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INTERNATIONAL ATOMIC ENERGY AGENCY

NUCLEAR DATA SERVICES

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

NDS EXFOR MANUAL

H.D. Lemmel, editor

Abstract: EXFOR is the agreed exchange format for the transmission of nuclear reaction data between national and international nuclear data centers for the benefit of nuclear data users in all countries.

The IAEA Nuclear Data Section uses the EXFOR system not only for the center-to-center data exchange but also as its data storage and retrieval system. This NDS EXFOR MANUAL therefore contains the agreed EXFOR coding rules and format, supplemented by NDS internal compilation rules.

The EXFOR system and the EXFOR nuclear data library with several million data records originate from the cooperation of an increasing number of data centers whose names and addresses can be found inside the Manual. Their contributions and cooperative efforts are gratefully acknowledged.

Other reports documenting the IAEA EXFOR system are:

IAEA-NDS-1	-	Short Guide to EXFOR
IAEA-NDS-2	-	EXFOR Dictionaries
IAEA-NDS-150	-	Online Nuclear Data Service
INDC(NDS)-359	-	The Nuclear Data Centres Network

August 1985

Updated November 1996

Citation guideline:

See pages 1.15 and 1.16.

NDS EXFOR MANUAL

Notes about the present update:

The NDS EXFOR Manual is based on, and largely reproduced from the "official" EXFOR Manual edited by V. McLane (see report IAEA-NDS-103) on behalf of the co-operating data centers. Whereas the "official" Manual is restricted to defining the EXFOR TRANS tapes for transmission of data among the centers, the NDS Manual includes some additional procedures for NDS internal operations and NDS services to customers.

This Manual describes the status of the EXFOR system as of 1985 with some updates until 1991. Further additions to the EXFOR rules can be found in the data centre network reports

Memo CP/D/190	(1988)
Memo CP-D/200	(1989)
Memo CP-D/210	(1990)
INDC(NDS)-262	(1991)
INDC(NDS)-279	(1992)
INDC(NDS)-308	(1994)
INDC(NDS)-343	(1995)
INDC(NDS)-360	(1996).

In the meantime the NDS EXFOR system was transferred from the IBM computer to a DEC computer under VMS operating system. Consequently, the following EXFOR reports are now superseded:

IAEA-NDS-4	System specifications for the NDS EXFOR System
IAEA-NDS-5	System specifications for the NDS EXFOR Dictionary Sub-system
IAEA-NDS-6	System specifications for the NDS Data Index System
IAEA-NDS-66	EXFOR Index.

The EXFOR database can now be accessed online. See the report

IAEA-NDS-150   C.L. Dunford, T.W. Burrows, "Online Nuclear Data Service".

Compared to the 1991 issue of this Manual, the front pages have been updated and an EXFOR bibliography has been added on pages 1.15 and 1.16.

Hans Lemmel
November 1996

N D S   E X F O R   M A N U A L

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PROTOCOL: Cooperation of Neutron Data Centers

Part One: EXFOR Systems Manual – For Programmers and Compilers

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PROTOCOL FOR COOPERATION BETWEEN

THE NUCLEAR REACTION DATA CENTERS

FOR THE SYSTEMATIC EXCHANGE OF NEUTRON DATA INFORMATION

Original Draft - April 1972

Revised - April 1977, June 1978, October 1979

A. DEFINITIONS

1. Neutron Data Information in the context of this protocol is defined to mean measured microscopic experimental data which have resulted from neutron physics experiments, and their associated bibliographic and physical descriptive information.

2. Charged Particle Data Information, in the context of this protocol, is defined to mean experimental or evaluated microscopic data which have resulted from nuclear physics experiments for incident charged particles with mass greater than or equal to one, and their associated bibliographic and physical descriptive information.

3. Photonuclear Data Information, in the context of this protocol, is defined to mean experimental or evaluated microscopic data which have resulted from nuclear physics experiments for incident gamma rays with all reaction products having a mass greater than or equal to one, except for outgoing gamma rays, and their associated bibliographic and physical descriptive information.

4. The Exchange Format, or EXFOR, is a computer-compatible set of agreed upon definitions and conventions, designed for the transmission of nuclear reaction data information between nuclear reaction data centers.

5. The EXFOR Manual, comprising the currently agreed set of EXFOR definitions, conventions, formats and codes, is designed to serve as the basis and guide for the description and coding of nuclear reaction data information in EXFOR and for data transmission between nuclear reaction data centers.

6. EXFOR data is defined as all nuclear reaction data information coded and exchanged in EXFOR.

B. THE FOUR NEUTRON DATA CENTERS

1. Service Areas

The responsibility for the collection, compilation and dissemination of neutron data information is shared among the four major neutron data compilation centers, each being responsible for a defined service area.

The four centers and their respective service areas are:

a)   The National Nuclear Data Center (NNDC), at the Brookhaven National Laboratory (USA), services the USA and Canada.

b)   NEA-Data Bank (NEA-DB), at Saclay (France), services the non-American member Countries of the OECD.

c)   The USSR Center po Jadernym Dannym (CJD) at Obninsk (USSR) services the USSR.

d)   The IAEA Nuclear Data Section (NDS) in Vienna (Austria) services IAEA Member States not included in the service areas of the above three centers, that is, countries in Eastern Europe, Asia, Africa, South and Central America, and Australia and New Zealand.

2. Four-Center Commitment

a)   Within the scope of this protocol each center is expected to compile the data measured in its service area as fast and as thoroughly as possible.

b)   The four centers agree that "new" data should be coded in EXFOR (where new is defined as data collected by the centers at the time of, or after, formal transmission of data was initiated). This does not preclude the transformation of "old" data into EXFOR.

c)   Each center may compile data measured outside its service area. Regular transmission of EXFOR data from any one center shall include data only from its own service area.

d)   Each center shall keep an archival copy of the latest version of each of the EXFOR entries which it originated and shall be ready to provide the data to any center should it be required.

C. NUCLEAR REACTION DATA CENTERS (NRDC)

1. ### Additional Centers

   For the purposes of exchanging nuclear reaction data, in addition to the four neutron data centers, additional centers or groups are included. The composite group of centers is named the Nuclear Reaction Data Centers (NRDC). Additional groups defined to date are:

   a) Charged Particle Nuclear Data Group (KACHAPAG) at Karlsuhe (Fed. Rep. of Germany)

   b) Centr po Dannyn o Stroenii Atomnogo Jadra i Jadernukh Reakcikh GKAE CCCP at the Kurchatov Inst., Moscow (USSR)

2. ### Nuclear Reaction Data Center Commitment

   a) All matters concerning the exchange of neutron data must be agreed to by the four centers.

   b) All matters that affect EXFOR in general must be agreed to by the Nuclear Reaction Data Centers.

   c) For non-neutron data there is no requirement for completeness.

D. IMPLEMENTATION OF EXFOR

1. Implementation schedule

   a) The date after which all "new" neutron data should be coded into EXFOR is 1 July 1970.

   b) Data tapes will be exchanged regularly between the four neutron data centers at a maximum interval of three months, with the possibility to transmit timely data at more frequent intervals. If deemed necessary, a stricter, or less rigid schedule could be agreed upon at any time in the future.

2. Method of data transmission

   a) EXFOR data will be transmitted in accordance with the conventions laid down in the EXFOR Manual.

   b) Only the character set specified in the EXFOR Manual is permitted.

   c) The working language of EXFOR shall be English, and all free text comments within all EXFOR entries shall be English.

3. Scope of transmitted data

   a) The general scope of EXFOR data will be all experimental microscopic nuclear reaction data.

   b) Modifications to the general scope of EXFOR data can be adopted only as a result of an agreement between the NRDC.

E. CORRECTIONS, REVISIONS AND DELETIONS OF TRANSMITTED EXFOR ENTRIES

1. Corrections or revisions

   In the event of partial corrections or revisions of an EXFOR entry, at least the subentry containing the correction shall be transmitted by the originating center to the other centers, in accordance with the conventions laid down in the EXFOR Manual.

2. Accession numbers used

   Once transmitted, no accession or subaccession number should be reused for another entry or subentry. The accession number of a deleted entry (subentry) should not be used for another entry (subentry).

F. EXFOR DICTIONARIES

1. **Updating of Dictionaries**

   a) To prevent duplications and conflicts, the NDS is responsible for the coordination and the updating. of the EXFOR dictionaries.

   b) Alterations (meaning additions, corrections or deletions) to EXFOR dictionaries can be termed consequential, which would entail changes in transmitted data, and thus required NRDC approval, or inconsequential, which would not entail changes in transmitted data or NRDC approval. Without exception, all changes to Dictionaries 1, 2, 4, 10, 11, 12, 16, 24, 28, 29, 30, 31, 32, 33, 34 and 35 are consequential and require NRDC approval.

   c) **Consequential Dictionary Alterations**

   Alterations of EXFOR dictionary entries which entail changes to data already transmitted cannot be implemented without specific NRDC approval.

   d) **Inconsequential Dictionary Alterations**

   Proposals for alterations of EXFOR dictionary entries which do not entail changes to data already transmitted, and which do not fall in the Dictionary list given in F.1.b., above, should be submitted by the centers to NDS, together with their mnemonic terms and definitions, via CP Memo. NDS shall transmit the approved dictionary entries to all centers simultaneously, in the form of photocopies of the input forms used for the NDS dictionary update program.

   e) In their function to update EXFOR dictionaries, the NDS is given some latitude in reformulating the definition, but must not change the meaning without the approval of the originating center. In questionable cases NDS shall consult with the other centers for their opinions. It is the responsibility of each Center to update its own sets of Dictionaries.

2. **Routine Transmission of Dictionaries**

   The NDS will transmit a complete set of dictionaries to the other centers every three months, as a separate EXFOR transmission.

G. COMPILERS' MANUAL

1. The EXFOR Compilers' Manual, LEXFOR, is designed as a companion to the EXFOR Manual giving more detailed guidelines for compilers on the specification and compilation of the data to be transmitted in EXFOR, as mutually agreed on by the data centers. Included are definitions of physics terms, their nomenclature and interrelations.

2. Changes and revisions to LEXFOR follow the same procedures as with the EXFOR Manual (see section I. below), in accordance with the conventions laid down in the EXFOR Manual.

3. The center responsible for the updating of LEXFOR is the NNDC.

H. EXFOR COMMUNICATIONS BETWEEN CENTERS

Three forms of documents are used for the proper distribution and referencing of all documentation on EXFOR.

1. CP Memos for the communication of proposals, programming details and other general considerations which touch upon the overall aspect of EXFOR. This series of memoranda are numbered as follows:

Memo-CP-n/m

(where n is the center identification number, and m the chronological memo number within the center).

2. Four-Center Memos for the communication of details dealing only with neutron data or other Four-Center (non-EXFOR) matters, e.g. WRENDA, CINDA.

3. Exchange Format Memos for the transmittal of updating EXFOR Manual pages. This series of memoranda is issued by the NNDC only, to each of the other three centers, and is numbered as follows:

Memo-X4-m

(where m is the chronological memo number).

I. CHANGES AND REVISIONS OF EXFOR

1. No changes in the structure of EXFOR will be allowed without NRDC agreement.

2. If any one of the NRD centers proposes an alteration which would result in changes of the EXFOR structure and content, it will be the responsibility of the center originating such proposal to obtain NRDC agreement, following the procedure outlined in Paragraph I.3, below.

3. The following procedure should be followed by each of the NRDC in obtaining the agreement to every one of its proposals to change or revise EXFOR within the context of Paragraph I.2, above; all communications with regard to such proposal shall be in the form of CP Memos.

   a) The initial proposal should be disseminated to all NRD centers.

   b) In the case where there is discussion on a proposal, the initiating center shall then collect and digest all comments, suggestions and counter proposals.

   c) In this review, the initiating center shall consider such facts which would affect the EXFOR data base and associated computer codes.

   d) The initiating center shall then distribute a technical evaluation of alternatives to the other centers.

   e) After receiving the response to this technical evaluation, the initiating center shall:

      (i) In the case of positive agreement of the six participating centers, submit the proposed alteration to the center responsible for the EXFOR Manual updating.

      (ii) Otherwise, submit it for inclusion in the agenda of the next NRDC meeting.

4. Proposals for changes to be considered at NRDC meetings should be sent out one month prior to the meeting date to allow center personnel time to review them.

5. Whenever decisions are made which require Manual changes, the new updates are to be prepared and sent out at most by one month after the draft minutes are received. The proposed changes should be written into the minutes in such a way that they can be inserted directly into the Manual if they are accepted.

6. The center responsible for the updating of the Manuals is the NNDC. Within one month after a decision has been made, this center shall be responsible for producing a sufficient number of copies of the updated pages and distributing them in accordance with an established EXFOR distribution list.

7. The center responsible for updating the Manual may introduce changes for the purpose of editing. However, proposed Manual wordings submitted in CP-Memos are entered in the Manual unchanged, unless an objection is expressed in due time. This center is also responsible for maintaining the internal consistency of the Manual; that means, e.g., to check whether an agreed proposal entails changes (cross-references, etc.) in other parts of the Manual.

8. A change on a Manual page, as compared to its previous version, is marked by a vertical line in the left-hand margin. The date of the latest revision to that page is given in the lower right-hand corner.

9. Further details on changes and revisions to EXFOR are laid down in the EXFOR Manual.

J. CHANGES AND REVISIONS OF THIS PROTOCOL

1. Any change to this Protocol which is deemed necessary shall come into effect only after submission of a proposal and approval at an NRDC meeting.

2. The center responsible for the updating of this Protocol is the NNDC.

Chapter 1

INTRODUCTION TO EXFOR

INTRODUCTION

This manual describes EXFOR, the exchange format designed to allow centre-to-centre transmission of nuclear reaction data between the cooperating data centres. It was originally conceived for the exchange of neutron data, through discussions held between programming personnel from a number of laboratories (i.e., Saclay, Vienna, Livermore and Brookhaven) and accepted in its initial form at an IAEA meeting held in Moscow in November 1969 with representatives of the neutron data centers of Brookhaven, Saclay, Vienna and Obninsk.

Subsequently, the format was further developed and finally adapted to cover all types of nuclear reaction data as a result of two IAEA meetings held in Vienna in 1975/1976 on Charged Particle Nuclear Data Compilation, attended by an increased number of data centres.

The format is designed to meet the diverse needs of the nuclear data compilation centres, and has been designed for flexibility rather than optimization of data processing. The centre-to-centre exchange format should not be confused with either a centre input-format or a centre-to-user format. The input-formats have evolved independently at each centre in order to allow the hardware at each centre to be used in an optimum manner (i.e., to minimize both input-format errors and the amount of work associated with input). Similarly, the centre-to-user format have been developed to meet the needs of the users within each centre's own sphere of responsibility.

The exchange format as outlined is designed to allow a large variety of numerical data tables with explanatory and bibliographic information to be transmitted in a format that can be read by personnel (for passing judgement on and for detecting mistakes) and can be read by machine (for applying computer codes for checking and file maintenance). In order to accomplish this end the exchange format has not been optimized for subsequent processing and retrieval. Converting the information from the exchange format to a format or formats that best meet the needs of their users is the responsibility of the individual centres.

General structure of the exchange format

1. Each EXFOR entry falls naturally into two parts - bibliographic or descriptive information (alphanumeric) and data (numeric). In addition, the data for each entry is divided into sub-entries. Bibliographic or descriptive information and common data may be associated with the whole entry and/or each subentry. A set of system-identifiers has been devised for separating these logical blocks of information within an entry.

2. Each item of bibliographic or descriptive information must be identified for retrieval purposes and a set of information-identifiers (keywords) has been devised for this purpose.

3. Each piece of information requiring coding (e.g., reference, laboratory, etc.) has these codes, enclosed in parentheses, following the identifier. A set of dictionaries is provided for these codes.

4. Unlimited free text is permitted with each information-identifier.

5. "Common" numerical data, meaning data values (constant parameters) which are common throughout the entry or subentry, may precede each data table.

6. The numerical data for a subentry is presented in the form of a table of fixed field width, but with no positional meaning. Each table is headed by its "column-headings" and "column-units", to identify the contents of the columns.

