-2009	6 (3)	Kellett	Approved and on-going	6.1.7

Table 4. Status of Coordinated Research Projects dedicated to nuclear data.

6.1.1. Improvement of the Standard Cross Sections for Light Elements (close to completion)

Objectives:

- Improve the methodology for the evaluation of the covariance matrix of uncertainty in the R-matrix model fits.
- Update the experimental database prepared by Poenitz for the evaluation of light and heavy element standards (objective added by participants at first RCM in 2002).
- Produce R-matrix evaluations of important light element standards.
- Produce new evaluations of heavy element standards (objective added by participants at first RCM in 2002).
- Produce new evaluations of high-energy standards consistent with low-energy standards (objective added by participants at second RCM in 2003).
- Produce combined evaluation of light- and heavy-element standards, including high-energy standards by the end of 2004 (objective added by participants at second RCM in 2003).

Activities:

- Second Research Coordination Meeting was held at NIST, Gaithersburg, USA, 13-17 October 2003.
- Third Research Coordination Meeting was held at IAEA Vienna, Austria, 18-22 October 2004.

Outputs:

• Cross-section files in ENDF format were submitted in November 2005 - covariance data

will be added in 2006.

• Preparation of documentation began in 2005, and will continue in 2006.

References:

- [1] A.D. Carlson, G.M. Hale and V.G. Pronyaev (Eds.), Summary Report of the Second RCM on Improvement of the Standard Cross Sections for Light Elements, IAEA Vienna, Austria, 13–17 October 2003, INDC(NDS)-453, March 2004.
- [2] A.D. Carlson, G.M. Hale and V.G. Pronyaev (Eds.), Summary Report of the Third RCM on Improvement of the Standard Cross Sections for Light Elements, IAEA Vienna, Austria, 18-22 October 2004, INDC(NDS)-463, November 2004.
- [3] V.G. Pronyaev *et al.*, Status of the International Neutron Cross-section Standards File, pp. 808-815 in Proc. Int. Conf. on Nuclear Data for Science and Technology, 27 September 1 October 2004, Santa Fé, USA, Editors: R.C. Haight, M.B. Chadwick, T. Kawano and P. Talou, Vol. 769, Part 1 (2005), AIP, Melville, New York, ISBN 0-7354-0254-X, ISSN 0094-243X.

6.1.2. Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle (on-going)

Objectives:

- Update nuclear data relevant to systems utilizing the Th-U fuel cycle.
- Identify in more detail the variances in nuclear data that are responsible for the discrepancies observed in the calculated parameters of Th-U fuel cycle systems.

Activities:

• Second Research Coordination Meeting was held at IAEA Vienna, Austria, 6-9 December 2004.

Outputs:

- Intensive development efforts were made to evaluate resonance parameters (including new experimental data) and to obtain input parameters for advanced theoretical calculations.
- Evaluated data file for ²³²Th was produced in December 2005 this evaluation was adopted for the US ENDF/B-VII library.
- Final versions of evaluated data files will be released in 2006, together with documentation.

Reference:

 A. Trkov (Ed.), Summary Report of the Second RCM on Evaluated Nuclear Data for Th-U Fuel Cycle, IAEA Vienna, Austria, 6-9 December 2004, INDC(NDS)-468, December 2004.

6.1.3 Reference Input Parameter Library for Nuclear Reactions of Relevance to Nonenergy Applications (RIPL-III) (on-going)

Objectives:

- Extend RIPL-II database to provide input parameters for nuclear model calculations required for emerging applications such as ADS, innovative reactors, medical radioisotope production, and astrophysics.
- Develop routines for calculation of certain input parameters in order to facilitate access of users to the RIPL library and prevent misuse of the parameters.
- Improve quality of the data by using new experimental results (from n_TOF and HINDAS

projects, heavy ion experiments) and microscopic approaches to derive parameters.

Activities:

- First Research Coordination Meeting was held at IAEA Vienna, Austria, 23-25 June 2004.
- Second Research Coordination Meeting was held at IAEA Vienna, Austria, 28 November 2 December 2005.
- Work is progressing as planned, in close cooperation with WPEC Subgroup A.

References:

- R. Capote Noy (Ed.), Summary Report of the First RCM on Parameters for Calculation of Nuclear Reactions of Relevance to Non-Energy Nuclear Applications (RIPL-III), IAEA Vienna, Austria, 23-25 June 2004, INDC(NDS)-462, August 2004.
- [2] R. Capote Noy and S. Goriely (Eds.), Summary Report of the Second RCM on Parameters for Calculation of Nuclear Reactions of Relevance to Non-Energy Nuclear Applications (RIPL-III), IAEA Vienna, Austria, 28 November – 2 December 2005, INDC(NDS)-0492, January 2006.

6.1.4. Nuclear Data for the Production of Therapeutic Radionuclides (on-going)

Objectives:

Reactor-produced radioisotopes

- Compile and evaluate the cross section as a function of energy in the range 0-20 MeV.
- Deduce spectrum-averaged data in the conventional way for thermal, epithermal and fast neutrons and compare with measurements.

Accelerator-produced radioisotopes

- Compile and evaluate cross sections as a function of energy up to 40 MeV (or 100 MeV, when necessary).
- Deduce from the microscopic cross sections the integral yield data as a function of incident energy, and compare with experimental thick target yields available in the literature.

All cases

- Carry out new measurements when required.
- Prepare missing entries of experimental data for inclusion in the EXFOR database.
- Assemble the new evaluated data library in ENDF-6 format.

Activity:

• Second Research Coordination Meeting was held at IAEA Vienna, Austria, 15-19 November 2004.

Reference:

 J.-Ch. Sublet and R. Capote Noy (Eds.), Summary Report of the Second RCM on Nuclear Data for the Production of Therapeutic Radionuclides, IAEA Vienna, Austria, 15-19 November 2004, INDC(NDS)-465, November 2004.

6.1.5. Development of a Reference Database for Ion Beam Analysis (on-going)

Objectives:

• Identify the most important nuclear reactions for Ion Beam Analysis (IBA).

- Compare data and perform measurements, apply model calculations, and incorporate all measured and evaluated data into a database.
- Create a nuclear cross-section database for IBA.

Activities:

- Project was approved on 7 December 2004, and initiated in 2005.
- First Research Coordination Meeting was held at IAEA Vienna, Austria, 21-23 November 2005.

Reference:

I. Vickridge and O. Schwerer (Eds.), Summary Report of the First RCM on Development of a Reference Database for Ion Beam Analysis, IAEA Vienna, Austria, 21-23 November 2005, INDC(NDS)-0481, December 2005.

6.1.6. Reference Database for Neutron Activation Analysis (on-going)

Objectives:

- Improve the database of integral nuclear constants for neutron activation analysis.
- Improve consistency between energy-dependent cross sections and integral constants.
- Contribute to the nuclear structure database.

Activities:

- Project was approved on 7 December 2004, and initiated in 2005.
- First Research Coordination Meeting was held at IAEA Vienna, Austria, 3-5 October 2005.
- Tasks were assigned to participants, and the work is progressing well.

Reference:

[1] R.B. Firestone and A. Trkov (Eds.), Summary Report of the First RCM on Reference Database for Neutron Activation Analysis, IAEA Vienna, Austria, 3-5 October 2005, INDC(NDS)-0477, October 2005.