7. Part of each record is reserved for record identification. This includes accession-numbers for entries and subentries and record numbering within subentries. This will guarantee that each record may be uniquely referenced within the system (i.e., no two records will have the same identification).

8. Tags are used to indicate records altered since the previous transmission of a particular entry.

9. The record size is 80 characters to allow card input to be used.

Summary of exchange tape format
=====

The exchange tape will contain a number of works. Each work will be divided into a number of sub-works. The sub-works will be further subdivided into bibliographic or descriptive information (hereafter called BIB-information), common data that applies to all lines of a data table in a sub-work and finally a data table. The tape may therefore be considered to be of the following form;
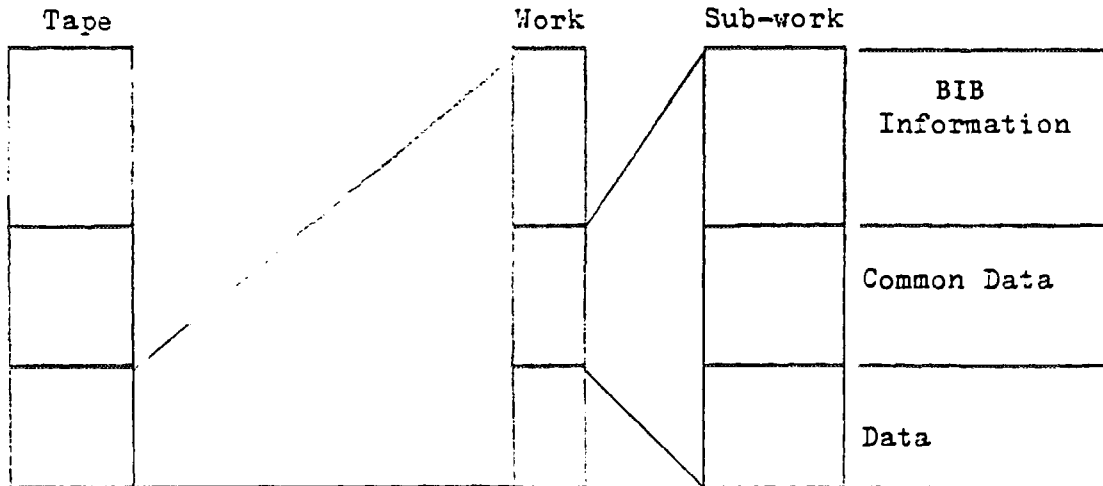
A number of system identifiers are used to define the beginning and end of each of the above units.

In order to avoid repetition of information that is common to all sub-sets within a set or to all lines within a sub-set, information may be associated with an entire set or with an entire sub-set. In order to accomplish this the first sub-set of each set which is given sub-accession number 1 must only contain information that applies to all other sub-sets, and within each sub-set the information common to all lines of the table simply precede the table. Two levels of hierarchy are thereby established to avoid repetition of information:
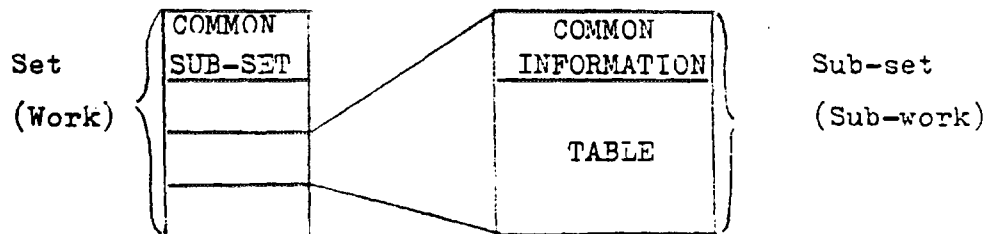
The common information (or common sub-set) is further subdivided into common BIB-information (alphanumeric) and common data (numeric) information.

DEFINITION OF A SUB-WORK

In order to avoid duplication of effort and to ensure that the identification scheme will be universally applicable, each centre will divide works into appropriate sub-works prior to transmission. This will ensure that a work has been divided into sub-works in a unique manner (by the originating centre) which may be referenced by all centers (i.e., avoids the possibility of two centers decomposing a work into different constituent sub-works, thus voiding the applicability of the universal identification scheme).

A sub-work will be defined as:

(1) A table of function of one or more independent variables: i.e., X, X' vs Y with associated errors for X, X' and Y (e.g., X = energy; = X' = angle; Y = differential cross section) and any associated variables (e.g., standard).

(2) Independent variables will precede dependent variables and will be monotonic in the left-most independent variable. Values in following independent-variable columns must be monotonic until the value in the preceding independent-variable column changes.

(3) When more than one representation of Y is present, the table may be X vs. Y and Y', with associated errors for X, Y and Y' and a possible flag (e.g., X = energy; Y = absolute cross section, Y' = relative cross section). The criteria for grouping a Y with a Y' is that they both be derived from the same experimental information by the author of the data.

(4) Variables may appear either in the COMMON portion of a sub-work (when uniformly applied to all points) or as an additional column of the data table (when applied pointwise).

(5) For some data the data-table does not have an independent variable X but only the function Y. (Examples: spontaneous nu-bar; resonance-energies without resonance-parameters; etc.)

(6) If the function Y is given for a single value of the variable X, and if this value of X is common for all sub-works in a given work, then X may be entered in the COMMON portion of the first sub-work. The following sub-works may then contain under DATA the value of Y only.

Permitted character set

The following characters are permitted for use in EXFOR:

All Roman capitals, A to Z. No lower case characters.

All digits, 0 to 9. No upper or lower case numbers.

The following 18 special characters

.	(decimal point and full stop)	:	(colon)
,	(comma)	;	(semicolon)
!	(exclamation mark)	?	(question mark)
'	(apostrophe)	&	(and)
+	(plus)	*	(asterisk, multiplied with)
-	(minus, hyphen)	/	(slash, divided by)
=	(equals)	%	(percent)
(	(left parenthesis)	)	(right parenthesis)
<	(smaller than)	>	(larger than)

Square brackets, Greek characters and others are forbidden (due to inconsistent bit configuration in different systems).

For transliteration of cyrillic characters (as for author names) see in LEXFOR under AUTHOR.

Short Guide to EXFOR

EXFOR - a computerized EXchange FORmat - presents in a convenient compact form experimental numerical data as well as physical information necessary to understand the experiment and interpret the data. Keywords and codes make the information computer intelligible. The structure of EXFOR is briefly described in the following.

An EXFOR "entry" usually contains the results of "one experiment" made at a given laboratory in a given time. As the results may consist of several data tables (e.g. cross-sections $\sigma(E)$ for several isotopes), an EXFOR "entry" consists of several "subentries". As a rule, the first "subentry" of an "entry" does not contain a data table but rather all that information, in particular bibliographic text information, which is common to all "subentries" of the given "entry".

As no numerical data table can be meaningful without a minimum of explanatory text, each EXFOR "entry" consists of

- text information, and

- numerical information.

The text part includes bibliographic information, bookkeeping information (e.g. origin of the data, date of compilation), definition of the data given in the numerical part, and related physics information such as error-analysis, standard reference data used, etc.

Each item of text information is identified by keywords such as

    TITLE
    AUTHOR
    INSTITUTE
    REFERENCE

    REACTION
    METHOD
    STANDARD
    DECAY-DATA
    ERR-ANALYS
    and others

The information given under these keywords may be unstructured free text, or structured information enclosed in parentheses using agreed codes and coding rules to be accessible by computer programs. Of particular importance is the keyword "REACTION". Under this keyword the DATA given in the data table are defined, as for example

REACTION   (92-U-235(N,F),,SIG) = $\sigma_{n,f}$ for ^{235}U

REACTION   (28-NI-60(P,N)29-CU-60,,DA = $\frac{d\sigma}{d\Omega}$ (ϑ) for
the reaction $^{60}Ni(p,n)^{60}Cu$

(In old EXFOR entries the keyword "ISO-QUANT" was used instead of "REACTION" with somewhat different coding rules. Similarly, the keywords "STANDARD" and "MONITOR" are equivalent.)

The numerical part of a subentry consists of the data table itself (also referred to as "DATA section" and, most often, of one or more constant parameters (also referred to as "COMMON section"). The numerical part is structured in six columns with a constant field length of 11 characters. All numerical columns are headed and defined by

- column heading keywords, for example

EN   for incident particle energy
DATA   for the actual data defined above under the keyword
            REACTION
DATA-ERR   for the uncertainty of the data etc.

- data-units, such as

EV   for electron-volts
MB   for milli-barns, etc.

EXFOR examples

The following pages show examples of EXFOR entries. The examples are given in two formats:

- the "standard format" primarily designed for the international exchange of data in computer processable form, and

- the "edited format" in which coded information and data tables are edited in an easily legible form.

The EXFOR structure, the standard and edited formats are illustrated in example 1. For simplicity, the actual data tables given in the second and third subentry consist here of only one line (they may consist of 100 or 1000 lines!). The "constant parameters" (resp. COMMON values) given in subentry 002 refere to this subentry only; whereas the "constant parameters" given in subentry 001 refer to all of the following subentries.

Some data tables may have a more complex structure, for example there may be several REACTION (resp. ISO-QUANT) codes per subentry; in this case each of them is connected to its pertinent column in the DATA TABLE by means of a "pointer", as illustrated in example 2. More generally a pointer can be used to connect related pieces of information (see example 3).

Note that in the examples given the data are defined under the keyword ISO-QUANT which was meanwhile replaced by the keyword REACTION with improved coding rules.

EXFOR ENTRY 30282.

"EDITED" LISTING

"STANDARD" LISTING

NUCLEAR DATA SECTION, INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA.   ACCESSION NUMBER EXFOR 35282.

BIBLIOGRAPHY, EXPERIMENTAL DESCRIPTION, EXPLANATIONS
TITLE   ACTIVATION CROSS-SECTIONS OF PT-198 WITH FAST NEUTRONS
AUTHOR   (I.URAY,A.SZALAY)
INSTITUTE ATOMKI, DEBRECEN, HUNGARY
         (3HUNDER)
EXP-YEAR (73)
REFERENCE ATOMKI(ATOMKG KUT.INTEZ.)KOZLEM., 15, (3), 161 (MAR.1973) : FULL INFORMATION.
          PROG.REPT. JNOC(MUR)-11, 14 (SEP.1973) : ABSTRACT ONLY
SAMPLE   MEASUREMENTS WERE MADE SIMULTANEOUSLY WITH NATURAL AND
          ENRICHED PT SAMPLES (87.00 PERCENT PT-198).
STANDARD

FIRST SUBENTRY 30282.001

INFORMATION COMMON
TO THE ENTIRE ENTRY

KEYWORDS

CODES

CONSTANT PARAMETERS
TO ALL SUBENTRIES
IN ENTRY 30282

STAND DEFINED ABOVE UNDER STANDARD.

THE ABOVE INFORMATION APPLIES TO ALL SUB-ACCESSION NUMBERS STARTING WITH 30282.

SECOND SUBENTRY 30282.002

CONSTANT PARAMETERS
VALID FOR SUBENTRY
30282 002 ONLY

"DATA" DEFINED UNDER
ISO-QUANT OF
SUBENTRY 30282 002

THIRD SUBENTRY 30282.003

CONSTANT PARAMETERS
VALID FOR SUBENTRY
30282 003 ONLY

"DATA" DEFINED UNDER
ISO-QUANT OF
SUBENTRY 30282 003.

Example 1

"EDITED" LISTING

SUB-ACCESSION NUMBER EXFOR 10499.002

BIBLIOGRAPHY, EXPERIMENTAL DESCRIPTION, EXPLANATIONS
●●

```
ISO-QUANT
    *10 |  9-F-19        RESONANCE ENERGY
    *20 |  9-F-19        NEUTRON-WIDTH
   (*30)  9-F-19         SPIN J
         1(9-F-19,EN,RES)
        ·2(9-F-19,EL/WID)
         3(9-F-19,J,RES)
ANALYSIS   (MLA) R-MATRIX MULTI-LEVEL ANALYSIS
```
●●

```
CONSTANT PARAMETERS
      MOMENTUM L = 1.           NO-DIM
```
●●

```
DATA TABLE
   DATA DEFINED ABOVE UNDER ISO-QUANT
   DATA      DATA      DATA-ERR     DATA
   *10       *20        *20        (*30)
   KEV       KEV        KEV        NO-DIM
1  26.99     0.325      0.020       2.
2  48.78     1.67       0.10        1.
3  97.50     14.5       0.6         1.
```
●●

3

*10 = "POINTER", WHICH LINKS RELATED PIECES OF NUMERICAL AND/OR TEXT INFORMATION

"STANDARD" LISTING

```
SUBENT      1C499002      750814              1049900200001
BIB              2              4              1049900200002
ISO-QUANT  1(9-F-19,EN,RES)                   1049900200003
           2(9-F-19,EL/WID)                   1049900200004
          (3)9-F-19,J,RES)                    1049900200005
ANALYSIS   (MLA) R-MATRIX MULTI-LEVEL ANALYSIS 1049900200006
ENDBIB           4                            1049900200007
COMMON           1              3             1049900200008
MOMENTUM L                                    1049900200009
NO-DIM                                        1049900200010
1.                                            1049900200011
ENDCOMMON        3                            1049900200012
DATA             4              3             1049900200013
DATA       1DATA          2DATA-ERR   2DATA   1049900200014
KEV        KEV            KEV         NO-DIM  1049900200015
26.99      0.325          0.029      2.       1049900200016
48.78      1.67           0.10       1.       1049900200017
97.50      14.5           0.6        1.       1049900200018
ENDDATA          5                            1049900200019
ENDSUBENT        18                           1049900299999
```

3

POINTERS LINK RELATED PIECES OF NUMERICAL AND/OR TEXT INFORMATION. IN THIS EXAMPLE, A POINTER (E.G. 3) LINKS AN
ISO-QUANT WITH ITS CORRESPONDING DATA COLUMN.

Example 2

"EDITED" LISTING

"STANDARD" LISTING

SUB-ACCESSION NUMBER EXFOR 30275.045

BIBLIOGRAPHY, EXPERIMENTAL DESCRIPTION, EXPLANATIONS

ISO-QUANT

| 22-TI-0 | DIFF,PARTL,NEUTRON-EMISSION CROSS-SECTION |

(22-TI-0,NEN,DA,PAR)
STATUS DATA WERE OBTAINED BY INTEGRATING OVER A 1 MEV INTERVAL
FROM 2 TO 11 MEV THE DOUBLE DIFFERENTIAL CROSS-SECTION
GIVEN IN SUBENTRY 11.