6.1.7. Update of Decay Data Library for Actinides (on-going)

Objectives:

- Measure specific actinide decay data judged to be inadequate, assuming suitable sources are available.
- Evaluate half-lives, and α -particle and γ -ray emission probabilities.
- Assemble database that constitutes improved/recommended decay data files for actinides of direct application in nuclear facilities, and for waste management.

Activities:

- Project was approved on 7 December 2004, and initiated in 2005.
- First Research Coordination Meeting was held at IAEA Vienna, Austria, 17-19 October 2005.

Reference:

M.A. Kellett (Ed.), Summary Report of the First RCM on Update of Decay Data Library for Actinides, IAEA Vienna, Austria, 17-19 October 2005, INDC(NDS)-0479, January 2006.

6.2. Data Development Projects (DDP)

Several data development projects were completed through consultancy visits, service agreements, and work undertaken directly by NDS staff.

6.2.1. FENDL-2.1 library

The application library for fusion neutronics calculations was updated in line with the recommendations from the Consultants' Meeting reported in INDC(NDS)-0451. The data and the documentation are available on the Web at *http://www-nds.iaea.org/fendl21/.* These files include data in ACE format for Monte-Carlo particle transport calculations, and MATXS format for deterministic transport calculations.

6.2.2. IRDF-2002 dosimetry library

Evaluated data files have been assembled, checked and uploaded onto the NDS Web server *http://www-nds.iaea.org/irdf2002/*, complete with draft documentation. The issue of the document is delayed due to problems concerning the Agency publications policy.

6.2.3. Application library for accelerator driven systems

Following the recommendations from a consultancy visit summarised in INDC(NDS)-0469, the JEFF-3.1 evaluated data library was selected as the source for a pilot library for accelerator driven systems (ADS). The data were concerted into a library in ACE format for Monte-Carlo particle transport calculations, and MATXS format for deterministic transport calculations. All the data are available from the Web server *http://www-nds.iaea.org/ads/*. Verification and limited validation of the library has been performed. This project is closely related to a CRP organised by the IAEA Department of Nuclear Energy on "Analytical and experimental benchmark analyses of accelerator driven systems (ADS)".

6.2.4. Updates to the WIMS-D library package

Following the release of the JEFF-3.1 library, the collection of available libraries was extended to include the new data. This work was judged to be important because the JEFF-3.1 library includes new decay and fission product yield data, in addition to the significantly improved neutron cross-section data. An updated version of the XnWlup package for display and intercomparison of the library data has been provided by Indian researchers. The new WIMS-D library package is available on Web site *http://www-nds.iaea.org/wimsd/*, and on CD-ROM.

6.2.5. Thermal scattering law library

Except for some minor cosmetic changes, the available scattering law libraries have not been seriously reviewed for many years. Although new experimental measurements are scarce, the decision was taken to instigate various improvements. New data were generated for hydrogen bound in water, deuterium bound in heavy water, and hydrogen bound in zirconium hydride and graphite. The data are available on Web site *http://www-nds.iaea.org/indltsl/*, and were adopted for the JEFF-3.1 evaluated nuclear data library. The methods described in the documentation were used for the preparation of the ENDF/B-VII library in the USA.

6.2.6. Resonance parameters for ⁵⁸Fe

Partial validation of the new dosimetry library revealed deficiencies in the resonance parameters of ⁵⁸Fe. Re-analysis of available experimental data was performed, and is reported in INDC(UK)-0089. The file was adopted for the JEFF-3.1 library.

6.2.7. Nuclear model parameter sets for the RIPL-2 database

Database maintenance tools and several new nuclear model parameter sets were included in the RIPL-II database through consultancy visits and service agreements. The extended database is available on Web site *http://www-nds.iaea.org/RIPL-2/*.

6.2.8. Ion Beam Analysis Nuclear Data Library (IBANDL)

Following the recommendations of an IAEA Technical Meeting in October 2003 (INDC(NDS)-449), a contract was awarded to A. Gurbich (FEI, Obninsk) in 2004 to assemble an Ion Beam Analysis Nuclear Data Library (IBANDL) of cross-section data for ion beam analysis applications. The starting point was the Sigmabase and NRABase data collections that were combined, checked, placed in a common format, and made available on the NDS Web page and on CD-ROM in spring 2004. Since that time, the database has been extended on a continuous basis, and will serve as the starting point for a reference database for ion beam analysis (see Section 6.1.5).

6.2.9. Nuclear data for the International Fusion Material Irradiation Facility (IFMIF)

A TM on "Nuclear data for the International Fusion Materials Irradiation Facility (IFMIF)" was jointly organized by the NDS and Forschungszentrum Karlsruhe/Institut für Reaktorsicherheit, and held on 4-6 October 2005. The overall objective of the meeting was to review the status of the nuclear databases used to assess radiation damage to the structural components of the IFMIF test facility. Evaluators and experimentalists were able to focus on those nuclear data of primary importance that are of poor quality. While deuteron-induced activation data libraries are crucial for the determination of the activity generated by the IFMIF high-intensity deuteron beam, the quality of the available data files is not sufficient to meet the required accuracy. The level of activation of the final stage of the accelerator will influence the final decision concerning the accessibility of the accelerator areas (direct or remote-handling), and therefore the detailed design of the facility. Participants have identified and agreed on a proposal to be submitted to the Agency for the creation of a CRP on "Deuteron-induced activation cross sections library for IFMIF".

6.2.10. Phase-space database for external beam radiotherapy

A Consultants' Meeting was held to discuss and define which formats and procedures are most appropriate in order to generate a database of radiation sources (phase-space data of the accelerator) with respect to detailed descriptions of the energy, direction, position and type of all primary and secondary particles emerging from either clinical accelerators or ⁶⁰Co irradiation units. Such databases are needed to assist greatly in the planning of medical treatment by means of Monte-Carlo computational techniques, and to circumvent the need for proprietary information concerning the detailed target and collimator design of commercial devices. The agreed work plan for the delivery of the database is described in INDC(NDS)-0484, January 2006.

6.2.11. Beta decay and decay heat

A Consultants' Meeting was held at IAEA Headquarters on 12-14 December 2005 to consider specific decay data and the impact of Total Absorption Gamma-ray Spectroscopy (TAGS) measurements on decay heat calculations when using national/international libraries assembled and released in the 21st century (e.g., JENDL-FPDD-2000 and JEFF-3.1 decay data libraries). Agreement was reached on the calculations and assessments to be undertaken to identify those nuclides that contribute the greatest uncertainties to the decay heat as a function of cooling time. A preliminary list of radionuclides was also formulated for TAGS measurements. The primary aim of this meeting was to provide the technical impetus to initiate a suitable programme of work to address the emerging worries associated with decay heat calculations, and to explore the possibility of undertaking a series of well-defined TAGS measurements to assist in these efforts. The assessments by and agreed actions of the CM participants were also designed to provide the most appropriate route forward for the deliberations of Sub-Group 25 of the OECD/NEA Working Party on Evaluation Cooperation (Validation of Fission Product Decay Data for Decay Heat Calculations).

A.L. Nichols (Ed.), Summary Report of Consultants' Meeting on Beta Decay and Decay Heat, 12-14 December 2005, IAEA Vienna, INDC(NDS)-0483, January 2006.

6.2.12. Input to JEFF project

Original NDS staff interest and technical expertise in the formulation of JEFF-3.1 has resulted in some limited studies for the JEFF project. Well-defined decay scheme evaluations were undertaken in preparation for the release of the JEFF-3.1 decay data library in 2005, and continue as support to the European Fusion programme (approximately 18 radionuclides per year). NDS staff have also actively participated at the JEFF Sub-Group on Decay Data and Fission Yields to maintain some degree of desired continuity.

7. TECHNOLOGY TRANSFER

Technology transfer activities throughout 2004-05 have focused on the identification of suitable mirror sites in key locations at which distant access is problematic (i.e., Indian subcontinent, Peoples' Republic of China, and South America). Some considerable progress has been made in locating and installing facilities at BARC, Mumbai, India, and improving software access to mirror our databases at IPEN, São Paulo, Brazil.

Direct training of young nuclear physicists has also involved a step change in emphasis, particularly with respect to identifying and mentoring "new blood" for mass chain evaluations (nuclear structure and decay data). This work will continue in conjunction with the demands of the international network of Nuclear Structure and Decay Data Evaluators.

7.1. Technical cooperation: regional centre for nuclear data services

NDS staff commissioned a mirror server at the Bhabha Atomic Research Centre (BARC), Mumbai, India, in September 2004. This work was undertaken in conjunction with counterparts at the BARC IT department, who supplied the server and installed the necessary software; NDS built the data services and the mirroring procedure. The new service was officially launched during a visit of the Director General of the IAEA to BARC on 15 November 2004.

During the course of May 2005, the VMS Alpha AS800 mirror server at IPEN, Brazil, was replaced by a new Linux server. This new service was officially launched on 1 June 2005. As with the BARC mirror server, the local facility supplied the hardware, software and a counterpart to build the basic system; NDS supplied the data services and mirror procedures.

NDS has full administrator access to both mirror servers. Access logs are collected periodically and added to the NDS access statistics, and the mirror servers are updated automatically every 24 hours. Both mirror computers provide the same services as the NDS main server with the exception of ENSDF, NuDat and NSR. Since the relational versions of ENSDF, NSR and NuDat as provided by the US NNDC are written around SYBASE DBMS (proprietary product), NDS is unable to provide these databases to remote mirror servers; electronic requests for these databases are directed to the NDS server at IAEA Headquarters.

Contact has also been made with the China Nuclear Data Center to initiate the provision of a mirror server.

7.2. Workshops

IAEA-NDS sponsored and organised five workshops in 2004-05, of which one was related to atomic and molecular data. The workshops on nuclear reaction, and nuclear structure and decay data are described below:

7.2.1. Nuclear Reaction Data and Nuclear Reactors – Physics, Design and Safety, ICTP Trieste, Italy, 16 February-12 March 2004

IAEA Workshop Directors: A.L. Nichols, A. Trkov (IAEA-NDS, NAPC) and J. Kupitz (IAEA, NENP). Lecturers from IAEA: O. Schwerer, M. Verpelli and R. Capote Noy

The four-week workshop is a continuation of a regular series of nuclear data/nuclear physics courses that started in 1978 on a biennial basis, organized by the IAEA in collaboration with ICTP Trieste, Italy. Both the contents and structure of this workshop continue to cover nuclear reaction model codes, data evaluation, processing and reactor design, with emphasis on thermal power and research reactors.

Objectives:

- Train engineers and scientists in modern nuclear reaction theory, nuclear data production and data use, with particular emphasis on applications in nuclear reactor physics, design and safety.
- Familiarize participants with the practical use of modern computer codes relevant to the topic.
- Introduce participants to rapidly advancing information technology for the retrieval of nuclear data, as well as new trends in advanced nuclear systems for energy generation.

Actions:

- Workshop material was presented as lectures (mornings) and exercises (afternoons) on personal computers running LINUX and Windows operating systems.
- Workshop covered nuclear data (2 weeks), followed by operational aspects (1 week) and nuclear reactor calculations (1 week).
- Computer codes:
 - EMPIRE nuclear model calculations,

- SAMMY resonance analysis,
- RIPL database of input nuclear model parameters,
- NJOY nuclear data processing, and
- WIMS lattice code.
- Participants also shared their experiences by making 10-minute presentations on their own work.

Outcomes:

- 42 participants from 25 countries received training from 5 directors and 22 lecturers.
- Provision of nuclear data knowledge and training to a significant number of young nuclear physicists from a wide range of developing countries.

7.2.2. Nuclear Data for Activation Analysis, ICTP Trieste, Italy, 7-18 March 2005

IAEA Workshop Director: A. Trkov (IAEA-NDS, NAPC). Lecturers from IAEA: M. Verpelli and M. Rossbach.

Two-week workshop was organized by the IAEA in collaboration with ICTP, Trieste, Italy.

Objectives:

- Review variants of the Activation Analysis method with respect to the probing particles, incident particle energy, and the nature of emitted radiation.
- Provide an overview of the methods and software for absolute detector calibration.
- Familiarise participants with nuclear constants for activation analysis (PGAA, k₀ method) and their relationship to differential cross-section data (definitions and data consistency).

Actions:

- Each participant received a package containing the k₀-IAEA software and a set of monitor materials for neutron spectrum characterisation of their irradiation facility to ease implementation of the method within the laboratories of their home countries.
- Theoretical work was complemented by computer exercises involving software for the analysis of the evaluated gamma-ray spectra.
- Participants also shared experiences by presenting their own work.

Outcomes:

- 26 participants from 17 countries received training from 4 directors and 9 lecturers.
- Audience was genuinely interested, and actively participated in lectures and exercises. The k₀-IAEA software package and the monitor materials for neutron spectrum characterisation allow participants to start NAA upon return to their home countries.

7.2.3. Nuclear Structure and Decay Data: Theory and Evaluation, ICTP Trieste, Italy, 4-15 April 2005

IAEA Workshop Director: A.L. Nichols (IAEA-NDS, NAPC).

Second two-week workshop organized by IAEA in collaboration with NNDC, USA and ENEA, Italy - structure based on previous two successful workshops of November 2002 (1 week trial, IAEA Vienna) and November 2003 (2 weeks, ICTP, Trieste). Workshop Directors: A.L. Nichols (IAEA-NDS), J.G. Tuli (NNDC) and A. Ventura (ENEA).

Objectives:

- Familiarize students with new experimental data that characterize the nucleus, and with modern nuclear models.
- Train participants in methodology of NSDD evaluations and in production of evaluated nuclear structure and decay data (as ENSDF mass-chain evaluations).

Topics:

- ENSDF evaluation philosophy (J. Tuli),
- NSDD network, relevant IAEA activities, and access to appropriate Webpages (A.L. Nichols and T. Burrows),
- nuclear structure models IBM (P. Van Isacker and S. Brant),
- experimental measurements (P. von Brentano and F. Kondev),
- statistical analysis techniques (T.D. MacMahon),
- ENSDF evaluations and computer codes (C. Baglin, E. Browne, T. Burrows and J. Tuli),
- databases (C. Baglin, E. Browne, T. Burrows, K. McLaughlin and J. Tuli),
- presentations of participants' own work.

Actions:

- Workshop material was presented as lectures (mainly mornings) and exercises (afternoons), with hands-on introduction of participants to mass chain evaluations through group and individual PC/computing activities.
- Students were given the opportunity to review the workshop through a written questionnaire and direct discussions.