CONSTANT PARAMETERS

1 ANG	= 60.	ADEG
2 ANG	= 60.	ADEG
3 ANG	= 90.	ADEG
4 ANG	= 120.	ADEG
5 ANG	= 150.	ADEG
EN-APRX	= 14.6	MEV

2

DATA TABLE
DATA DEFINED ABOVE UNDER ISO-QUANT

	1 E-MIN MEV	2 E-MAX MEV	3 DATA-CM *1* MB/SR	4 DATA-ERR *1* MB/SR	5 DATA-CM *2* MB/SR	6 DATA-ERR *2* MB/SR	7 DATA-CM *3* MB/SR	8 DATA-ERR *3* MB/SR	9 DATA-CM *4* MB/SR	10 DATA-ERR *4* MB/SR
1	2.	3.	30.88	0.57	24.60	0.25	26.68	0.39	25.19	0.44
2	3.	4.	22.61	0.50	14.99	0.20	14.50	0.24	13.60	0.27
3	4.	5.	13.92	0.30	9.30	0.14	7.94	0.15	6.14	0.13
4	5.	6.	10.17	0.25	7.02	0.11	6.12	0.13	2.79	0.06
5	6.	7.	8.53	0.23	5.73	0.10	4.45	0.12	2.35	0.06
6	7.	8.	7.47	0.22	5.27	0.09	3.43	0.11	1.94	0.06
7	8.	9.	5.44	0.17	4.18	0.08	2.50	0.09	1.04	0.05
8	9.	10.	3.98	0.11	3.02	0.06	1.76	0.06	0.47	0.02
9	10.	11.	2.94	0.08	2.10	0.05	0.95	0.04	0.27	0.01

	11 DATA-CM *5* MB/SR	12 DATA-ERR *5* MB/SR
1	18.06	0.69
2	8.52	0.56
3	3.11	0.40
4	2.56	0.28
5	2.76	0.36
6	1.40	0.14
7	2.46	0.28
8	1.96	0.21
9	0.62	0.10

1 = 'POINTER', WHICH LINKS RELATED PIECES OF NUMERICAL AND/OR TEXT INFORMATION

SUBENT	30275045	750521				3027504500001
BIB	2	4				3027504500002
ISO-QUANT	(22-TI-0,NEN,DA,PAR)					3027504500003
STATUS	DATA WERE OBTAINED BY INTEGRATING OVER A 1 MEV INTERVAL					3027504500004
	FROM 2 TO 11 MEV THE DOUBLE DIFFERENTIAL CROSS-SECTION					3027504500005
	GIVEN IN SUBENTRY 11.					3027504500006
ENDBIB		4				3027504500007
COMMON		6	3			3027504500008
ANG	1ANG	2ANG	3ANG	4ANG	SEN-APRX	3027504500009
ADEG	ADEG	ADEG	ADEG	ADEG	MEV	3027504500010
40.	60.	90.	120.	150.	14.6	3027504500011
ENDCOMMON		3				3027504500012
DATA		12	9			3027504500013
E-MIN	E-MAX	DATA-CM	1DATA-ERR	2DATA-CM	2DATA-ERR	3027504500014
DATA-CM	3DATA-ERR	3DATA-CM	4DATA-ERR	4DATA-CM	5DATA-ERR	3027504500015
MEV	MEV	MB/SR	MB/SR	MB/SR	MB/SR	3027504500016
MB/SR	MB/SR	MB/SR	MB/SR	MB/SR	MB/SR	3027504500017
2.	3.	30.88	0.57	24.60	0.25	3027504500018
26.68	0.39	25.19	0.44	18.06	0.69	3027504500019
3.	4.	22.61	0.50	14.99	0.20	3027504500020
14.50	0.24	13.60	0.27	8.52	0.56	3027504500021
4.	5.	13.92	0.30	9.30	0.14	3027504500022
7.94	0.15	6.14	0.13	3.11	0.40	3027504500023
5.	6.	10.17	0.25	7.02	0.11	3027504500024
6.12	0.13	2.79	0.06	2.56	0.28	3027504500025
6.	7.	8.53	0.23	5.73	0.10	3027504500026
4.45	0.12	2.35	0.06	2.76	0.36	3027504500027
7.	8.	7.47	0.22	5.27	0.09	3027504500028
3.43	0.11	1.94	0.06	1.40	0.14	3027504500029
8.	9.	5.44	0.17	4.18	0.08	3027504500030
2.50	0.09	1.04	0.05	2.46	0.28	3027504500031
9.	10.	3.98	0.11	3.02	0.06	3027504500032
1.76	0.06	0.47	0.02	1.96	0.21	3027504500033
10.	11.	2.94	0.08	2.10	0.05	3027504500034
0.95	0.04	0.27	0.01	0.62	0.10	3027504500035
ENDDATA		22				3027504500036
ENDSUBENT		35				3027504599999
ENDENTRY		2				3027599999999

2

IN THIS EXAMPLE, A POINTER LINKS AN ANGLE AND THE CORRESPONDING DIFFERENTIAL CROSS - SECTION.
ALSO NOTE THAT TABLES WITH MORE THAN 6 COLUMNS WHICH ARE TEDIOUS TO DECIPHER IN "STANDARD" FORMAT, ARE CLEARLY
PRESENTED IN THE "EDITED" LISTING.

1.11

Example 3

Brief Guide for the Coding of EXFOR-Entries

1. Start with studying some EXFOR-Examples together with the "Short Guide to EXFOR" = IAEA-NDS-1.

2. The detailed coding rules are laid down in the "Dictionaries" = IAEA-NDS-2 and the "Manual" = IAEA-NDS-3.

    Note that for historic reasons much of the contents relates to neutron data and may be less relevant to charged-particle data. EXFOR is designed for nuclear reaction data and related parameters, not for nuclear structure data for which the ENSDF system exists.

3. The most important parts of the Manual are:

    a. how to code the data definition under the keyword "REACTION" - see Manual pages 8.REACTION and Dictionaries 28 to 36.

    b. the structure of the numerical tables under "DATA" and "COMMON" - see Manual chapter 5. (More details see chapter 6.)

    c. the column-headings defining contents and units of the data tables - see Dictionaries 24 and 25.

4. For the text section ("BIB"-Section) it is essential to decide what information to include. Although different opinions are recognized, all items concerning the quality or reliability of the data appear to us as the most important items. These are

    -   reference values used (keyword "MONITOR"),
    -   decay data used for the evaluation of the experiment (keyword "DECAY-DATA"),
    -   properties of the incident projectile beam (keyword "INC-SOURCE"),
    -   corrections and uncertainties (keywords "CORRECTION" and "ERR-ANALYS"),
    -   the origin of the data, e.g. from table x in reference y; or directly from the author; or read from a curve. - Such information is included under the keywords "HISTORY" and "STATUS".

5. The structuring of data tables into EXFOR entries and subentries is, to some extent, left to the discretion of the compiler. Different data tables obtained at one institute under similar experimental conditions may be included in one EXFOR entry. For practical reasons it is essential to observe strictly that all information in subentry 001 is valid for all following subentries of the same entry.

6. For each EXFOR-entry or subentry, all relevant bibliographic references should be quoted. (See Manual pages 8.REFERENCE and Dictionaries 4 to 7). Each reference should be followed by a mini-abstract indicating which of the references may be helpful to the EXFOR user. It is always essential to include also hints to published but superseded data. Examples:

(J,NP/A,25,37,7912) FULL INFORMATION
(C,78HARWELL,7809) METHOD, NO DATA
(R,JUEL-123,7701) PRELIMINARY DATA, SUPERSEDED

Note, that there is not a one-to-one correspondence between an
EXFOR-entry and a publication. Usually, there will be several
references for each EXFOR-entry, and occasionally the different data
from one reference may be coded in two or more EXFOR-entries.

7. Computer-codes: Our EXFOR-check-program is available, but it is quite
complex. For the beginning we would propose to code some trial'
entries, send them to us on magnetic tape, and we check them with our
EXFOR-check-program. We still work by filling in entry-forms, of
which some are attached. Only the record identification in cols.
67-80, and some control numbers in the ENTRY and ENDENTRY records are
created here by a computer program.

Later on, coding of EXFOR-entries will be possible directly on a
screen, but we do not yet have a supporting computer code. Our
EXFOR-check-program still works in batch-mode.

8. Accession-numbers: Assignment of accession-numbers is incidental.
Note that EXFOR accession-numbers (= entry numbers) once assigned
should never be changed. (The only exception are mistakes in the
compilation that cannot be corrected without a change of the
accession-number.)

9. If you need new codes to be included in the Dictionaries, you are
free to send us your proposals, e.g. by telex. We will inform you
immediately whether—the code proposed can be used (or whether there
is some conflict with other codes). However, new codes should be
introduced only if really necessary, often free text will be
preferable.

10. Note the limited set of special signs (see Manual p.1.5). This is
essential so that EXFOR tapes can be read also in countries or
institutes with small or unusual computers.

11. Finally, it is essential to realize that many features in EXFOR could
perhaps be solved in a more elegant and more modern way, but that the
EXFOR system as it is is successfully used for the international
exchange of data. Each cooperating data center is free to develop
an improved system, e.g. for more compact data storage, according to
its needs and optimized to its computer facilities, but it must be
fully compatible (machine convertible) to the EXFOR format used for
the exchange between the centers.

Reference Guidelines for EXFOR

When quoting EXFOR data in a publication this should be done in the following way:

"A.B. Author et al: Data file EXFOR-12345.002 dated 1980-04-05,
compare J. Nucl. Phys. 12, 345, (1979). EXFOR data received
from IAEA Nuclear Data Section, Vienna."

Explanations

1.   The **author(s)** of an EXFOR entry can always be found under the keyword 'AUTHOR'.

2.   EXFOR data are identified by the Data Library Name (i.e. EXFOR) plus the **accession-number** of the EXFOR entry (e.g. 12345. or 12345.002). It should be realized that authors receive proof-copies of the EXFOR data.

3.   Data in EXFOR are often more uptodate than published data. For unique identification of the data used it is therefore necessary to refer primarily to the **EXFOR data**. However, **a related publication** should also be quoted. Publications pertinent to an EXFOR entry are always given under the keyword REFERENCE. If more than one reference is given, only the first one needs to be quoted.

4.   **Many EXFOR entries are updated, sometimes even repeatedly,** when the author revises his data or when the EXFOR compiler receives additional information about the data. It is therefore essential to quote also the date which can always be found behind the accession-number of an EXFOR entry or subentry. This is the date of entry or the last revision of the EXFOR data.

Do not use old EXFOR retrievals. In case of doubt check back with the IAEA Nuclear Data Section whether your EXFOR data are still up-to-date and request a new retrieval.

References on the EXFOR System

1. EXFOR Summary descriptions:

   H.D. Lemmel, "Short guide to EXFOR", IAEA report IAEA-NDS-1 Rev. 7 (1996).
   V.McLane, "EXFOR Basics", U.S. report BNL-NCS-63380 (1996).

2. EXFOR online services

   C.L. Dunford, T.W. Burrows, "Online nuclear data service", report IAEA-NDS-150 Rev. 96/8 = U.S. report NNDC/ONL-96/8.

   NEA Data Bank, "User guide to numerical neutron data retrievals", and "Data Bank guides to on-line and neutron data services", unnumbered reports available from the NEA Data Bank, Paris, France.

3. Detailed EXFOR manuals on format and compilation rules:

   V. McLane (ed.), "EXFOR Manual" version 89-1, report IAEA-NDS-103 Rev. 89-1.

   H.D. Lemmel (ed.), "NDS EXFOR Manual", report IAEA-NDS-3 Rev. 96/11.

   O. Schwerer, H.D. Lemmel (eds.), "EXFOR/CINDA Dictionaries", report IAEA-NDS-2 Rev. 96/11.

4. The EXFOR data centers network

   H.D. Lemmel, V.N. Manokhin, V. McLane, S. Webster, "The network of the nuclear reaction data centres", Nuclear Data for Science and Technology, Proc. Conf. Jülich, Springer Verlag (1991), p. 811.

   H.D. Lemmel (ed.), "the nuclear data centers network", IAEA report INDC(NDS)-359.

   H.D. Lemmel, D.E. Cullen, J.J. Schmidt, "Nuclear data files for reactor calculations and other applications: experimental data - evaluated data". Computer Physics Communications 33 (1984) pp. 161-171.

   H.D. Lemmel, J.J. Schmidt, "Standardizing exchange formats", Proc. 11th Int. CODATA Conf., Karlsruhe, Germany, 26-29 Sept. 1988.

Chapter 2

RECORD IDENTIFICATION

RECORD IDENTIFICATION AND ALTER FLAGS

Columns 67-80 are used to identify uniquely each record and to flag altered records. These columns are divided into five fields as follows:

67	originating centre identification)	universal accession number
68-71	centre assigned accession number)	= entry number
72-74	centre assigned sub-accession number	= subentry number
75-79	sequential record numbering within a sub-accession number (subentry)	
80	alter flag	

Each of these fields is described in detail below.

ORIGINATING CENTRE IDENTIFICATION

Column 67 of every record, the first position of accession-numbers, and the first position of a transmission tape number contain a number or letter indicating the centre at which the information originated. The following identifications have been assigned:

    0   Preliminary: may be assigned by data producers when transmitting information to the centre in the exchange format, or by centres for their internal use.

---

experimental neutron reaction data:

1	NNDC (Brookhaven)	
2	NEA-DB (Saclay)	
3	NDS (Vienna)	
4	CJD (Obninsk)	
(5	data from area 1)	converted by NNDC from the SCISRS-1 NND
(6	data from area 2)	Library to Exfor format; not part of the
(7	data from area 3)	normal NND Exfor transmission; series 5, 6 and 7
8	data from area 4	were meanwhile deleted and converted into
		series 1, 2 and 3, series 8 still exists

---

    9   special use for transmission of Dictionaries, see page 7.1

---

charged-particle reaction data, experimental and evaluated:

A	CAJaD (Moscow)
B	KACHAPAG (Karlsruhe)
C	NNDC (Brookhaven)
D	NDS (Vienna)
E	"Study Group" (Sapporo)
(N)	NEA-DB (Saclay) (code N used for CP-Memos only, not for data)
P	McGowan CPX file converted by Kachapag and NDS
R	RIKEN (Wako-Shi, Saitama)
S	IAE-CP (Beijing)

---

photonuclear reaction data:

G	NDS (Vienna)
L	NNDC (Brookhaven), Berman photoneutron file (previously coded under accession-numbers starting with C7...
M	CDFE (Moscow)

    V   NDS (Vienna), for selected evaluated neutron data, "VIEN" - file, not part of the normal EXFOR transmission

For the abbreviations of the centres' names and their addresses see page 9.6

CENTER ASSIGNED ACCESSION NUMBER (COLUMNS 67-71)

Columns 67-71 contain a five digit accession number assigned by the originating center. Col. 67 is the centre identification (see preceding page); cols. 68-71 contain a number between 0001 and 9999, thus allowing 9999 entries for each center identification. The accession-numbers do not carry any information (except for the originating centre identification) and have the only purpose to identify a data set.

The same accession number must be associated with an entry throughout the life of the EXFOR system. If an entry is deleted from the system the accession number may not be assigned to a different entry. This is the only manner in which the accession number may be used universally to reference an entry over an extended period of time.

The methods of assigning accession numbers may be different at each center. That is to say, a center may wish to assign them manually, or automatically by computer. The accession numbers need not be assigned sequentially, however on the exchange tape the EXFOR entries must be sorted in ascending number order. A center may assign legal EXFOR accession numbers only to works within its agreed area of responsibility. In the case that the responsibility for compiling a given data set is not uniquely defined, the centres concerned should consult each other before compiling the data, in order to avoid duplicate entries for the same data. Compare also in Lexfor under Institute.

The terms "accession-number" and "entry-number" are equivalent.

Accession-numbers assigned by NDS:

30001-31999:	neutron data, normal
	Within this range 30800-30899 was reserved for data from the "Interregional Project", and some numbers starting with 31... were used for data converted from SCISRS-1 (previously 70001 and up).
32001-32999:	neutron data by external compilers
	320.. GDR
	321.. Cuba
	325.. China
D0001 and up:	CPND, normal
D2001 and up:	CPND coded by NEA-DB
D3001 and up:	CPND coded at Swierk
G0001 and up:	photonuclear data
H0001 and up:	half-lives, internal trial, not for transmission
P0001 and up:	McGowan's CPX file converted by Kachapag
Q0001 and up:	NSDD, internal trial, not for transmission
V0001 and up:	evaluated neutron data

EXFOR for "Atomic and Molecular Data" is a similar but not identical system which is not dealt with in this Manual.

CENTER ASSIGNED SUBACCESSION NUMBER (COLUMNS 72-74)

Columns 72-74 contain a three digit subaccesion number assigned by the originating center. The subaccession number is used to divide an entry into a number of subentries while maintaining an inter-relationship between the subentries of the same entry. Each subentry may be conceptually thought of as an individual table of data and its associated BIB-information.

Up to 998 subentries (tables) may be associated with each entry (universal accession number). The center assigned subaccession numbers should be sequentially assigned within each work starting at 001 and increasing toward 998.

The same subaccession number must be associated with a subentry throughout the life of the EXFOR system. If a subentry is deleted from the system, the subaccession number may not be re-assigned to another data table within the same entry.

The subentry numbers should have leading zeros; but computer codes should be designed such that blanks instead of leading zeros can be accepted. (See note next page)

The terms "subaccession number" and "subentry number" are equivalent.

SEQUENTIAL RECORD NUMBERING WITHIN A SUB-ENTRY (Cols. 75-79)

These columns will contain a five-digit sequential number. The sequential number will be used to divide a subentry (sub-accession number) into uniquely defined records associated with the subentry (all records within a subentry contain the same sub-accession number).

Up to 99,999 records may be associated with each subentry (sub-accession number). The sequential numbering within each sub-work MUST begin at 1 and sequentially increase toward 99,999.

The function of the sequential numbering within each subentry (sub-accession number) is to allow for reference at the record level during the ALTER procedure and to allow for personnel and machine checking the card sequence (e.g., check for cards out of order or for missing cards). Therefore, a given sequence number need not be associated with a given record over an extended period of time. As such, the records within a subentry should be re-numbered sequentially following an ALTER procedure. Alterations on a work may be transmitted only by the origination centre.
THE RECORDS WITHIN A SUBENTRY MUST ALWAYS BE MAINTAINED IN SEQUENTIAL ORDER.

The record numbers should have leading zeros; but computer codes should be designed such that blanks instead of leading zeros can be accepted. (Note: If NDS receives a TRANS tape which has blanks instead of zeros in the record identification field, blanks are replaced by zeros within the MERGE program when the TRANS tape is merged to the master file.)

ALTER FLAG (Col. 80)

In a new entry which is transmitted for the first time, column 80 is blank in all records. When an entry (or subentry) is revised and re-transmitted, "alter flags" in col. 80 are used to indicate what records have been altered since the previous transmission. The following alter flags are used:

C the record flagged has been Corrected or Changed.

D one or more records have been Deleted FOLLOWING the record flagged.

I the record flagged has been Inserted. In the case of the SUBENT record, the subentry has been inserted.

T Two alters have occurred as follows:
  (a) the record flagged has been inserted or corrected and
  (b) one or more records have been deleted following the record
    flagged.

R the record flagged is a Replacement (when, for example, a block of 10 old records was replaced by a block of 24 new records). This should be used when e.g., the complete BIB-Section or a part of the DATA-Section was revised. The flag R will appear on each replacement record.

* in ENTRY or SUBENT record means: this entry or sub-entry has been deleted. (See page 9.3 for details on deletion of entries or subentries.)

When one of these flags shows up within a subentry, the flag C must also show up in the corresponding SUBENT and ENTRY records where the date of alteration must be updated in field N2 (see pages 3.5 and 3.6). When receiving a TRANS tape, the receiving center will rely on the alter flag in the ENTRY record to distinguish new entries from re-transmitted entries.

The alter flag is used to inform other centers when an alter procedure has been performed on a work. Alter flags should not be accumulated over a number of transmissions (i.e., alter flags should be set only on those records that have been altered since the last time the work was transmitted). As such, all flags should, at least conceptually, be considered reset to blank after the work has been transmitted. The procedure that is actually carried out at each center will depend upon the use that the center intends to make of the information conveyed by the alter flags.

Each center must design its own scheme how to process alterations of EXFOR-entries. The alter flags as described above do nothing else than pointing to the differences between the re-transmitted EXFOR-entry and its previous transmission.

Insertions and deletions of records have the consequences

 — that the record numbering of the subsequent records will change (see records f and g in the example next page);

 — that the record counts which must be included in some of the System-Identifier records (see Chapter 3) must be updated so that these System-Identifier records must also obtain the alter flag 'C' (See example next page.)

For each alteration (resp. re-transmission) some text must be added under the BIB-Keyword HISTORY explaining what was changed and why; see page 8.HISTORY.

Example for Alter Flags

The following example shows first an original EXFOR entry with its record numbering. (See chapter 3 for explanation of 'ENTRY record' and the other System Identifier records). Then some records are changed, deleted or inserted, and the corresponding alter flags are shown below.

original entry

ENTRY record	00001
SUBENT record	00001
BIB record	00002
...	.....
record a	00085
record b	00086
record c	00087
record d	00088
record e	00089
record f	00090
record g	00091
...	.....
ENDBIB record	00122
...	.....
ENDSUBENT record	99999
...	.....
ENDENTRY record	99999

operations performed

records b and c revised
records d and e deleted
record x inserted after record f
two HISTORY records inserted for explanation

re-transmitted entry with alter flags

ENTRY record (new date)	00001C
SUBENT record (new date)	00001C
BIB record (record count changed)	00002C
...	.....
record a	00085
record b rev.	00086C
record c rev.	00087T
record f	00088
record x	00089I
record g	00090
...	.....
new HISTORY record	00121I
new HISTORY record	00122I
ENDBIB record (record count changed)	00123C
...	.....
ENDSUBENT record (record cound changed)	99999C
...	.....
ENDENTRY record	99999

RECORD IDENTIFICATION SUMMARY

Columns 76-79 of each record are used to uniquely identify each record in the
EXFOR system. This is accomplished by dividing the record identification into
four fields as shown below. Column 80 is used as an alter flag (see page 2.6).

```
                                    67|68     71|72  74|75        79|80
                                      |         |      |           |
                                    ↑       ↑        ↑           ↑         ↑
                                    |       |        |           |         |
           | Originating center  |  _____|        |           |         |
Universal  | identification      |                 |           |         |
accession  |                     |                 |           |         |
number     | Center-assigned     |                 |           |         |
(Entry number) | accession-number | ─────────────|           |         |
                                                               |         |
           Center-assigned          |                          |         |
           sub-accession number     | ──────────────────|      |         |
           (Subentry number)        |                          |         |

           Sequential numbering     | _____|     |
           within subentry          |

           Alter flag  |  ── ─────────────────────────────────────────────|
```
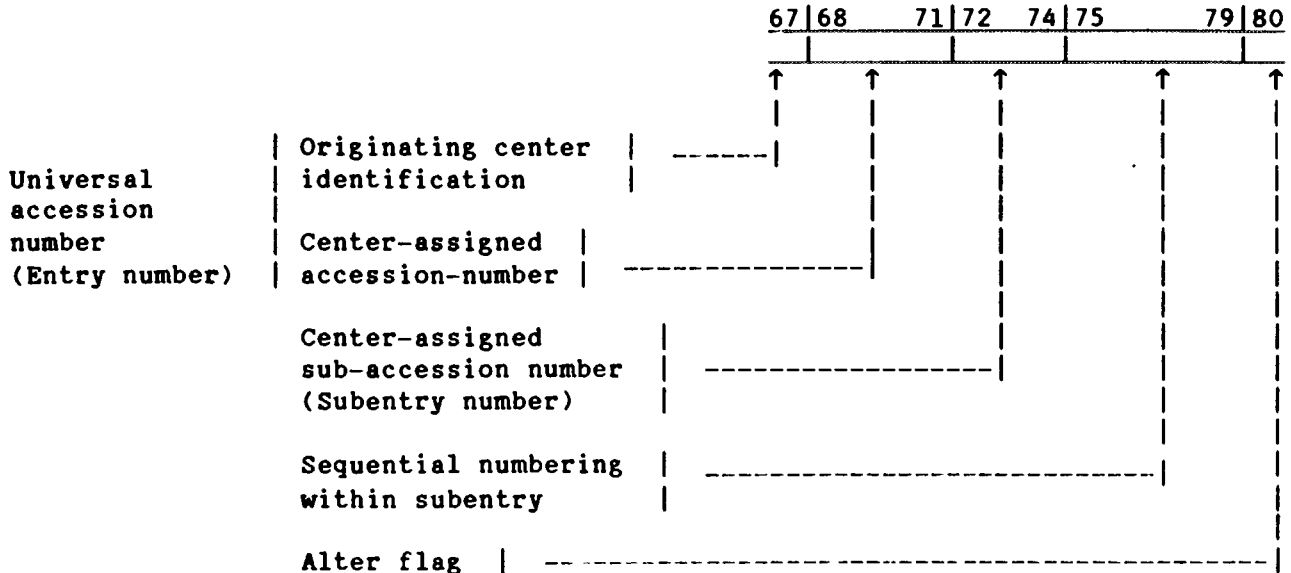
The first field (column 67) is alphanumeric, the next 3 fields (columns 68-79)
are strictly numeric and may vary over the following ranges:

(1) Originating center identification: see page 2.2
(2) Center-assigned accession number: 0001 to 9999
(3) Center-assigned sub-accession number: 001 to 999
(4) Sequential numbering in a subentry: 00001 to 99999

They may be used in combination to uniquely reference information within the
library at any of a number of levels as follows:

(1) Col. 67:   Uniquely identifies all information from a given center
(2) Cols. 67-71: Uniquely identifies an entry within the EXFOR system
(3) Cols. 67-74: Uniquely identifies a subentry within the EXFOR system
(4) Cols. 67-79: Uniquely identifies a record within the EXFOR system

The first three fields (columns 67-74) are associated with a subentry through-
out the life of the system. That is, accession numbers and sub-accession
numbers may not be changed, once they are assigned. If the subentry is
deleted from the system, the same identification should not be assigned to
another subentry. The fourth field (columns 75-79) is maintained in
sequential order, but the contents will change when one or more records are
inserted or deleted.

Columns 67-79 should be padded with zeros (0) rather than blanks. This will
allow the entire library to be handled by the standard sort/merge packages
available on a wide variety of computers. On a transmission tape the records
must be in ascending order of the record identification column 67 to 79.

Chapter 3

SYSTEM IDENTIFIERS

SYSTEM IDENTIFIERS

A set of basic system identifiers has been defined to identify different units of information contained on a transmission tape. These units and corresponding basic system identifiers are:

TRANS   — A transmission tape is the unit

ENTRY   — An entry (accession number) is the unit

SUBENT   — A subentry (sub-accession number) is the unit

BIB   — The BIB-section of a subentry is the unit.
(The BIB-section in subentry 001 refers to the entire entry)

COMMON   — The COMMON section of a subentry is the unit.
(The COMMON section in subentry 001 refers to the entire entry)

DATA   — The data table section of a subentry is the unit

The basic system identifiers may be combined with the prefixes

NO
END

to indicate three conditions:

(1) The beginning of a unit (basic system identifier only)
(2) The end of a unit (prefix END)
(3) A positive indication that a unit is intentionally omitted (prefix NO)

However, only those combinations of basic system identifiers and prefixes which are defined on the following pages, and are included in Dictionary 1, may be used.

The general format of a system identifier records is:

1	11	22	33	44	55	66
[System Identifier]		N_1	N_2	N_3	N_4	N_5

The fields N_3 to N_5 are assigned to a specific purpose in few cases only. Usually, these fields are blank but may contain any free text that the centre wishes to enter.

[System Identifier] may be any of the permitted system identifiers (the brackets should not be included) left adjusted to begin in col. 1; N_1 and N_2 are integers right adjusted into cols. 22 and 33, respectively. The significance of N_1 and N_2 will depend on the system identifier used.

The following pages describe all permitted system identifier records in detail. The detailed description is followed by a brief summary of the characteristics of the system-identifier records.

(1) TRANS
_____

This record __must__ be the __first__ one on the transmission tape. The following fields are defined:

N_1 –   The transmission tape number, consisting of

         Col. 19:   the originating centre identification ·
         Cols. 20-22: a three digit number, sequentially assigned to allow other centres a simple means of determining whether or not they have received all tapes transmitted

N_2 –   A six-digit number containing the data (year, month, and day) on which the transmission tape was generated. The format should be YYMMDD.

$N_4 - N_5$ Exfor tapes transmitted by NDS contain in this field the information 'EXFOR – IAEA NUCL.DATA'

The record identification (Cols. 67-79) should contain the originating centre identification code in Col. 67 and zeroes (not blanks) in Cols. 68-79.

(2) ENDTRANS
_____

This record __must__ be the __last__ one on the transmisstion tape.

N_1 is interpreted as:

N_1 –   The number of entries (accession numbers) on the tape.

The record identification field contains the centre identification code in Col. 67 and 9's in Cols. 68-79. If however the transmission tape contains data originating from different centres, then Col. 67 of the ENDTRANS record should be such that the record sorts at the end of the tape. For example, the centre identification of the last entry included on the tape may be used. (Tapes by NDS always have '9' in col. 67 although this is not quite legal.)

Trailing records to fill up the last block are repetitions of the ENDTRANS record.

(3) DICTION
_____

for EXFOR Dictionary Transmissions see page 7.1

<u>NDS internal page</u>:

In addition to the normal transmission of EXFOR tapes identified by the system-identifier TRANS, NDS transmits EXFOR tapes identified by the system identifier UPDAT. UPDAT tapes include a cumulation of several TRANS tapes received in a given period; in cases of <u>retransmitted</u> EXFOR <u>subentries</u>, UPDAT tapes include the entire revised <u>entry</u>.

The UPDAT system identifier records are defined as follows:

(4) UPDAT

This record replaces the TRANS record in the case of an UPDAT tape. The following fields are defined:

Cols. 1-11:   UPDAT-N   when the tape contains neutron data only
                            (accession-numbers starting with 1,2,3,4,V)

              UPDAT-CP+PH   when the tape contains charged-particle and
                            photonuclear data (accession-numbers starting
                            with a character except V)

N_1 — the UPDAT tape number, starting with 3001, then sequentially numbered right adjusted

N_2 — the date (yymmdd) the tape was retrieved, right adjusted

N_3 — the date (yymmdd) of the previous UPDAT tape. This means that the UPDAT tape contains all EXFOR entries that were added or changed between the dates N_3 and N_2.

Cols. 45-66:   'EXFOR-IAEA NUCL.DATA'
Col. 67:   '3'
Cols. 68-79:   zeroes

(5) ENDUPDAT

This is the last record of an UPDAT tape.

Cols. 1-11:   'ENDUPDAT'

N_1 — the number of EXFOR entries on the tape, right adjusted

Cols. 23-66:   blank
Col. 67:   'Z'
Cols. 68-79:   nines
Col. 80:   blank

Trailing records to fill up the last block are repetitions of the ENDUPDAT record.

(6) ENTRY N_1 N_2

This record __must__ be the __first__ one of each entry. N_1 and N_2 are interpreted as:

N_1 - a five-digit universal accession number (originating centre identification and centre assigned accession number).

N_2 - Date of __last__ alter (or date of entry if never altered) (year, month, day).

N_4 - At NDS this field, starting in col. 45, contains the initials of the physicist who compiled the entry or made the last revision.

The record identification (Cols. 67-79) should contain the universal accession number (Cols. 67-71), the sub-accession number zero (000) (Cols. 72-74), and the sequence number one (00001) (Cols. 75-79).

(7) ENDENTRY N_1 N_2

This record __must__ be the __last__ one of each entry. N_1 and N_2 are interpreted as:

N_1 - The number of subentries (sub-accession numbers) in the work

N_2 - Presently unused (may be blank or zero).

The record identification (cols. 67-79) should contain the universal accession number (Cols. 67-71), the sub-accession number 999 (Cols. 72-74), and the sequence number (99999) (Cols. 75-79).

NOTE: When NØSUBENT records are included in a work, then they should be counted as sub-works when computing N_1.

(8) (cancelled)
----

(9) SUBENT N_1 N_2

This record __must__ be the __first__ one of each subentry.
N_1 and N_2 are interpreted as:

N_1 — An eight digit universal sub-accession number (originating centre identification, centre assigned accession and sub-accession number).

N_2 — Date of __last__ alter (or date of entry if never altered) (year, month, date).

N_3 — Except for neutron data this field may contain flags as follows:
R in col. 42: recommended data
E in col. 43: evaluated data
D in col. 44: differential data

When used in subentry 001 these flags apply to all subentries.

N_4 - N_5 — In Kachapag entries columns 52-66 contain center internal information which is of no interest to the recipient of the entry.

The record identification (Cols. 67-79) should contain the universal accession and sub-accession numbers (Cols. 67-74) and the sequence number one (00001) (Cols. 75-79).

(10) ENDSUBENT N_1 N_2

This record __must__ be the __last__ one of each subentry. N_1 and N_2 are interpreted as:

N_1 — The number of records within the subentry. (Excluding the SUBENT and ENDSUBENT records. — HDL)

N_2 — Presently unused (may be blank or zero).

The record identification (Cols. 67-79) should contain the universal accession and sub-accession numbers (Cols. 67-74) and the sequence number 99999 (Cols. 75-79).