Outcomes:

- 27 participants from 18 countries received training from 10 lecturers and demonstrators,
- audience relatively young (compared with November 2003 workshop) participants were primarily nuclear physicists,
- 8 participants expressed strong interest in undertaking NSDD evaluation work (some are already working with evaluators from NSDD network),
- addendum training document prepared from lecturers' new material (also CD-ROM)
 INDC(NDS)-452, Workshop on Nuclear Structure and Decay Data: Theory and

Evaluation, Manual – Parts 1 and 2, November 2004;

– INDC(NDS)-0473, Workshop on Nuclear Structure and Decay Data: Theory and Evaluation, Manual – Addendum, July 2005.

These NSDD workshops have been particularly successful in achieving significant technology transfer and the identification of "new blood" for ENSDF mass chain evaluations (subsequently pursued through a mentoring process in association with the international network of Nuclear Structure and Decay Data Evaluators).

7.2.4. Processing of Applications Libraries for Monte-Carlo Transport Calculations, IAEA Vienna, Austria, 12-16 September 2005

IAEA Workshop Director: A. Trkov (IAEA-NDS, NAPC).

One-week workshop was organized by the IAEA.

Objectives:

• Train participants to use nuclear data processing codes (MCNP family) to generate applications libraries for Monte-Carlo transport calculations, and to study and discuss library verification and validation.

Actions:

- Computer exercises included preparation of photon and charged-particle libraries for MCNPX.
- Preparation of libraries for the TRIPOLI code was described.

Outcomes:

- 11 participants from 9 countries received PC-based training from 3 lecturers.
- Audience participated actively in the lectures and exercises they gained experience in library preparation, verification and validation.

8. COMPUTER SUPPORT

Major highlights in computer services during 2004-2005 are as follows:

- acquisition of a Compaq ML530 G2 backup and development server,
- release of a mirror server at BARC, India,
- conversion of VMS Alpha mirror server to Linux at IPEN, Brazil,
- progress made on the provision of platforms and technologies for new data services.

8.1. Computer networks

As required to conform with the Agency-wide computer network security policy, the NDS Ethernet sub-network with addresses in the range 161.5.7.0 to 161.5.7.254 remains inside the Agency Firewall within a special network zone known as the De-Militarized Zone (DMZ). This zone is designed for servers and other computers that are accessed from the internet, and is secured by a network firewall. The firewall filters all traffic into and out of the DMZ, and also between the DMZ and the Agency Intranet. NDS works closely with IT specialists to meet Agency security requirements, and to ensure the continued efficient provision of the data services.

All NDS Ethernet–based computers have been grouped into functional sets within the Agency's firewall management software. Network access rules through the firewall decide access from the world and to/from the Agency Intranet. These rules have been assigned on the basis of group properties for service classes such as data servers, development servers and workstations. Intercommunication between nodes on the NDS Ethernet is unrestricted. An overview of the Section's positioning within the Agency firewall is shown in Fig. 2.



Fig. 2. Overview of NDS Ethernet and Agency firewall.

The Agency as a whole replaced the Token-Ring computer network with fast-Ethernet in 2004. Since NDS was already using Ethernet, this change caused little or no interference and has resulted in a much simpler interface between the NDS network and the Agency Intranet. Agency IT security also continued to be tightened: classical services such as Telnet and ftp have been prohibited, and other services and internet protocols have been restricted.

Terminal access to production and development servers is carried out through Hummingbird Exceed X-emulation on Agency standard PCs. This works from node to node on the NDS Ethernet and from nodes on the Agency Intranet to the NDS network over secure firewall tunnels. SSH and Secure Copy are now used instead of Telnet and ftp, in compliance with Agency IT security.

8.2. Data servers

8.2.1. VMS systems

NDS continued to maintain three Compaq Alpha servers: an AS2100 and a DS20 at IAEA Headquarters, and an AS800 at IPEN, Brazil, through 2004 and into 2005. The VMS Alpha AS800 at IPEN, Brazil was decommissioned in May 2005 and replaced with a Linux server. Furthermore, the DS20 VMS Alpha server at IAEA Headquarters was decommissioned in November 2005 - this machine was replaced by a Linux server in June 2004. The VMS server was maintained in parallel to ensure recovery during the transition period, although at the end of 2005 NDS maintained only one VMS alpha server (AS2100) at IAEA Headquarters - this machine will remain in place for the short term.

8.2.2. Linux systems

On 22 June 2004, Nuclear Data Services were released on a Linux platform, using a Compaq ML530 2G that ran Red Hat Linux 9. A second Compaq ML530 was acquired towards the end of 2004 to act as a development server and as a back-up for the primary server. This machine runs Red Hat Linux Fedora Core 3. Both RAM and disk storage on these machines has been increased to better meet the needs of the relational data services.



Fig. 3. Principal components of NDS network.

Fig. 3 shows the principal components of the NDS network. The Web and development servers run Redhat Linux, while Apache, Jakarta Tomcat, Java, MySQL, Perl, SYBASE ASE and the other systems facilities are in place to serve the new relational databases. The development server also has FORTRAN compilers and other tools to allow users to run processing and pre-processing codes and other analysis programmes.

8.2.3. Microsoft systems

NDS acquired a Windows File server in 2004 that is located inside the Agency Intranet, and is therefore protected by the firewall and within the Agency internal disk back-up process. This server is equipped with CD and DVD writers, and is used to store master copies of all data libraries and services distributable on CD-ROM, diskette and other media.

8.3. Software and applications

The Address List Database (ADLIST) has been converted from VMS Codasyl format to a relational format. New maintenance and user interfaces have been written, and this project is passing through the final test phase. All primary Web pages were converted to the standard Agency template. Existing Web services were left in their existing format, while new Webs for on-going CRPs and other projects conform to the "look and feel" standard of the Agency.

Over the course of 2005, NDS collaborated with Agency IT specialists on the development of an Agency Nuclear Information and Knowledge Portal (NUCLEUS). There will be 3 portals (or gateways) to the information that the Agency holds in electronic format. OASIS will be the gateway for IAEA staff, and iaea.org will be adopted for the general public and media. NUCLEUS will allow Member State counterparts and members of the public access to more detailed scientific, technical and regulatory Agency information and knowledge (stored in documents, Websites and databases). The first version of NUCLEUS was launched at the end of November 2005, and can be seen at address:

http://nucleus.iaea.org/nucleus/nucleus/Content/index.jsp

NDS will continue to collaborate on the NUCLEUS project by providing links, indices and descriptions of data services to the NUCLEUS team to ensure that all nuclear data are up-to-date and accessible.

8.4. Equipment acquisition

Table 5 lists the main computer hardware acquisitions during the reporting period of 2004-2005.

Item	Quantity
Compaq Proliant ML530 G2 Server, 4GB RAM, 250GB RAID	1
Disk storage	
Agency standard XTRA PCs	12
Laptops	7
Large capacity Canon DR-6080 Sheetfed batch scanner	1
Toshiba TDP-P5 data projector	1
HP Laserjet 4100 MFP printer	1
HP Colour Laserjet 5500DN printer	1
Seiko Smart Label printer model 200	6
C-Pen 800C handheld scanner	1
Netgear 5 port fast Ethernet switch	4
Iomega 120 GB USB/Firewire external disk	4
Iomega 250 GB USB/Firewire external disk	1
21" monitor	2
HP 150GB Ultra SCSI hotswap hard disk (for ML530 servers)	12
HP Scanjet 7560 flatbed document scanner	1

Table 5. NDS computer hardware purchases for 2004 – 2005.

8.5. Software acquisition

NDS has continued to acquire PC and other software as deemed necessary to facilitate the continued provision and enhancement of NDS data services. Principal among the software acquired during 2004-2005 have been the following:

Item	Quantity
Red Hat Enterprise Linux AS v2.1	1
PC Tex Publisher v5 departmental license	1
Microsoft Visio Pro 2003	1
Origin Pro v7.5	1

9. CONCLUDING REMARKS

INDC members are encouraged to consider and generate well-defined recommendations for possible implementation by the IAEA Nuclear Data Section. Both the budget and expertise of the indigenous staff do create some restrictions in the ability of NDS to explore and undertake <u>all</u> advised activities. A significant number of nuclear data issues have been discussed at INDC meetings (for example, see INDC/P(02)-23, October 2002; INDC/P(04)-13, November 2004), and specific topics have been selected below to illustrate NDS staff endeavours to address these user demands. Points of note in no particular order of importance are as follows:

(a) A multi-platform nuclear reaction database system has been developed that includes EXFOR, ENDF and CINDA-relational databases. This system contains unified software for data maintenance and retrieval. All the related utilities have already been supplied to several nuclear data centres with different database software tools and operating systems. An on-line Web retrieval system has also been developed in-house, and is presently operating at NDS, NNDC, BARC and IPEN. A new type of CD-ROM "for applications" has been produced: contains a stand-alone database and software that can be called from any other package (including FORTRAN programs), and used to retrieve data from the database without programming skills or knowledge of the database structure (e.g., EXFOR-CD is used by the EMPIRE-II nuclear model code and ENDVER packages). The open structure of the databases and popular relational formats allow the user to write independent applications in various languages, allowing the development of common software projects shared between centres and encouraging software exchanges (e.g., EXFOR-CINDA database distributed on CD-ROM under MySQL is used in the Web retrieval systems of IPPE, Obninsk).

(b) Recent years have seen a significant expansion of nuclear data needs within the major populations of Latin America, India and the People's Republic of China. Concomitant with this growth has been an increasing awareness of some inadequacies associated with Internet communications in various geographical areas of the world, and also the effect that a regional mirror server can have on stimulating local interest in the use of up-to-date nuclear data. After some debate, the decision was taken to create a nuclear data mirror site at BARC, Mumbai, India, by September 2004. This achievement has been realised, and discussions are now underway to create a similar system during the course of 2006 in association with staff at the China Nuclear Data Centre.

(c) An IAEA Coordinated Research Project was launched in 2002 entitled "Improvement of the standard cross sections for light elements", that was designed to explore the significant uncertainty reduction observed in R-matrix model fits, improve the methodology for the determination of the covariance matrices of the uncertainties, and prepare new recommendations for the light-element cross sections. This programme was subsequently extended to the cross-sections standards for the heavy nuclides in 2003. The R-matrix model least-squares fit of the experimental data was used in the evaluation of the ⁶Li(n, t), ¹⁰B(n, α_0) and ¹⁰B(n, $\alpha_1\gamma$) standard cross sections, while the non-model least-squares fit was applied to the evaluation of the ¹⁹⁷Au(n, γ), ²³⁵U(n, f) and ²³⁸U(n, f) reactions. More than 400 experimental data sets were used in the combined fits of all of these standards, including absolute, relative and shape cross-section measurements. Cross sections for other reactions and the results of integral measurements were also taken into account for the combined fits. Great attention was paid to the problems that remained unsolved from the earlier evaluation exercise:

- ambiguities and reductions in the uncertainties of the R-matrix model fits;
- possible biases in the evaluated cross sections arising from Peelle's Pertinent Puzzle (PPP),
- analysis and treatment of discrepant experimental data.

The newly-recommended cross-section standards data exhibit general increases (particularly the fission cross sections for neutron energies above 14 MeV) that are supported by criticality benchmark experiments. Although this work is close to completion, any developments for future consideration continue to be monitored through a Service Agreement.

(d) There is a rising interest in innovative fuel cycle concepts based on thorium. Unfortunately, due to the previous lack of interest in the thorium fuel cycle, the quality of nuclear data for the relevant materials is significantly lower than for comparable materials in the uranium and mixed-oxide fuel cycles. Important experimental measurements of the cross sections of materials relevant to the Th-U fuel cycle have been reported recently – these data need to be evaluated, verified and validated on integral benchmarks to ensure valid design calculations. Thus, there has long been a need to improve nuclear data for the Th-U fuel cycle, and an IAEA Coordinated Research Project was initiated in 2002 to undertake the necessary work, as recommended by the INDC:

- neutron cross-section data for ²³²Th, ^{231, 233}Pa and ^{232, 233, 234, 236}U;
- critical assessment of available experimental information, and renormalization to standard cross sections, if necessary;
- evaluation of experimental data, derivation of resonance parameters (when relevant), and completion of data by means of nuclear model calculations to produce a suitably comprehensive database in ENDF-6 format;
- verification of the formatted data;
- processing of the data into application libraries for validation against benchmark test cases.

As noted elsewhere, this work is close to completion.

(e) The Fusion Evaluated Nuclear Data Library (FENDL) has been validated and extensively tested for thermonuclear fusion applications, and used in the design development of ITER. Nevertheless, significant effort was expended in 2004 to improve and up-date FENDL/E (converted to FENDL/E-2.1) and associated sub-libraries, based on the detailed recommendations of an IAEA Consultants' Meeting held in Vienna, 10-12 November 2003, INDC(NDS)-451. Basic nuclear data (neutron-nucleus interaction, including photon production and photon-atom interaction cross sections) were assembled for 71 materials (point-wise data), and processed sub-libraries were also prepared for use in discrete-ordinate and Monte-Carlo transport calculations (FENDL/MG-2.1 and FENDL/MC-2.1). All of the work carried out to produce FENDL-2.1 is described in INDC(NDS)-467, December 2004; further information and the databases can be downloaded from: <u>http://www-nds.iaea.org/fendl21/index.html</u>

(f) Workshops at the Abdus Salam International Centre of Theoretical Physics, Miramare, Trieste, Italy, continue to be a most attractive means of undertaking technical training by means of IAEA sponsorship. NDS has long been associated with this mode of technology transfer, and this involvement has and will continue throughout 2004-2007 (see also <u>http://www.ictp.it/pages/events/calendar.html</u>):

2004

Nuclear reaction data and nuclear reactors – physics, design and safety.

2005

Nuclear data for activation analysis, Nuclear structure and decay data: theory and evaluation.

Plans for 2006 have been approved, and include:

Nuclear structure and decay data: theory and evaluation, [Atomic and molecular data for fusion energy research (A+M Data Unit)].

and two proposals have already been submitted for consideration in 2007:

Nuclear data for advanced reactor technologies,

Nuclear data for science and technology: medical applications.

Competition for the funding of such courses within the IAEA has increased significantly over the previous 2 years, and their acceptance can no longer be guaranteed. Another problem has been associated with the long-standing IAEA-ICTP course on "Nuclear reaction data and nuclear reactors – physics, design and safety": serious discontinuities arose within this 4- or 5-week course when shared with the Department of Nuclear Energy (NE), and the decision was taken to set such training aside for one year. Our links with NE have been re-assessed, and a more focused 2-week starter course has been proposed for 2007, as noted above.