(11) NOSUBENT N_1 N_2

This record indicates that a sub-accession number has been assigned by the centre but that either the information associated with it was not ready at the time the tape was transmitted by the centre, or that the subentry has been deleted, or combined with another subentry according to page 9.3.

N_1 and N_2 are interpreted as:

N_1 — An eight-digit universal sub-accession number (originating centre identification, centre assigned accession and sub-accession number).

N_2 — Date of __last__ alter or blank (if merely assigned and not yet used).

The record identification (cols. 67-79) is the same as on a SUBENT card.

(12) BIB

This record _must_ be the _first_ one of each BIB section if one is present.
N_1 and N_2 are interpreted as:

N_1 — Number of keywords in the BIB section (not counting pointers in column 11, see page 6.1)

N_2 — Number of records in the BIB section (not counting the BIB and ENDBIB records)

(13) ENDBIB

This record _must_ be the _last_ one of each BIB section if one is present.
N_1 and N_2 are interpreted as:

N_1 — Number of records in BIB section (same as N_2 in the BIB record)

N_2 — Presently unused (may be blank or zero)

(14) NOBIB

Positive indication that there is no BIB section associated with sub-work.
N_1 and N_2 are blank or zero.

Note: The record identification (columns 67-79) for these system identifiers contains the universal accession and sub-accession numbers of the sub-entry in which they are located, and the sequence number should naturally be assigned sequentially within the sub-entry.

(15) COMMON

This record **must** be the **first** one of each Common Section if one is present. N_1 and N_2 are interpreted as:

N_1 — Number of values given in the COMMON Section.

N_2 — Number of records in the COMMON Section (= 3 if up to 6 values are given).

(16) ENDCOMMON

This record **must** be the **last** one of each Common Section if one is present. N_1 and N_2 are interpreted as:

N_1 — Number of records in the Common Section (same as N_2 in the COMMON record).

N_2 — Not used (may be zero or blank).

(17) NOCOMMON

Positive indication that there is no Common Section associated with the sub-entry. N_1 and N_2 are blank or zero.

Note: The record identification (columns 67-79) for these system identifiers contains the universal accession and subaccession numbers of the sub-entry in which they are located, and the sequence number should naturally be assigned sequentially within the sub-entry.

(18) DATA N_1 N_2

This record _must_ be the _first_ one of each data table section if one is present.

N_1 and N_2 are interpreted as:

N_1 — Number of fields (variables) associated with each line of a data table. N_1 must not exceed 18.

N_2 — Number of data _lines_ in the table (excluding headings and units).

Note that if N_1 is larger than 6, a _line_ will consist of more than one _record_.

(19) ENDDATA N_1 N_2

This record _must_ be the _last_ one of each data table section if one is present.

N_1 and N_2 are interpreted as:

N_1 — Number of _records_ in the data section (including headings and units)

N_2 — Not used (may be zero or blank)

(20) NODATA

Positive indication that there is no data table associated with the entry or subentry. For the use of this keyword, see in Lexfor under _NODATA_.

N_1 and N_2 are blank (or zero).

Note: (1) The record identification (cols. 67-79) for these system-identifiers should contain the universal accession and subaccession numbers of the sub-entry in which they are located, and the sequence number should naturally be assigned sequentially within the subentry.

(2) The above 3 system-identifiers may _not_ appear in subentry 001.

(21) XDATA N_1 N_2 (cancelled)

Prior to 1978 this keyword could be used optionally when entries were retransmitted with alterations in the BIB or COMMON section only, leaving the DATA section unaltered. In this case the DATA section, in particular when it was large, could be abbreviated to contain only an XDATA record, the column headings and units, the first and last data line, and the ENDDATA record. - This feature was cancelled in 1978 but may still exist in some NDS programs.

SUMMARY OF SYSTEM IDENTIFIER RECORDS

The following similarities may be noted between system identifier records:

(1) All [System Identifier] and NO[System Identifier] records are identical as far as the significance of N_1 and N_2.

(2) The TRANS, ENTRY, and SUBENT records all use N_1 to uniquely identify the unit (tape, entry, subentry, respectively) and use N_2 to signify a date (TRANS – date tape was generated; ENTRY and SUBENT – last alter date).

(3) The BIB, COMMON and DATA records (the units that actually contain information) use N_1 and N_2 to define the contents of the information records.

(4) All END[System Identifier] records use N_1 to indicate the number of sub-units within the unit (ENDTRANS – the number of works; ENDENTRY – the number of subentries; ENDSUBENT, ENDBIB, ENDCOMMON, and ENDDATA – the number of records). To be consistent at all levels (e.g. entry, subentry, record), the system identifier records should not be included in the record count for BIB, COMMON, and DATA. N_2 is presently unused on all END[System Identifier] records.

Since the above four rules describe all of the system identifier records, only a small number of rules need be remembered.

The following hierarchy has been established on the tape:

(1) The transmission will be one logical file

    (A) Headed by . . . . . TRANS   CXXX   YYMMDD

    (B) Ended by . . . . . ENDTRANS N_1

        CXXX – tape identification
     YYMMDD – date tape was generated
       N_1 – number of works on the tape

(2) <u>Entries</u> will be:

(a) Headed by . . . . . ENTRY   CXXXX   YYMMDD
(b) Ended by . . . . . ENDTRANS N_1

CXXXX   – universal accession number
YYMMDD – date work was last altered
N_1 – number of sub-works in the work (including NOSUBENT's)

(3) Entries will be subdivided into subentries (sub-accession number).
The subentry will be

(a) Headed by . . . . . SUBENT N_1 YYMMDD)   or NOSUBENT N_1 YYMMDD
(b) Ended by . . . . . ENDSUBENT N_2)

N_1 – sub-accession number
YYMMDD – date sub-work was last altered
N_2 – number of records in the sub-work (excluding the SUBENT and
       ENDSUBENT records)

(4) Each subentry but the first <u>must</u> contain the three sections (when
applicable there will be a positive indication of no information in a
section). The sections will be:

BIB section:
(a) Headed by . . . . . BIB   K N_2)   or NOBIB
(b) Ended by . . . . . ENDBIB N_1)

K – number of keywords in the BIB-section
$N_1=N_2$ – number of records in the BIB-section
       (excluding the BIB and ENDBIB records)

COMMON section:
(a) Headed by . . . . . COMMON   M N_2)   or COMMON
(b) Ended by . . . . . ENDCOMMON N_1)

M – number of pieces of common data
$N_1=N_2$ – number of records in the COMMON section
       (including column headings and units but excluding
       the COMMON and ENDCOMMON records)

DATA section:
(a) Headed by . . . . . DATA   C   L)   or NODATA
(b) Ended by . . . . . ENDDATA N_1)

C – number of columns (fields) in the table
L – number of lines (rows) in the table
N_1 – number of records in the data table section (including column
      headings and units, but excluding the DATA and ENDDATA records)

The <u>DATA</u> (or <u>NODATA</u>) section may never appear in the first
(all common) subentry (subentry 001).

The transmission tape then has the following form:
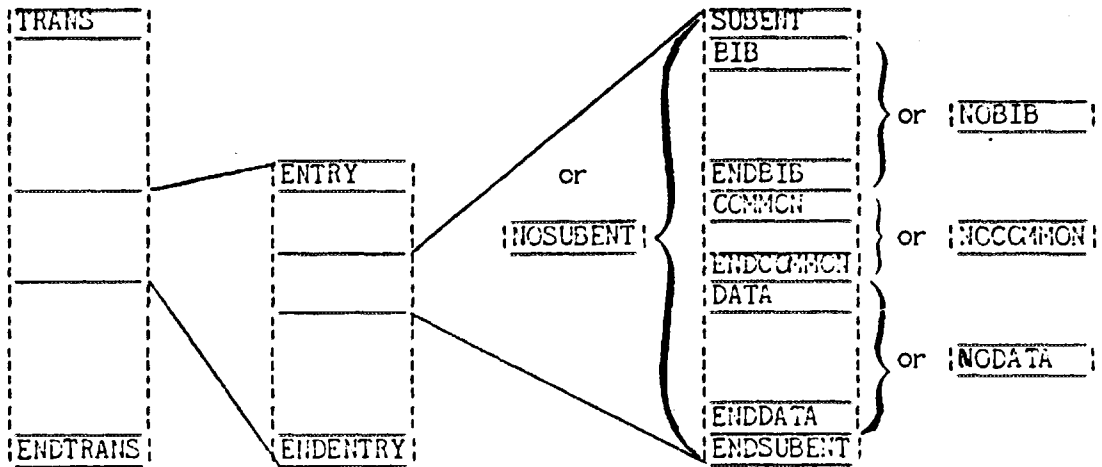
Note: DATA, ENDDATA, and NODATA must not appear in the first (all common)
sub-accession number.

LEGAL SYSTEM IDENTIFIER SEQUENCES

The following two tables specify the permissible order in which system identifiers may appear. The first table lists all records that may follow a given system identifier. The second table lists all records that may precede a given system identifier. The two tables are provided for clarity rather than necessity (i.e., one table can easily be derived from the other).

SYSTEM IDENTIFIER	LEGAL FOLLOWING RECORD
TRANS	ENTRY
ENDTRANS	(no information follows ENDTRANS)
ENTRY	SUBENT, NOSUBENT
ENDENTRY	ENTRY, ENDTRANS
SUBENT	BIB, NOBIB
ENDSUBENT	SUBENT, ENDENTRY, NOSUBENT
NOSUBENT	SUBENT, ENDENTRY, NOSUBENT
BIB	(a record starting with an information identifying keyword)
ENDBIB	COMMON, NOCOMMON
NOBIB	COMMON, NOCOMMON
COMMON	(a column heading record)
ENDCOMMON	in subentry 001: ENDSUBENT in other subentry: DATA, NODATA
NOCOMMON	in subentry 001: ENDSUBENT in other subentry: DATA, NODATA
DATA	(a column heading record)
ENDDATA	ENDSUBENT
NODATA	ENDSUBENT

SYSTEM IDENTIFIER	LEGAL PRECEDING RECORD
TRANS	(no information precedes TRANS)
ENDTRANS	ENDENTRY
ENTRY	ENDENTRY, TRANS
ENDENTRY	ENDSUBENT, NOSUBENT
SUBENT	ENTRY, ENDSUBENT, NOSUBENT
ENDSUBENT	in subentry 001: ENDCOMMON, NOCOMMON in other subentry: ENDDATA, NODATA
NOSUBENT	ENTRY, ENDSUBENT, NOSUBENT
BIB	SUBENT
ENDBIB	(a text record)
NOBIB	SUBENT
COMMON	ENDBIB, NOBIB
ENDCOMMON	(a numerical record)
NOCOMMON	ENDBIB, NOBIB
DATA	ENDCOMMON, NOCOMMON
ENDDATA	(a numerical record)
NODATA	ENDCOMMON, NOCOMMON

Chapter 4

BIB SECTION

BIB SECTION

Each Exfor data table is accompanied by explanatory text which is identified
on a transmission tape as that information between the system-identifiers BIB
and ENDBIB. Although it is called 'BIB-section' it contains information other
than the strictly bibliographic, that is information required to describe an
experiment (e.g. source of incident particles, method, facility,
error-analysis, etc.) and administrative information (e.g. history).

A BIB record consists of three fields:

    Col. 1 - 11:   keyword field
    Col. 12 - 66: information field, which may contain coded information
                   and/or free text.
    Col. 67 - 80: record identification as described in Chapter 2.

The keywords are used to identify specific information; this may be given in
coded form, with or without free text explanation, or may be given in free
text without codes. Codes can be used for retrieval purposes. Information in
free text cannot be used for retrieval purposes. The keywords may, in
general, appear in any order within the BIB section. The identification has
been described in Chapter 2 and will not be dealt with further.

The BIB information for a given subentry nnn is contained partly in the BIB
section of subentry 001, and partly in the BIB section of subentry nnn. A
specific BIB keywork may show up either in subentry 001 or in subentry nnn or
in both. (Information included in subentry 001 must apply to all following
subentries of the same entry.)

(1) Keyword (Information Identifier)

The keyword is used to define the significance of the information given in columns 12-66. Dictionary 2 contains all keywords and a summary of coding rules. For the detailed coding rules of all keywords see Chapter 8.

Keywords must be left adjusted to begin in column 1 and must not exceed a length of 10 characters; col. 11 is either blank or contains a "pointer" as explained in Chapter 6. Columns 1 - 10 of continuation records must be blank and col. 11 must be blank or contain a pointer.

In a given BIB-Section a keyword must not be repeated. However, a keyword given in subentry 001 may be given again in one or all of the following subentries. For example, a bibliographic REFERENCE may be given in subentry 001 if it refers to all subentries of the entry; the keyword REFERENCE may be given again in subentry 00n to give reference information that refers to subentry 00n only.

(2) Machine Retrievable Information (Codes)

Machine retrievable information in the BIB-section may be used, to define the actual BIB-information, or as a link to the COMMON and DATA sections, or even include numerical data. The machine retrievable information must be enclosed in parentheses and left adjusted so that the opening parenthesis appears in col. 12. More than one piece of machine retrievable information may be associated with a keyword. For details see page 8.1.

For some keywords a restriction is placed upon the maximum length of the associated machine retrievable information; it may be continued onto successive records. Information on continuation records must not begin before col. 12. The machine retrievable information should be kept as concise as possible if it is to be used efficiently.

Note that some keywords have no machine retrievable information associated with them and that, for many keywords that may have machine retrievable information associated with them, it need not always be present.

See Chapter 8 for formats and coding rules, and Chapter 7 and the Dictionaries for the codes.

(3) Free Text

Under each of the keywords in the BIB-section free text may be entered either starting in col.12 or following the closing parenthesis of the machine retrievable information, observing the formalism given under (4) below.

The free text may be continued on to any number of records. Free text on continuation records must not begin before col. 12. The free text may include parentheses, but a left parenthesis within the free text must not be placed in col. 12 (as this implies the opening parenthesis of machine retrievable information).

The free text must use clear English phrasing and no codes should be used within the free text.

Free text information should be entered under the keyword to which it pertains.

(4) <u>Codes and free text</u>

1. Coded information may serve a double purpose:

   - it contains the most essential information in machine retrievable form, whereas information given in the free text is not machine retrievable;

   - much of the coded information is also essential for eyeball reading of the Exfor entry. For this purpose, an Exfor output format may be prepared by an "edit" program, whereby codes may be replaced by easily readable code expansions as provided in the Dictionaries.

2. "Edit" programs, not being subject to the Exfor agreement, may be developed by each Centre according to its needs and facilities. However, it is understood that such "edit" programs will provide expansions

   (a) always for the following keywords:

   INSTITUTE
   REFERENCE, REL-REF, MONIT-REF,
   REACTION, MONITOR
   DECAY-DATA, DECAY-MON, RAD-DET

   (b) for the following keywords only if so indicated by the compiler:

   METHOD, N-SOURCE, FACILITY, DETECTOR, ANALYSIS,
   PART-DET, RESID-NUC, ADD-RES, STATUS.

3. For the keywords listed under 2(b) the indication to the "edit" program to replace the code by its expansion, may be given

   <u>either</u> by a point immediately following the closing parenthesis

   <u>or</u> by a completely blank field between the closing parenthesis and column 66.

4. In those cases where an expansion of the codes by an "edit" program is foreseen, the coded information should not be repeated in the free text, since the "edit" program would then create duplicate information.

5. If, for the keywords listed under 2(b) above, the coded information is <u>not</u> supposed to be expanded in an "edit" program, the free text must be self-explanatory, repeating or specifying further the coded information. In this case the code is a retrievable abstract of the free text and must not be considered as part of the free text. In an "edited" listing the coded information, which serves only as a means for computer retrieval, may as well be suppressed.