(g) An important issue that will arise in 2009 and beyond concerns NDS plans for new Coordinated Research Projects. Suggestions from the INDC and other users of nuclear data include:

uncertainties and covariances;

IFMIF materials database;

²³⁵U evaluated cross-section file (particularly capture-to-fission ratio in the epithermal region, double-differential inelastic cross section, prompt fission neutron spectrum and nu-bar (\overline{v})).

While every effort will be made to undertake such important work, competition between initiatives will be significant (e.g., medical and analytical needs). INDC advice and a clearly recommended set of priorities is always welcome.

MEETINGS AND SCIENTIFIC VISITS IN 2004

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
<u>March</u> 15.3 - 14.9	Pronyaev	SSA	M. Lammer: preparation of IAEA technical report Report for CRP on 'Fission Product Yield Data required for Transmutation of Minor Actinide Nuclear Waste'		Vienna
<u>April</u> 13-16	Costello	CV	A. Sonzogni: development of new relational version of NuDAT nuclear database	Brookhaven National Laboratory (BNL), USA	Vienna
<u>May</u> 4-7	Nichols	ТМ	25th International Nuclear Data Committee		Vienna
17-21	Clark	CV	A. Dubois: internet interface to computer codes for calculations of collision cross sections for collision of ions and atoms	Université Pierre and Marie Curie, France	Vienna
25-28	Trkov	CV	A. Ignatyuk, and) NEA Working Party .) on International Nuclear	Institute of Physics and Power Engineering (IPPE), Russia	Aix-en-Provence France
		CV	Yu Hongwei) Data Evaluation	China Institute of Atomic Energy	
<u>June</u> 1-4	Humbert	CV	Y. Ralchenko: development of new web search engine DANSE and definition of AMBAS database structure.	National Institute of Standards And Technology, Gaithersburg, USA	Vienna
21-25	Clark	CV	R.K. Janev: installation of data on collision processes in hydrocarbons	Macedonian Academy of Sciences and Arts	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Ty	ype of Visit	Home Institute	Location
<u>June (cont'd.)</u> 24-25	Clark	ТМ	14th Meeting of t on Atomic and M	the IFRC Subcommittee Iolecular Data for Fusion		Vienna
23-25	Capote Noy	RCM	Parameters for C Reactions of relev Nuclear Application	Calculation of Nuclear vance to non-energy ions		Vienna
<u>July</u> 5-9	Pronyaev	CV CV	G. Hale Zhenpeng Chen) light standard elements) evaluations EDA and RAC) R-matrix codes 	Los Alamos National Laboratory (LANL), USA Tsinghua University, China	Vienna
19-20	Clark	RCM	Final Research Co on Atomic and M Fusion Plasma Di	oordination Meeting Iolecular Data for iagnostics		Vienna
<u>August</u> 2-4	Trkov	CV	L. Leal: light stan	ndard elements evaluations	Oak Ridge National Laboratory (ORNL), USA	Vienna
2-13	Clark	CV	J. Abdullah: calcu electron and phot	ulational capabilities for on processes in atomic ions	Los Alamos National Laboratory (LANL), USA	Vienna
September 1-3	Clark	CV	P. Krstic: enhanci of molecular data	ing A&M databases in area	Oak Ridge National Laboratory (ORNL), USA	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
October 2-10	Capote Noy	CV	E. Soukhovitski: soft rotator optical model development	Joint Institute of Energy and Nuclear Research, Belarus	Vienna
4-7	Schwerer	ТМ	Coordination Meeting of the Network of Nuclear Reactions Data Centres		Brookhaven, USA
18-19	Clark	RCM	Second Research Coordination Meeting on Tritium Inventory in Fusion Reactors		Vienna
18-22	Pronyaev	RCM	Third Research Coordination Meeting on Improvement of the Standard Cross Sections for Light Elements		Vienna
18.10 – 17.12	Trkov	SSA	P.K. McLaughlin: assist in preparation of IRDF-2002 dosimetry file		Vienna
27.10 – 21. 12	Trkov	SSA	D. Lopez Aldama: implement outcome of CM 'Maintain FENDL library for fusion applications'	Centro de Tecnología Nuclear Cuba	Vienna
<u>November</u> 1-2	Clark	RCM	Final Research Coordination Meeting on Data for Molecular Processes in Edge Plasmas		Vienna
15-19	Capote Noy	RCM	Second Research Coordination Meeting on Nuclear Data for Production of Therapeutic Radionuclides		Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
15-17	Trkov/ Stanculescu (NE	TM 2)	Technical Meeting on Application Libraries for ADS and Transmutation		Vienna
December					
6-7	Schwerer	CV	A. Gurbich: assist with preparation of CD version of IBANDL database	Institute of Physics and Power Engineering (IPPE), Russia	Vienna
6-9	Trkov	RCM	Second Research Coordination Meeting on Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle		Vienna
10-17	Capote Noy	CV	M. Sin: validation of the fission level density and transitional states formulation in FORTRAN	Bucharest University, Rumania	Vienna
13-17	Humbert	CV	K. Olsen: establish and maintain authoritative databases in support of fusion energy research and other nuclear-related technologies	National Institute of Standards and Technology	Vienna

MEETINGS AND SCIENTIFIC VISITS IN 2005

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
<u>January</u> 17.1 - 16.3.	Nichols	SSA	P.K. McLaughlin: assemble and edit Manual of Workshop on Nuclear Structure and Decay Data: Theory and Evaluation, 17-28 November 2003 – also Web and CD-ROM functions		Vienna
31.1 - 4.2.	Capote Noy	CV	E. Soukhovitsi: implementation of the dispersive optical model within the OPTMAN code for actinides description	Joint Institute of Energy and Nuclear Research, Belarus	Vienna
<u>February</u> 2-4	Capote Noy	CV	J.M. Quesada: dispersive optical model parameters and their implementation into EMPIRE code thru RIPL library	Universidad de Sevilla, Spain	Vienna
<u>March</u> 16-17	Clark	ТМ	7th Meeting of Technical Steering Comittee for International Database on Irradiated Nuclear Graphite Properties		Vienna
<u>April</u> 4-15	Schwerer	CV	A. Gurbich: extending IBANDL database to include PIGE (protein-induced gamma emission) data	Institute of Physics and Power Engineering (IPPE), Russia	Vienna
11-13	Trkov	ТМ	Technical Meeting on Covariances of Nuclear Reaction Data		Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
11-15	Capote Noy	CV	M. Sin: validate nucleon induced fission cross- section calculations of newly released version of 2.19 EMPIRE system	Bucharest University, Rumania	Vienna
11-15	Capote Noy	CV	M. Herman: final release of EMPIRE-2.19 system and validation of optical model segment of new EMPIRE version	Brookhaven National Laboratory (BNL), USA	Vienna
19-20	Nichols	CV	P. Oblozinsky: discuss EXFOR, EMPIRE, NSR and future plans in other areas such as platform- independent systems and specialised databases	Brookhaven National Laboratory (BNL), USA	Vienna
25-28	Trkov	CV CV	 A. Ignatyuk, and) NEA Working Party on .) International Nuclear Data Yu Hongwei) Evaluation 	Institute of Physics and Power Engineering (IPPE), Russia China Institute of Atomic Energy	Antwerp, Belgium
25-28	Zerkin	СМ	Consultants' Meeting on CINDA-EXFOR: revision of contents, compilation and plans		Vienna
Mav					
23-24	Trkov	CV	M. Looman: MCNP simulation of the lead-slowing Down spectrometer		Vienna
23-25	Clark	ТМ	Technical Meeting on Establishment of A+M Computer Code Network		Vienna
23-27	Humbert	CV	Y. Ralchenko: develop extended markup language (XML) format for atomic and molecular data	National Institute of Standards and and Technology, Gaithersburg, USA	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
26-27	Humbert	CV	D.R. Schultz: (as above for Ralchenko)	Oak Ridge National Laboratory (ORNL), USA	Vienna
<u>June</u> 6-10	Nichols	TM	Technical Meeting on the Coordination of the International Network of Nuclear Structure and Decay Data (NSDD) Evaluators		McMaster University, Canada
6.6 - 26.8	Trkov	SSA	D. Lopez Aldama: application library for ADS, and nuclear data for safeguards	Centro de Tecnología Nuclear Cuba	Vienna
14-16	Clark	ТМ	Technical Meeting to Assess Data relevant to Spectral Analysis of Fusion Plasmas		Vienna
17.6 - 1.7.	Nichols	SSA	P.K. McLaughlin: assemble and edit Addendum to Manual of Workshop on Nuclear Structure and Decay Data: Theory and Evaluation, 4-15 April 2005 – also Web and CD-ROM functions		Vienna
<u>August</u> 8-12	Humbert	CV	Y. Ralchenko: establish and maintain authoritative database in support of fusion energy research and other nuclear related technologies	National Institute of Standards and and Technology, Gaithersburg, USA	Vienna
8-12	Humbert	CV	P. Krstic: (as above for Ralchenko)	Oak Ridge National Laboratory, USA	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
22-26	Humbert	CV	K. Olsen: (as above for Ralchenko)	National Institute of Standards and and Technology, Gaithersburg, USA	Vienna
27.8 - 5.9	Capote Noy	CV	M. Sin: validation of nucleon induced fission cross-section calculations of EMPIRE system	Bucharest University, Rumania	Vienna
<u>September</u>					
12-16	Trkov	WS	Workshop on Data Libraries for Monte Carlo Calculations (MCNPX)		Vienna
26-28	Humbert	RCM	First Research Coordination Meeting on Atomic and Molecular Data for Plasma Modelling		Vienna
26-28	Humbert	CV	Z. Herman) advise at 1RCM) as above	J. Heyrovsky Institute of Physical Chemistry, Czech Republic	Vienna
		CV	S. Matejcik)	Comenius University, Slovakia	
October					
3-5	Trkov	RCM	First Research Coordination Meeting on Reference Database for Neutron Activation Analysis		Vienna
3-5	Trkov	CV	M. Blaauw: advise on 1RCM as above	Interfaculty Reactor Institute, Delft, Netherlands	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
4-6	Mengoni	ТМ	Technical Meeting on International Fusion Materials Irradiation Facility (IFMIF)		Karlsruhe, Germany
10-11	Humbert	ТМ	18th Meeting of the Atomic and Molecular Data Centres and ALADDIN Network		Vienna
10-11	Humbert	CV	U. Fantz: advise at 18 th Meeting as above		
10-14	Humbert	CV	L.E. Machado: linking data files to A&M Unit web pages, and participate in 18th Meeting as above	Universidade Federal de Sao Carlos, Brazil	Vienna
10-11	Humbert	CV	D.R. Schultz: develop extended markup language (XML) format for atomic and molecular data	Oak Ridge National Laboratory (ORNL), USA	Vienna
10-12	Humbert	CV	Y. Ralchenko: as above Schultz	National Institute of Standards and and Technology, Gaithersburg, USA	Vienna
10-14	Dunaeva	CV	V.V. Varlamov: compilation of photo- nuclear reactions for EXFOR-CINDA	Lomonosov Moscow State University, Russia	Vienna
10-14	Dunaeva	CV	S. Taova: EXFOR-CINDA compilation of Russian journals	All-Russia Scientific Research Institute of Experimental Physics, Russia	Vienna
10-14	Dunaeva	CV	G. Pikulina: EXFOR-CINDA compilation of Russian journals	All-Russia Scientific Research Institute of Experimental Physics, Russia	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
12-14	Schwerer	ТМ	Coordination Meeting of the Network of Nuclear Reaction Data Centres		Vienna
17-19	Kellett	RCM	First Research Coordination Meeting on updated decay data library for actinides		Vienna
17-19	Kellett	CV	G. Mukherjee: advise at 1RCM as above	Grand Accelerateur National D'Ions Lourds, France	Vienna
November					
7-18	Capote Noy	CV	E. Soukhovitski: extend optical model in RIPL: RIPL-OPTMAN interface	Joint Institute of Energy and Nuclear Research, Belarus	Vienna
14-15	Clark	RCM	First Research Coordination Meeting on Atomic Data for Heavy Element Impurities in Fusion Reactors		Vienna
14-18	Clark	CV	Luo Zhengming: measurements of ionization cross sections for heavy elements	KeyLab for Radiation Physics and Technology of Education Ministry of China	Vienna
21-23	Schwerer	RCM	First Research Coordination Meeting on Development of a Reference Database for Ion Beam Analysis		Vienna
21-25	Capote Noy	CV	T. Belgya: update reference input library discrete level library	Institute of Isotope and Surface Chemistry, Hungary	Vienna

Month/ Duration	Responsible Officer	Туре	Meeting Title/Type of Visit	Home Institute	Location
28.11 - 2.12	Capote Noy	RCM	Second Research Coordination Meeting on Parameters for Calculation of Nuclear Reactions of Relevance to Non-energy Nuclear Applications		Vienna
28.11 - 2.12.	Capote Noy	CV	A. Ignatyuk: advise at 1RCM as above	Institute of Physics and Power Engineering (IPPE), Russia	Vienna
28.11 - 9.12	Schwerer	CV	V. McLane: finalise EXFOR manual, update EXFOR related software, advise on modified new CINDA system	Brookhaven National Laboratory (BNL), USA	Vienna
<u>December</u> 5-9	Capote Noy	CV	M. Sin: development of input parameters for calculations of neutron-induced reactions for Pa-231 and Pa-233	Bucharest University, Rumania	Vienna
5-9	Capote Noy	CV	M. Herman: develop and validate sensitivity matrix capabilities for cross section covariance calculation	Brookhaven National Laboratory (BNL), USA	Vienna
12-14	Nichols	СМ	Consultants' Meeting on Beta-decay and decay heat		Vienna
12-14	Capote Noy	СМ	Consultants' Meeting on Phase-space database for external beam radiotherapy		Vienna

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IAEA Co-ordinated Research Project: Update of X-ray and gamma-ray decay data standards for detector calibration and other applications

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by F. Sánchez-Doblado, R. Capote, A. Leal, J.V. Roselló, J.I. Lagares, R. Arráns and G.H. Hartmann, presented at Advanced Workshop on Current Topics in Monte Carlo Treatment Planning, 3-5 May 2004, McGill University, Medical Physics Unit, Montréal, Québec, Canada; published in *Phys. Med. Biol.* **50** (2005) pp. 959-970.