An example of several BIB information entries is given below:

```
1         1112
ENTRY             00001
SUBENT            00001001
BIB               4         15
AUTHOR     (J.W.DOW, M.P.JONES) THIS SPACE MAY CONTAIN ANY FREE TEXT.  THE
           BEGINNING OF A NEW BIB ENTRY IS INDICATED BY A NON-BLANK IN THE
           KEYWORD FIELD COLS. 1 - 10.
INSTITUTE  (3AAABBB) SINCE THE KEYWORD FIELD IS NON-BLANK, THIS IS CONSIDERED
           A NEW BIB ENTRY.
N-SOURCE   (ABC,WXYZ) THIS IS AN EXAMPLE OF A BIB ENTRY WITH MORE THAN ONE
           PIECE OF MACHINE-RETRIEVABLE INFORMATION IN ONE SET OF
           PARENTHESES.  THE ABSENCE OF A POINTER IN COLUMN 11 SHOWS THAT
           THIS INFORMATION REFERS TO ALL DATA.
COMMENT    THIS IS AN EXAMPLE OF A BIB ENTRY WITHOUT MACHINE-RETRIEVABLE
           INFORMATION.
          1THE POINTER IN COLUMN 11 INDICATES THAT THIS RECORD, AND THE
           FOLLOWING RECORDS UNTIL A NEW POINTER IS ENCOUNTERED, REFER TO ALL
           DATA WITH THE SAME POINTER IN ALL FOLLOWING SUBENTRIES.
ENDBIB            15
NOCOMMON
ENDSUBENT
SUBENT            00001002
BIB               2         13
REACTION   1(92-U-235,(N,EL),,WID) THIS IS AN EXAMPLE OF MULTIPLE
           2(92-U-235,(N,F),,WID) REACTIONS WITH POINTERS
ANALYSIS   1(CDEFG).   THIS IS AN EXAMPLE OF A BIB ENTRY WITH MORE THAN ONE
                       PIECE OF MACHINE-RETRIEVABLE
           2(HIJ).     INFORMATION EACH CODED IN ITS OWN SET OF PARENTHESES.  EACH
                       PART OF THE BIB ENTRY IS LINKED BY A POINTER IN COLUMN 11
                       TO OTHER INFORMATION IN THIS SUBENTRY AND IN SUBENTRY 1
                       WITH THE SAME POINTER.
                        THE POINT AFTER THE CLOSING PARENTHESIS INDICATES THAT
                       THE CONTENTS OF THE PARENTHESES IS NOT REPEATED IN FREE
                       TEXT, AS WOULD BE REQUIRED IF THE POINT WERE ABSENT.
ENDBIB            13
NOCOMMON
DATA              4         10
EN         DATA      1DATA-ERR 1DATA      2
EV         MILLI-EV  MILLI-EV  MILLI-EV
 ----      ----      ----      ----
ENDDATA           12
ENDSUBENT
ENDENTRY
```

For pointers see page 6.1

Chapter 5

COMMON-Section and DATA-Section

Structure of COMMON and DATA SECTIONS

The COMMON section is identified by the system identifier keywords COMMON and ENDCOMMON. The DATA section is identified by the system identifier keywords DATA and ENDDATA.

The format of the COMMON and DATA section is similar but the significance of the content is different. Each section looks like a table of data with a heading and unit associated with each column. The difference between the two is that the table in the COMMON section contains constant parameters arranged in a single row, whereas the table in the DATA section usually contains data values as a function of one or more independent variables arranged in a number of rows. A row in the DATA section contains information associated with a "data point", e.g. energy, energy resolution, angle, angular error, cross-section, cross-section error, standard value, etc. A row in the COMMON section contains parameters which are not associated to each other but which are associated to all "data points" of the DATA section.

A datum which has a constant value in all rows of the DATA section, e.g. a gamma ray energy or a relative cross-section error, can as well be entered as a constant parameter in the COMMON section. Vice versa, a parameter given in the COMMON section can as well be entered in a column of the DATA section with its value repeated in all rows.

Since each record contains six information fields, each 11 characters wide, up to six fields of information may be contained on a record without resorting to a continuation record. If more than six fields must be used, the remaining information should be contained on the following record(s). The records which refer to the same data point, form together a "data-line"; within one DATA section the number of records per data-line is constant. The number of fields is restricted to 18. See the examples on page 5.2.

Records must not be packed. If only one or two fields are used in the COMMON or DATA section, the remaining fields are left blank. Similarly, if 8 fields were used, the remaining four fields on the second record remain blank. The number of fields and records resp. data-lines used is entered in the records of the System Identifier Keywords COMMON, ENDCOMMON, DATA, ENDDATA, respectively. See Chapter 3.

The tables in the COMMON and DATA section consist of:

(1) Data heading for each column. The data heading shall be left adjusted to the beginning of each field (Cols. 1, 12, 23, 34, 45, 56). See Dictionary 24 for permissible data-heading keywords. A one-character pointer can be placed in the last (eleventh) position of any data-heading field if the corresponding column is to be linked to some other part of the same subentry or subentry 001. For further information on pointers see page 6.1.

(2) Data units for each column. The data units shall be left adjusted to the beginning of each field (Cols. 1, 12, 23, 34, 45, 56). See Dictionary 25 for permissible data-units keywords.

(3) The numerical data which shall be FORTRAN readable using an 'E' format, see page 5.3. The values given must be either zero or have absolute values between 1.0000E-38 and 9.9999E+38. If more than six fields are needed, data are continued on successive records.

An <u>example of a COMMON section</u> is shown below with its associated COMMON and ENDCOMMON records.

1	12	23	34	45	56	66
COMMON		4	3			
EN	EN-ERR	E	E-ERR			
MEV	MEV	MEV	MEV			
2.73	0.16	1.38	0.21			
ENDCOMMON		3				

An example of a COMMON section with more than 6 columns

1	12	23	34	45	56	66
COMMON		7	6			
EN	EN-ERR	EN-RSL	E-LVL	E-LVL	ANG	
ANG-ERR						
MEV	MEV	MEV	MEV	MEV	ADEG	
ADEG						
4.1	0.05	0.1	3.124	3.175	90.	
10.						
ENDCOMMON		6				

An <u>example of a DATA section</u> is shown below with its associated DATA and ENDDATA records.

1	12	23	34	45	56	66
DATA		4	7			
ANG	ANG-ERR	DATA	DATA-ERR			
ADEG	ADEG	MB/SR	MB/SR			
10.4	0.8	243.	8.7			
22.9	1.2	127.	4.2			
39.1	0.9	83.2	3.7			
59.1	0.7	14.8	2.9			
83.0	1.0	19.2	3.4			
112.	1.3	21.2	4.1			
173.	1.1	16.8	3.8			
ENDDATA		9				

Numerical Data Formats

The prescribed format of numerical data entered in the **COMMON** or **DATA** section of an EXFOR-entry is defined as "FORTRAN readable according to an E-format".

That means in detail:

* A decimal-point is always required, also for integers.

* A decimal number without an exponent can have any position within the 11-characters field.

* No blank is allowed behind a sign (+ or -).

* A plus sign can be omitted, except that of an exponent when there is no E.

* In a notation with exponent the exponent must be right-adjusted within the 11-character field. The mantissa can have any position.

* The exponent must not be larger than 38. The values given must be either zero or have absolute values between1.0E-38 and 9.9999E+38.

All the following examples are valid entries:

Fixed-point numbers   Floating-point numbers
with decimal point   with exponent

```
|0 1 4             |+ 0 . 0 0 1 4 E + 0 2|
|          0 . 1 4|  0 . 0 0 1 4 E + 2|
|    0 . 1 4       |    0 . 0 0 1 4 E 2|
|  + 0 . 1 4       |        . 0 0 1 4 + 2|
|  - 0 . 1 4 0     |  - 0 . 1 4 0 E + 0 0|
|      - . 1 4     |        - . 1 4 E 0|
|                  |          1 . 4 E - 1|
|                  |          1 . 4 - 1|
|                  |1 . 4 0        - 0 1|
|                  |  1 . 4 0    E   0 0|
```

Compilers should aim at a neat-looking and easily-readable arrangement of the numbers.

Centers using PL/1 may have to apply special manipulation when numerical fields include embedded blanks.

Repetition of column-headings

Within the three sections: COMMON section of subentry nnn ≠ 001,
DATA section of subentry nnn ≠ 001,
COMMON section of subentry 001 of same entry,

no column-heading (data-heading keyword plus perhaps a pointer) may be
repeated except for the following cases. (Any further case of repeated
column-headings which the centers may agree to accept, must be described here).

Any columns with identical column-heading must be adjacent and may appear
within only one of the three sections mentioned above.

(1) Two or more unresolved energy levels (given as level energies or Q-values)
    are entered as follows:

         E-LVL   E-LVL   E-LVL
         MEV   MEV   MEV
         0.077   0.107   0.177

    The same applies to the column-heading EN-RES in the case of unresolved
    resonance energies and some secondary energies, e.g. E in the case of
    unresolved gamma-lines. (Other cases may be added here when they occur.)

(2) An angle given in degrees and minutes must be entered in two separate
    columns with the data heading ANG repeated; as follows:

         ANG   ANG
         ADEG   AMIN
         90.   47.

    Similarly, other keywords beginning with ANG-... may be repeated in the
    same way.

(3) Half-life values in different units to be given in a column of the DATA
    Section (such as SEC, D, YR), should not be converted into a single unit
    but should be entered as follows:

         HL   HL   HL
         SEC   D   YR
                        15.
                                       28.3
         4.8

    Similarly, any other data-heading keyword starting with HL... may be
    repeated in the same way. This case cannot occur in a COMMON section.

4) <u>Two or more flags</u> defined under the BIB keywork FLAG which apply to the same line of the data table, may be entered as follows:

```
FLAG      FLAG
NO-DIM    NO-DIM
1.
3.
2.        3.
1.        2.
```

<u>Note</u>: The data-heading keyword FLAG cannot occur in a COMMON section

5) <u>Errors or resolutions given in different units</u> over an energy range may be entered as follows:

```
EN-RSL    EN-RSL
KEV       PER-CENT
20.
20.
          10.
20.
```

6) <u>Two or more unresolved masses</u> (for mass yields) may be entered as follows:

```
MASS      MASS
NO-DIM    NO-DIM
135.      136.
```

Column Sequence in a DATA Table

The example on p.5.2 illustrates the simplest type of table representing the dependent variable DATA as a function of the independent variable ANG (one-dimensional table). The rules for multi-dimensional tables require distinction between four data categories occurring in data tables, namely

- independent variables (EN, EN-MIN, EN-RES, E, ANG,...);
- dependent variables (DATA, RATIO,...);
- associated quantities (EN-ERR, ANG-RSL, DATA-ERR,...);.
- additional information (STAND, MISC, FLAG, HL1,...).

The division between different categories and families within categories are defined in Dictionary 24 (Data-heading keyword dictionary). (See page 7.14).

Data tables must be arranged as follows:

- All columns with independent variables precede the columns with dependent variables. Columns on the left-hand side of the first dependent-variable column are considered as independent-variable columns, except those with associated quantities.

- Columns with additional information are preferably placed after the last dependent-variable column but if they refer to a specific column they may be placed next to it.

  Note: Some data-heading keywords may be used either as independent variables or as additional information.

- Columns with associated quantities are placed right after the column they refer to.

If the COMMON section is included an EXFOR table must then look as follows.

```
-----------------------------------------------------------------
      COMMON
        .
        .
        .
      ENDCOMMON
-----------------------------------------------------------------
      DATA
          independent                dependent variable(s)
             variable(s)             +  associated quantities
        +  associated
             quantities             +  additonal information

      ENDDATA
-----------------------------------------------------------------
```

Line sequence in a DATA Table

1. **One-dimensional tables** (one independent variable)
   The values of the independent variable must increase or decrease monotonically throughout the table.

2. **Multi-dimensional tables** (more than one independent variable)

If columns for more than one independent variable are needed they are to be arranged so that the rate with which the numbers change within each column increases from left to right. Obviously this rule cannot apply to associated-quantity columns. Values in a given independent-variable column must increase or decrease monotonically until the value in the preceding independent-variable column changes or the end of the table is reached.

Example

DATA				
EN	EN-ERR	ANGLE	ANGLE-ERR	DATA
MEV	MEV	ADEG	ADEG	MB/SR
1.	.02	35.	10.	−
1.	.02	60.	10.	−
1.	.02	90.	10.	−
2.	.02	30.	5.	−
2.	.02	60.	5.	−
2.	.02	90.	5.	−
3.	.03	30.	5.	−
3.	.03	60.	5.	−
3.	.03	90.	5.	−
ENDDATA				

Alternatively, this table can be arranged in the "vector common data" formalism using pointers; see page 6.3.

A slight complication arises with families of independent variables referring to basically the same quantity, as for instance the columns referring to excitation energies of the residual nucleus in the following example. In this case the monotonicity rule applies to the sequence of numbers consisting of the first (left-most) non-blank value within the group on each line.

Example

DATA						
EN	E-LVL	E-LVL	E-LVL	E-LVL-MIN	E-LVL-MAX	DATA
MEV	MEV	MEV	MEV	MEV	MEV	B
3.0	0.506					−
3.0	0.720	0.725				−
3.0	0.81					−
3.0	0.990	0.998	1.02			−
3.0				1.250	1.300	−
3.0	1.400	1.412				−
4.5	0.405					−
ENDDATA						

Note: In general, the same value of the independent variable should not occur twice. In the few cases that it must occur twice (e.g. repetition of the measurement at same energy) it is advisable to give the reason in free text. (Otherwise it may be interpreted as a mispunch or inadvertent duplication.)

Blank fields in a DATA table

Every line in a data table must give data information. This means for example that a blank in a column headed DATA is only permitted when another column contains the data information on the same line, e.g., under DATA-MAX. In the same way, each independent variable should occur at least once in each line (e.g. either under column headings E-LVL or E-LVL-MIN, E-LVL-MAX, see example on page 5.7). Supplementary information such as resolution or standard values must not be given in a line of a data table which has no data information.

In the multiple reaction formalism (see page 8.REACTION.12) at least one of the columns headed DATA (resp. RATIO, SUM, DATA-MAX, etc.) must contain data information in a given line. In general, each line should contain data information for each of the Reactions given; however, this is not obligatory.

Under each column heading there must be numerical information in at least one line.

With above restrictions blanks are permitted in all fields of a DATA table.

Chapter 6

LINKS BETWEEN BIB, COMMON AND DATA SECTIONS

Pointers

Different pieces of EXFOR information can be linked together by pointers. These are numeric or alphabetic characters (1,2,...9.A,B,...Z) placed in the eleventh column of information-identifier keyword field in the BIB-Section and in the eleventh column of the data-heading keyword field in the COMMON and DATA Sections.

Pointers can link, for example:

- one of several REACTION codes with its DATA column;

- one of several REACTION codes with a specific piece of information in the BIB section (e.g. ANALYSIS), and/or with a value in the COMMON section, and/or with a column in the DATA section;

- a value in the COMMON section with any column in the DATA section.

In general, a pointer is valid for one subentry only. A pointer used in the first subentry must apply to all subentries and must have a unique meaning throughout the entire entry.

In the BIB-section the pointer should be given in the first record of the information to which it is attached and should not be repeated on continuation records. The pointer is assumed to refer to all BIB - information until either another pointer is encoutered or until a new keyword is encountered. This implies that pointer-independent information for each keyword appears first.

Where feasible, the compiler may choose as pointers meaningful digits or characters. For example, when the pointers refer to an isomeric ratio and the partial isomeric cross-sections leading to ground-state and metastable state, he may choose as pointers the characters R, G and M respectively. Or when the pointers refer to the Legendre coefficeint numbers 0., 2., and 4., he may choose as pointers the digits 0, 2 and 4.

The use of pointers is restricted to the cases described on the following pages. In a given subentry only one of the cases described can be applied.

1. <u>Multiple REACTION Formalism</u>

In certain cases more than REACTION unit may be given under the keyword
REACTION, each unit having its own data field(s). Each data field is then
linked to the appropriate REACTION code by means of a pointer.

    Example:

```
BIB
REACTION   1(92-U-235(N,O),,EN)
           2(92-U-235(N,O),,J)
           3(92-U-235(N,TOT),,WID)
           4(92-U-235(N,F),,WID)
    .
    .
    .
ENDBIB
COMMON
MOMENTUM L DATA-ERR   3DATA-ERR  4
NO-DIM     PER-CENT    PER-CENT
0.         8.          10.
ENDCOMMON
DATA
DATA      1DATA       2DATA       3DATA       4
EV         NO-DIM      MILLI-EV    MILLI-EV
    .
    .
    .
ENDDATA
```


In the example above, the field headed "MOMENTUM L" in the COMMON Section does
not have a pointer and, therefore, relates to all fields of the DATA Section.
The two fields headed 'DATA-ERR' in the COMMON Section are linked, by means of
pointers, to fields of the DATA Section and to specific REACTION units in the
BIB Section.

This formalism must be used <u>only</u> in the specific cases listed on page
8.REACTION.12 and in LEXFOR under <u>Multiple REACTION Formalism</u>.

2) <u>Vector COMMON</u>

Two-dimensional tables can be coded in different ways if pointers are used. The following examples illustrate this.

<u>First alternative</u>

.

.

DATA			The values of the two independent
EN	ANG	DATA
MEV	ADEG	MB/SR
1.	10.	11.
1.	20.	12.
1.	30.	13.
2.	10.	21.
2.	20.	22.
2.	30.	23.
3.	10.	31.
3.	20.	32.
3.	30.	33.
ENDDATA		

The values of the two independent variables EN and ANG are entered repetitively in two columns of the DATA-Section

<u>Second alternative</u> ("Vector COMMON" formalism)

.

.

COMMON			
ANG	1ANG	2ANG	3
ADEG	ADEG	ADEG	
10.	20.	30.	
ENDCOMMON			
DATA			
EN	DATA	1DATA	2DATA	3
MEV	MB/SR	MB/SR	MB/SR	
1.	11.	12.	13.	
2.	21.	22.	23.	
3.	31.	32.	33.	
ENDDATA				

One of the two independent variables, ANG, is placed in the COMMON-Section, and its three values are linked to their corresponding DATA columns by pointers.

The following rules apply:

- The 'Vector COMMON' formalism cannot be combined with the 'Multiple Reaction' formalism.

- Headings and units referring to a given independent variable under 'Vector COMMON' must be the same for all pointers. In particular, the case of repeated column headings (e.g. angles given in degrees and minutes) must be applied in the same way for all pointers.

Examples:	COMMON				
	ANG	1ANG	1ANG	2ANG	2
	ADEG	AMIN	ADEG	AMIN	
	30.	30.	40.	0.	

Forbidden:	E	1E	2E-MIN	3E-MAX	3
	KEV	KEV	KEV	KEV	

3) BIB/DATA links

Pointers used for "Multiple Reactions" or for "Vector COMMON" may also be used
elsewhere in the BIB-Section in order to link, for example, certain
information under STANDARD, ANALYSIS, COMMENT, etc, to one of the multiple
reactions or to one of the vector common data.

```
Examples:    REACTION   1(.....)
                        2(.....)
             PART-DET   1(G).
                        2(N).
             DETECTOR   1(ABCDE).
                        2(FGHIJ).


     or      REACTION    (.....)
             COMMENT    1FREE TEXT about data at first angle
                         FREE TEXT
                        2FREE TEXT about data at second angle
             ENDBIB
             COMMON
             ANG        1ANG         2
             ADEG        ADEG
             10.         20.
             ENDCOMMON
             DATA
             EN         DATA        1DATA        2
             ...         ...         ...
```

Forbidden:

```
             REACTION    (...)
             MONITOR    1(...)
                        2(...)
             MONIT-REF  1(...)
                        2(...)

             COMMON
             .....      MONIT      1MONIT     2
```

This case is rejected by NNDC.

4) BIB/BIB links

Pointers may be used to link pieces of BIB information, but all referring to
the same REACTION.

Example: REACTION   (.....)
              PART-DET   1(G).
                         2(N).
              DETECTOR   1(ABCDE).
                         2(FGHIJ).

Note: If the 'Multiple Reaction' or 'Vector COMMON' formalism is used,
          BIB/BIB links may only be used to link to pointers already used, as
          in 3) above.

NDS internal note: In this example pointers may occur under all BIB-Keywords
except REACTION, according to above wording. However, pointers under the BIB
keywords MONITOR, MISC-CØL etc (which define the contents of columns in
the DATA Section) must be used with caution as this may entail pointers in the
DATA Section, too. There is no official agreement about this case.

5) <u>Alternative results</u>

Different results of the same quantity obtained in the same experiment by,
e.g., two different ways of analysis, may be entered in the same subentry,
distinguished by pointers. In this case the REACTION code must be repeated,
although there will be twice the same code.

Example: REACTION   1(92-U-235(N,G),,WID)
                        2(92-U-235(N,G),,WID)
             ANALYSIS   1(AREA). FREE TEXT
                        2(SHAPE). FREE TEXT
             ENDBIB
             NOCOMMON
             DATA
             EN   DATA   1DATA   2
             ...   .

From a processing point of view, this is the same concept as "Multiple
Reactions" described on page 6.2.

Note: Alternatively, such data can be entered in two separate subentries
         linked to each other by a STATUS entry such as

             STATUS   (COREL,10123004) SEE SUBENTRY 10123004 FOR
                        RESULTS FROM SAME EXPERIMENT BY xxx-ANALYSIS

Links between Data-Heading Keywords and Information-Identifier Keywords

In the COMMON- and DATA-sections some data-heading keywords require specific keywords and codes in the BIB-section. These are listed below. See also Chapter 8 for further information about keywords and coding rules, and page 6.1 for information about pointers.

The following shorthand is used throughout this section.

- Particle is used to mean particle, nuclide or radiation.

- Data-heading Keywords as listed are understood to include their derivatives (e.g., if DATA is given, DATA-CM, DATA-APRX, etc. are also included).

1. DATA (resp. RATIO, SUM)

The data given under the column-heading keyword DATA is defined in the BIB-Section under REACTION. The column-heading DATA must be present in each DATA-Section. It is the "dependent variable" (e.g. cross-section) which requires usually one or more "independent variables" (e.g. energy, angle, see below) depending on its definition under REACTION. The heading DATA and its derivatives must not be used in the COMMON-Section, except for those derivatives which contain the suffix "-ERR".

In the specific cases mentioned on pages 6.1. to 6.6 there may be two or more DATA columns distinguished by pointers.

At the discretion of the compiler the column-heading DATA may be replaced by the heading RATIO or SUM. The use of RATIO and SUM is restricted to explicit ratios or sums coded in the form

REACTION   ((...)/(...))   resp.   ((...)+(...))

and to isomeric ratios and sums coded with the separators '/' resp. '+' in the isomer coding of the reaction product; compare page 8.REACTION.5. Any implicit ratios, such as the quantity "alpha" (capture-to-fission cross-section ratio), and implicit sums, such as a total cross-section deduced from partial cross-sections, are coded with the data-heading DATA. The use of the keywords RATIO and SUM is optional; the keyword DATA may be used instead.

2. Column heading keywords for independent variables

The coded information under the keyword REACTION requires the presence, or
absence, of data-heading keywords for certain families of independent
variables. The classification of families is given on page 7.14. The meaning
of each data-heading keyword is given in dictionary 24 together with the
character indicating to which family it belongs. The rules concerning the
links between data-specification keywords and independent variables follow.

EN   **Incident particle energy** (Family A)

Is used for the energy of the indicent particle, which is
specified in SF2 under the keyword REACTION.
This heading must always be present except in the following cases
when it is forbidden:

- if SF2 of REACTION contains 0 (zero);
- if EN-DUMMY is used - see below;
- if resonance energy is given - see below.

EN-DUMMY   **Dummy energy** (Family A)

Is used for the numerical equivalent of an incident particle
spectrum.
EN-DUMMY must be used instead of EN when SF3 for QUANTS or SF8
for REACTION contains the modifier code MXW, SPA or FIS.
Explanation must be given under the keyword INC-SPECT.
The data-heading keywords EN-MEAN and KT are used in a similar
manner.

EN-RES   **Resonance energy** (Family C)

Is used for resonance parameters. Resonance parameters are
flagged in dictionary 36 by a point in column 22. In dictionary
14 they are grouped together, but not flagged for computerized
handling.
This heading must be used for the resonance energy except when
SF5 of REACTION contains the code EN, in which case the resonance
energy is entered under the heading DATA.
Refer to Lexfor under Single-level resonance-parameters.

E   **Secondary energy** (Family E)

Is used for the energy of the outgoing particle considered.
Secondary energy must be coded:
- if SF5 for REACTION contains the modifier code PAR;
- if SF6 for REACTION contains the code DE or SPC.
When two or more particles are considered the headings E1, E2 etc
are used. These are explained under the keyword EN-SEC.

(independent variables, continued)

ANG, COS   Angle of outgoing particle (Family G)

   Are used for the angles when angular differential data are given.
   These headings must be used if SF6 for REACTION contains the code
   DA, except for LEG or COS coefficients.
   When two or more angles are considered, the headings ANG1, ANG2
   etc are used. These are explained somewhere in the BIB-section.

NUMBER   Legendre or cosine coefficients (Family N)

   Is used to give the coefficient-number of Legendre or cosine
   coefficients, coded as an integer with a decimal point.
   This heading must be used if SF8 for REACTION contains the code
   LEG or COS.

MOMENTUM L   Angular momentum   (Family 2)

   The angular momentum   must be specified for
   - strength-functions,
   - average level spacing,
   - reduced resonance-widths except when these have the factor 2g,
      2ag etc.
   The angular momentum is specified either using the column-heading
   "MOMENTUM L" or using the quantity ",L" under REACTION. The
   values are coded as fixed-point numbers with decimal point, if
   necessary with a sign.

ELEMENT, MASS, ISOMER   Variable product nuclei (Family I)

   When the "variable product nuclei" formalism (see page
   8.REACTION.6) is used, Z-number, mass-number and isomer of the
   product nuclei are entered as variables in the DATA table where
   they are coded as integer with decimal point under the headings
   ELEMENT, MASS, ISOMER respectively (unit: NO-DIM).

   The headings ELEMENT and/or MASS must be used when, and only
   when, REACTION SF4 contains the codes ELEM and/or MASS
   respectively.

   ISOMER is used only when both ELEMENT and MASS are present.
   For codes permitted under ISOMER see Dictionary 24 under ISOMER.

   See also below under DECAY-FLAG.

   In the case of "Pn-values" (see in LEXFOR under
   Delayed Fission Neutrons) the headings ELEMENT and MASS refer to

   ELEM/MASS coded in REACTION SF1.

(independent variables, continued)

<u>N-OUT, P-OUT</u>   <u>Variable number of emitted nucleons</u> (Family I)

        Under these headings (unit: NO-DIM) the number of emitted
        nucleons is entered in the DATA table (as integer with decimal
        point), when the "variable product nucleus" formalism (see page
        8.REACTION.8) is used and when REACTION SF3 contains the process
        codes XN, YP or XN+YP (see page 8.REACTION.4).

<u>HL</u>   This data-heading denotes an independent variable, e.g. for
        delayed fission-neutron groups. Compare in Lexfor under
        <u>Half-lives</u> and <u>Delayed Fission Neutrons</u>.

        Several Exfor compilers use the heading HL in the same way as the
        headings HL1, HL2; see further below.

3. Other column-heading keywords

-ERR, ERR- Data-heading keywords having the suffix -ERR or starting with
ERR- are called "associated quantities". Their meaning must be
explained under ERR-ANALYS.
If there exist data-heading keywords having a modifier of the
type -ERR1, -ERR2 etc then the data-heading keyword must always
be repeated as a code under the keyword ERR-ANALYS.

STAND No longer used. May still exist in old entries instead of MONIT.

MONIT This data-heading is used to give the data defined under MONITOR,
which must be present if MONIT is used. Compare page 8.MONITOR.

-NRM Data-heading keywords having the suffix -NRM refer to the MONIT
column in the same way as the data-headings EN, E and ANG refer
to the DATA column. Their presence requires the presence of the
BIB Keyword MONITOR.

HL1, HL2 etc. These data-headings are used to give the half-life values
of the nuclei specified under the keyword HALF-LIFE which must be
present if HL1 etc are used.

The half-life must be coded if SF4 for REACTION contains a
product with a metastable state extension (see page 8.2) and the
half-life is not coded under DECAY-DATA.

The data-heading keyword HL is usually an independent variable
which does not require explanation under HALF-LIFE, although it
has often been used in the same way as HL1, HL2 etc. If a
half-life column-heading is not explained under the BIB keyword
HALF-LIFE (as may occur in older entries) it refers to the
residual nucleus of the reaction.

See also in Lexfor under Half-lives.

ASSUM   This is used for data assumed by the author for the derivation of the results given, other than standard or monitor data, half-lives or other decay-data. The meaning of the ASSUM column(s) is explained under the keyword ASSUMED, which must be present if the data-heading ASSUM is used.

        See also in Lexfor under Assumed values.

FLAG   Flags are used to supply information about specific lines in a data-table.
The meaning of the flags is explained in the BIB Section under the keyword FLAG, which must be present if the data-heading flag is used.
The actual flags are fixed point numbers with decimal point (that is n. or n.n) under the data-heading FLAG; these numbers must all be repeated as codes under the keyword FLAG.
There may be more than one column with the data-heading FLAG.
(See page 5.5).
Flags must not be used in a COMMON Section.
See also in Lexfor under FLAG.

DECAY-FLAG When the "variable product nucleus" formalism (see page 8.REACTION.6) is used, "decay flags" are used for linking
- product nuclei coded in the DATA table under the headings ELEMENT, MASS, ISOMER (see above in this chapter),
- to related codes under the BIB keywords DECAY-DATA, RAD-DET, or PART-DET (see these keywords in chapter 8).

        The decay-flags are integers with a decimal point entered
- in the DATA table under the heading DECAY-FLAG (unit: NO-DIM), and
- in the BIB section, enclosed in parentheses, preceding the relevant codes under the above BIB keywords.

MISC   This is used for miscellaneous numerical data, which are pertinent to the subentry but cannot conveniently be given under a more specific heading.
The meaning of the data entered under MISC is explained under the keyword MISC-COL, which must always be present when the data-heading MISC is used.
If the keywords MISC1, MISC2, etc, are used, they must always be repeated as codes under the keyword MISC-COL.
The data-headings MISC etc should not be given in the COMMON-Section, where it is meaningful in exceptional cases only.
In 1979, headings MISC-ERR, MISC1-ERR etc were introduced without specifying in detail the necessary links to the keywords MISC and ERR-ANALYS.

        See also in Lexfor under Miscellaneous.

EMS   The headings EMS, EMS1 etc are used for "effective mass squared" of outgoing particles. To what particle or nuclide it refers , is defined under the BIB keyword EMS-SEC.

MOM-SEC   THe headings MOM-SEC, MOM-SEC1 etc are used for the linear momentum of outgoing particles. To what particle or nuclide it refers, is defined under the BIB keyword MOM-SEC.

Note: This was introduced for photonuclear data. For neutron data and CPND this formalism has not yet been used.

Chapter 7

DICTIONARIES

1. Transmission tapes for Dictionaries

Dictionary transmission tapes have much the same format as an EXFOR data transmission tape.

The first record is a TRANS record as described on page 3.3. The TRANS tape number starts with the digit "9". In col. 67 the centre identification "3" is used throughout.

The last record is an ENDTRANS record as described on page 3.3, where however, N_1 is blank. Instead, N_2 contains the number of Dictionaries transmitted. Trailing records to fill up the last block are repetitions of the ENDTRANS record.

Each Dictionary is identified by a Dictionary identification number ranging between 001 and 099.

Beginning and end of a Dictionary is identified by two system-identifier records:

(1) DICTION

This record must be the first one of each dictionary. N_1 and N_2 are interpreted as:

N_1 -   The Dictionary identification number
N_2 -   Date of last alter (year, month, day - YYMMDD)
N_3 - N_5:col. 34 blank; col. 35-66 title of Dictionary in free text.

  Col. 67-79: '300000NN00001' where NN is the dictionary number in cols. 73,74.
  Col. 80 blank or alter flag.

(2) ENDDICTION

This record must be the last one of each dictionary. N_1 is interpreted as:

N_1 -   Number of records in the dictionary, excluding the DICTION and ENDDICTION records.

The record identification is the same as in the DICTION record, except that the record sequence number in cols. 75-79 is "99999".