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Nuclear decay data: On-going studies to address and improve radionuclide decay characteristics

by A.L. Nichols (invited paper), presented at International Conference on Nuclear Data for Science and Technology, 27 September – 1 October 2004, Santa Fé, USA; also published in AIP Conf. Proc. - Int. Conf. on Nuclear Data for Science and Technology, Eds.: R.C. Haight, M.B. Chadwick, T. Kawano and P. Talou, Vol. 769, Part 1 (2005) pp. 242-251, AIP, Melville, New York, ISBN 0-7354-0254-X, ISSN 0094-243X.

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by R. Capote Noy, A.L. Nichols and V.G. Pronyaev presented at Enlargement Workshop on Neutron Measurements, Evaluations and Applications, NEMEA-2, Bucharest, Romania, 20-23 October 2004, EUR 22136 EN (2005), pp. 7-16, Ed.: A.J.M. Plompen, Luxembourg, ISBN 92-894-8618-X.

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Revisiting the ²³⁸U thermal capture cross section and gamma-ray emission probabilities from ²³⁹Np decay

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by R. Capote, M. Herman, M. Sin and A. Trkov, presented at National Conference on Physics, 13-17 September 2005, Bucharest-Magurele, Romania.

The future of n TOF: the physics case for experimental activities in 2006 and beyond

by A. Mengoni (the n_TOF Collaboration), invited presentation at the International Workshop Nuclear Physics and Astrophysics at CERN (NuPAC), 12 October 2005, CERN, Geneva, Switzerland.

NDS Publications in 2004 and 2005

(necessary change to 4-digit numbering system)

Series and No.	Titles
Periodicals	Bulletin on Atomic and Molecular Data for Fusion Nº 63.
Newsletter	Nuclear data newsletter N ^{os.} 37, 38, 39 and 40.
INDC(NDS)-452	Workshop on NSDD: Theory and Evaluation (Manual for ICTP Workshop – on Web only).
INDC(NDS)-453	Summary Report of the Second Research Co-ordination Meeting on Improvement of the Standard Cross Sections for Light Elements.
INDC(NDS)-454	IAEA International Database on Irradiated Nuclear Graphite Properties (A&M restricted).
INDC(NDS)-455	Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee for the Period January 2002 - December 2003.
INDC(NDS)-456	Co-ordination of the International Network of Nuclear Structure and Decay Data Evaluators, Summary Report of an IAEA Technical Meeting.
INDC(NDS)-457	Franck-Condon Factors, Transition Probabilities and Radiative Lifetimes for Hydrogen Molecules and their Isotopomeres.
INDC(NDS)-458	Second IAEA Research Co-ordination Meeting on Data for Molecular Processes in Edge Plasmas, Summary Report.
INDC(NDS)-459	Second IAEA Research Co-ordination Meeting on Atomic and Molecular Data for Fusion Plasma Diagnostics, Summary Report.
INDC(NDS)-460	IAEA Workshop on Atomic and Molecular Data for Fusion Energy Research, Summary Report.
INDC(NDS)-461	IAEA Technical Meeting: Assess and Co-ordinate Modelling Needs and Data Providers, Summary Report.
INDC(NDS)-462	Parameters for Calculation of Nuclear Reactions of Relevance to Non- Energy Nuclear Applications (Reference Input Parameter Library: Phase III), Summary Report of the First Research Coordination Meeting.
INDC(NDS)-463	Summary Report of the Third Research Co-ordination Meeting on Improvement of the Standard Cross Sections.
INDC(NDS)-464	Report on the IAEA Technical Meeting on Network of Nuclear Reaction Data Centres.
INDC(NDS)-465	Nuclear Data for Production of Therapeutic Radionuclides, Summary Report of Second Research Coordination Meeting.

- INDC(NDS)-466 Graphite Database, Report of Consultants' Meeting (on Web only).
- INDC(NDS)-467 FENDL-2.1, Update of an evaluated nuclear data library for fusion applications.
- INDC(NDS)-468 Evaluated Nuclear Data for Th-U Fuel Cycle, Summary Report of Second Research Coordination Meeting.
- INDC(NDS)-469 Report on the Technical Meeting on Application Libraries for ADS and Transmutation.
- INDC(NDS)-0471 Summary Report on a Technical Meeting on Covariances of Nuclear Reaction Data: GANDR Project.
- INDC(NDS)-0472 7th Committee Meeting, Graphite Database (on Web only).
- INDC(NDS)-0473 Addendum Workshop on NSDD: Theory and Evaluation (on Web only).
- INDC(NDS)-0474 ADS-Lib/VI.0, A test library for Accelerator Driven Systems.
- INDC(NDS)-0475 Status of Thermal Neutron Scattering Data for Graphite.
- INDC(NDS)-0476 Co-ordination of the International Network of Nuclear Structure and Decay Data Evaluators, Summary Report of an IAEA Technical Meeting.
- INDC(NDS)-0477 Summary Report of the First Research Coordination Meeting on Reference Database for Neutron Activation Analysis.
- INDC(NDS)-0479 Summary Report of the First Research Coordination Meeting on Updated Decay Data Library for Actinides.
- INDC(NDS)-0481Summary Report of the First Research Coordination Meeting on
Development of a Reference Database for Ion Beam Analysis.
- INDC(NDS)-0482 Summary Report of the First Research Coordination Meeting on Atomic and Molecular Data for Plasma Modelling.
- INDC(NDS)-0483 Summary Report of Consultants' Meeting on Beta-decay and Decay Heat.
- INDC(NDS)-0484 Summary Report of Consultants' Meeting on Phase-Space Database for External Beam Radiotherapy.
- INDC(NDS)-0485 Summary Report of Technical Meeting on Establishment of A+M Computer Code Network.

INDC(NDS)-0486	Summary Report of Technical Meeting to Assess Data Relevant to Spectral Analysis of Fusion Plasmas.
INDC(NDS)-0487	Summary Report of the First Research Coordination Meeting on Atomic Data for Heavy Element Impurities in Fusion Reactors.
INDC(NDS)-0488	Summary Report of Technical Meeting, 14 th Meeting of the IFRC Subcommittee on Atomic and Molecular Data for Fusion.
INDC(NDS)-0489	Summary Report of Technical Meeting, Technical Aspects of Atomic and Molecular Data Processing and Exchange – 18 th Meeting of the A+M Data Centres and ALADDIN Network.
INDC(NDS)-0490	Summary Report of Final Research Coordination Meeting on Atomic and Molecular Data for Plasma Diagnostics.
INDC(NDS)-0491	Summary Report of Final Research Coordination Meeting on Data for Molecular Processes in Edge Plasmas.

Other INDC Reports, 2004/2005 (as at 31 December 2005)

<u>Report</u>	Country of Origin	Numbers of Reports	<u>Total Reports</u>
INDC(BLR)	Belarus	0019, 0020	2
INDC(CCP)	Russia	0437, 0438, 0439, 0440,	,
		0441, 0442	6
INDC(CPR)	P. R. China	0060	1
INDC(GER)	Germany	0050, 0051	2
INDC(HUN)	Hungary	0036	1
INDC(IND)	India	0047	1
INDC(ITY)	Italy	0012	1
INDC(SEC)	Nuclear Data Section (Sec) 0106, 0107	2
INDC(UK)	United Kingdom	0058, 0089(*)	2
INDC(USA)	United States of America	0107	1
INDC(VN)	Vietnam	0011	1

* (0059 – 0088 not used)

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