A Dictionary transmission tape always includes all Dictionaries. In NDS internal operations the absence of a certain Dictionary may be indicated by just giving its DICTION and ENDDICTION records.

For interim Dictionary updates see pages 7.5 - 7.9.

2. Format of Dictionaries

The Dictionaries contain explanations for all keywords and codes used in EXFOR. The format of the Dictionaries is in general similar to that of the BIB-Section in Exfor entries. There are 4 keyword Dictionaries:

Dict. 1   for System-Identifying keywords (compare Chapter 3);
Dict. 2   for Information-Identifying keywords to be used within the BIB-Section (compare Chapter 4);
Dict. 24   for Data-Heading keywords, and
Dict. 25   for Data-Units keywords, the latter two types of keywords being used in the COMMON and DATA Sections as Column-Headings (Compare Chapter 5).

The other Dictionaries explain codes to be used within the BIB-Section under specific Information-Identifying keywords (Copare Chapter 8).

For a table of dictionaries see page 7.10.

The Dictionaries contain the following items of information:

(1)   The **keyword or code** to be explained is given left adjusted in field 1 which is usually in cols. 1-11, but is longer in some cases. Keywords must not be longer than 10 characters. Codes may be restricted to a length of 3 or 5 characters, some may be longer. See the Table of Dictionaries on page 7.10.

(2)   The **explanation** is contained in the explanation field which usually starts in col. 12 (sometimes in col. 23) and usually (with some exceptions) ends in col. 66. The explanation may be given

- either in free text,
- or in an "expansion"
- or in an "expansion" followed by free text.

(3)   The "expansion" may be used to replace the code in an "edit" program, so that the Exfor user may read the entries without having to consult the Dictionaries for finding the meaning of the codes. Expansions are provided only in certain Dictionaries; others are considered as self-explanatory and easy to remember. The expansion is enclosed in parentheses, where the opening parenthesis is given in the first column of the explanation field (usually col. 12). The expansion is in general restricted to the length of the explanation field of one record, but for certain dictionaries (see page 7.10) the expansion may continue, within the explanation field, on the follow-up records.

(4)   The _free text_ may immediately follow the closing parenthesis of the
      expansion or, if no expansion is given, begin in the first column of
      the explanation field. It may continue, within the explanation
      field, onto any number of records. The free text may include
      parentheses but a left parenthesis which is part of the free text,
      must not be entered in the first column of the explanation field
      (where it would signal the presence of an expansion).

(5)   An "_obsolete flag_" (O=oh) in col. 80 indicates that the keyword or
      code given in the same record must not be used anymore in TRANS tapes
      but may still occur in EXFOR files that had been transmitted
      earlier. Explanation is given in free text why the code is obsolete
      and which code (if any) is to be used instead. Obsolete codes remain
      in the dictionaries until it was verified that the co-operating
      centers have removed them from their files.

      An "_extinct flag_" (X) in col. 80 indicates that the code given in the
      same record designates an extinct institute, journal or report
      series. The code is still valid in TRANS tapes but it will occur in
      entries with old data only and not with new data.

(6)   The _record identification field_ (col. 67-79) of a Dictionary record
      contains "30000" in cols. 67-71, the Dictionary identification number
      in cols. 72-74 with leading zero(s), and in columns 75-79 the record
      sequence number with leading zeros.

(7)   _Other coded information_ is included in some of the Dictionaries (e.g.
      the country of origin in the case of journal codes, certain flags for
      checking puposes in the case of Data Heading Keywords, etc.). For
      detail see pages 7.10 and following, and the Dictionaries themselves.

Described above is the _transmission_ format of the Dictionaries. It will be
the responsibility of each center to re-arrange the Dictionary information for
their own purposes, e.g. for optimum computer use, if they so wish.

Some examples of Dictionaries are shown in the following, omitting columns 67-80:

```
DICTION              3      930505 INSTITUTES                        C
1 CAN ALA  (UNIVERSITY OF ALBERTA,EDMONTON,ALBERTA)
1 CAN BUQ  (BISHOP'S UNIVERSITY, QUEBEC)
1 CAN CAN  (CANADA)
1 CAN CPO  (AECL COMMERCIAL PRODUCTS, OTTAWA)
1 CAN CRC  (A.E.C.L.,CHALK RIVER, ONTARIO)
1 CAN CRL  (CARLETON UNIVERSITY, OTTAWA, ONTARIO)
1 CAN GUE  (UNIV.OF GUELPH,ONTARIO)
1 CAN KQU  (KINGSTON, QUEEN'S UNIVERSITY) ONTARIO          .
1 CAN LUQ  (LAVAL UNIVERSITY, QUEBEC)
1 CAN MCG  (MCGILL UNIVERSITY, MONTREAL,QUEBEC)
1 CAN MCM  (MCMASTER UNIVERSITY, HAMILTON,ONTARIO)
1 CAN MGW  (MONTREAL, SIR GEORGE WILLIAMS UNIV.)


DICTION              5      930505 JOURNALS                          C
             NOTE= IN CINDA, 5-CHAR JOURNAL-CODES (E.G. ACR/A)
                   ARE CONVERTED TO 4-CHAR CODES BY OMITTING THE
                   SLASH (E.G. ACRA). 4-CHAR CODES REMAIN THE
                   SAME, EVEN IF THEY INCLUDE A SLASH.
                   THE CINDA-CODE FOR JNE/AB IS JNAB.
             -------------------------------------------------------
AAA          (ASTRON.AND ASTROPHYS.) ASTRONOMY AND ASTROPHYSICS 2GER
AAB          (AN.ACAD.BRASIL.CIENC.)ANAIS DA ACADEMIA BRASILEIRA3BZL
             DE CIENCIAS
AAF          (ANN.ACAD.SCI.FENN.SER.A6) ANNALES ACADEMIAE       2SF
             SCIENTIARUM FENNICAE,SERIES A6:PHYSICA
AANL         (ATTI ACCAD.NAZ.LINCEI,REND.,CL.SCI.FIS.,MAT.NAT.) 2ITY
              ATTI DELLA ACCADEMIA NAZIONALE DEI LINCEI (ROMA),
             RENDICONTI, CLASSE DI SCI.FIS.,MATEM.E NATURALI
AAST         (ATTI ACCAD.SCI.TORINO,CL.SCI.FIS.MAT.NAT.)        2ITY
             ATTI DELLA ACCADEMIA DELLE SCIENZE DI TORINO, CLASSE
             DI SCIENZE FISICHE, MATEMATICHE E NATURALI


DICTION              24     930505 DATA-HEADING KEYWORDS             C
             ==========================================================
             ENERGY OF INCIDENT PARTICLE
             ==========================================================
EN           ENERGY OF INCIDENT PARTICLE, LAB-SYSTEM                 A
             ===NOTE= THE SAME DEFINITION APPLIES TO ALL FOLLOWING
             CODES STARTING WITH 'EN' (EXCEPT WHEN 'CM' IS GIVEN)
EN-NM        EN FOR NUMERATOR OF REACTION RATIO                      A
EN-DN        EN FOR DENOMINATOR OF REACTION RATIO                    A
EN-APRX      APPROXIMATE VALUE OF 'EN'                                A
EN-CM        INCIDENT PARTICLE ENERGY IN C.M.SYSTEM                   A
EN-MIN       LOW LIMIT OF 'EN' RANGE                                  A
EN-MIN-NM    LOW LIMIT OF 'EN' RANGE F.NUMERATOR OF REACTION RATIO A
EN-MIN-DN    LOW LIMIT OF 'EN' RANGE F.DENOMIN. OF REACTION RATIO A
```

3. Alteration of Dictionaries

The format of dictionary update records and the resulting alterations
(actions) are described in the following:

First record:

```
Col. 1 -  5    ALTER
     6 - 16    blank
    17 - 22    YYMMDD. "Date of update." (If this field is blank, then
               "Today's date" is inserted into the DICTION record of all
               altered dictionaries).

    23 - 44    blank
    45 - 80    Free text, e.g. reference to relevant Memo(s).
```

Last record:

```
Col. 1 -  8    ENDALTER
     9 - 11    blank
    12 - 80    Free text
```

Alteration records:

1) **Change**

```
Col.  1 - 11    Same as Col. 1-11 of the record to be changed.
     12 - 66    New text to replace old text.
     67 - 79    ID of record to be changed.
     80         'C'

     Action:    The record having the specified ID has the old text
                (Col. 12-66) replaced by the new text (if Col. 1-11
                agree) and flagged as a change (C). The obsolete/
                extinct flag remains unaltered.
```

2) **Delete**

```
Col.  1 - 11    Same as Col. 1-11 of the record to be deleted.
     12 - 66    Free text. E.g., reason for deletion and/or reference
                to relevant 4C-Memo.
     67 - 79    ID of record to be deleted
     80         'D'

     Action:    The record having the specified ID is deleted (if Col.
                1-11 agree), and the preceding record flagged.
```

3) <u>Insert</u>

    (a) Insertion of a single record

    Col. 1 - 66   Text of record to be inserted
         67 - 79   ID of record <u>after</u> which insert is to be made
         80   'I'

    (b) Insertion of several consecutive records

First record as above
Continuation records:
Col. 1 - 66   Text of record to be inserted
     67 - 74   As a) above.
     75 - 80   Continuation number, starting with 2, right adjusted
              without leading zeros

     Action: The records are inserted following the record having
               the ID specified on the first insert card, and each
               inserted record is flagged (I).

    (c) Insertion of an entire new dictionary

Fist record:
Col. 1 - 7   'DICTION'
    21 - 22   dictionary number
    35 - 66   free text (title of dictionary)
    67 - 79   '300000NN00001' (NN=dictionary number)
    80   'I'

Dictionary records:

Col. 1 - 66   dictionary information
    67 - 74   '300000NN' (NN=dictionary number)
    75 - 80   blank

Last record:
Col. 1 - 10   'ENDDICTION'
    11 - 66   blank
    67 - 79   '300000NN99999' (NN=dictionary number)
    80   blank

4) <u>Obsolete/Extinct</u>

    Col. 1 - 11   Same as col. 1-11 of the record to be flagged as
                 obsolete/extinct
       12 - 66   Free text. E.g., reason for obsoletion and/or
                reference to relevant Memo. (This text will not
                show up in the Dictionary.)
       67 - 79   ID of record to be obsoleted.
       80   'O' (letter Oh), or 'X'.

       Action: The flag 'O' or 'X' is added to the record having the
                 specified ID if col. 1-11 agree.

Notes: 1) Records may be in any order, except for the ALTER and ENDALTER
            records, which must be first and last, respectively; also, for
            a multiple insertion, the records must be in the correct order,
            by continuation-number.

        2) If a specific code (as opposed to its associated text) is to be
            changed, the record must be deleted and the new code and text
            inserted. (Changes of codes should rarely happen.)

        3) In order to remove an obsolete/extinct flag in col. 80 the
            record must be deleted, and the same record inserted, without
            the flag.

        4) A combination of flags in the same dictionary update record is
            not possible. For example: A record cannot be inserted and
            obsoleted in the same run; it must be inserted and then
            obsoleted at the next update run.

        5) The alter flags of the alter records do not show up on the
            dictionary transmission tape. However, alter flags do show up
            in the printed dictionaries distributed by NDS. These are
            retrieved from an NDS-internal dictionary version having a
            record length of 88, where

            - col. 81 = the alter flags C,D,I, or T as defined for EXFOR
                         entries (see page 2.6)

            - col. 82 = the obsolete/extinct flag

            - col. 83-88 = date of last change.

4. Procedure for Updating and Transmitting Dictionaries

According to Section E of the Protocol, NDS is responsible for maintaining the Master File of the Dictionaries and transmitting it to the cooperating centers in regular intervals.

a) Introduction of new codes and Dictionary alterations

Dictionary alterations include additions, corrections or deletions (complete deletions or adding of the "obsolete/extinct" flag, see page 7.6).

The cooperating Centers are invited to propose new codes or any other code and explanation to be entered in the Dictionary and, if appropriate, a corresponding Manual entry (e.g. Lexfor entry) and/or a pertinent bibliographic reference.

NDS is responsible for checking the consistency of proposed alterations with other codes and with the Exfor Manual. The cooperating Centers should assist by checking, within their respective areas, the up-to-date status of the Dictionaries for Laboratories and bibliographic References. NDS is given some latitude in the formulation of a proposed Dictionary entry but must not change the meaning without the approval of the originating centre. In questionable cases NDS shall consult with the other Centers.

A proposed Dictionary alteration which appears to NDS to be trivial ("inconsequential") will be added to the Dictionaries within a week after receipt. Other proposals, which appear to NDS less trivial ("consequential", in particular alterations to Dictionaries 1, 2, 4, 13, 16, 24, 30-34, or any alterations which may entail changes in computer programs) will be entered to the Dictionaries only after approval by the Centers (either after explicit approval, or after implicit approval by lack of an objection within four weeks.)

If a Center uses, in a data transmission, a new Dictionary-code prior to its inclusion in the relevant Dictionary, the Center must be prepared to correct the entry and re-transmit it, if the new code does not find approval. Disapproval must be expressed (for example by telex) within a fortnight after receipt of the transmission. If no disapproval is expressed, NDS will enter the new code into the relevant Dictionary, whenever NDS discovers it and if its meaning is obvious.

In general, a Dictionary alteration becomes effective with its transmission to the cooperating Centers. Entries compiled or transmitted earlier need not be updated according to later Dictionary alterations, except when the contrary is explicitly agreed.

b) Routine Transmission of Dictionaries

Each Dictionary update is transmitted to all cooperating Centers in the form
of a copy of a listing of the input records. Such update pages are numbered
sequentially as "Rev. n" to the last complete Dictionary transmission. (NNDC
receives these Dictionary updates on tape.)

At latest every three months, or whenever a major alteration was made, NDS
will transmit to the cooperating Centers

- the complete Dictionary file on magnetic tape;

- in printed form those Dictionaries which have been changed since the
  last transmission.

    (See page 9.9)

A Dictionary Transmission Tape will have a label stuck on the outside
indicating the transmission tape number.

It is the responsibility of each Center to verify that Exfor information is
compiled according to the latest version of the Dictionaries.

5. Table of Dictionaries

Number	Name	Max code length	Expansion provided	Additional information see page:
†1.	System-Identifier Keywords	10	–	–
†2.	Information-Identifier Keywords	10	yes	7.11
3.	Institutes	7*	yes ext	7.12
†4.	Reference Type	1	yes	7.13
5.	Journals	6*	yes	7.13
6.	Reports	11	–	7.14
7.	Books and Conferences	10	yes(ext)*	7.15
8.	Elements	6	yes	–
†9.	Chemical Compounds	7 to 10	yes	7.16

10.-14.   ISO-QUANT subfields

Number	Name	Max code length	Expansion provided	Additional information see page:
-10.	Process/Parameter (Quantity SF1)	3	–	–
-11.	Function (Quantity SF2)	3	–	–
-12.	Modifier (Quantity SF3)	3	–	–
†13.	Particle (PART-DET and Quantity SF4)	3	yes	–
-14.	Quantity (SF1-4)	18	yes ext	–
15.	HISTORY	1	yes	–
16.	STATUS	5	yes	–
17.	REL-REF SF1	1	yes	–
18.	FACILITY	5	yes	–
19.	INC-SOURCE	5	yes	–
20.	Additional Results (ADD-RES)	5	yes	–
21.	METHOD	5	yes	–
22.	DETECTOR	5	yes	–
23.	ANALYSIS	5	yes	–
24.	Data-Heading Keywords	10	–	7.17
25.	Data-Unit Keywords	10	–	7.18
27.	Nuclides	10	*	7.19

28.-36.   REACTION subfields

Number	Name	Max code length	Expansion provided	Additional information see page:
†28.	Incident Particles (REACTION SF2)	3	yes	–
†29.	Product Particles (REACTION SF3)	3	yes	–
†30.	Process (REACTION SF3)	3	–	–
†31.	Branch (REACTION SF5)	5+	–	–
†32.	Parameter (REACTION SF6)	3	–	–
†33.	Particles Considered (REACTION SF7)	3	yes	–
†34.	Modifiers (REACTION SF8)	3	*	7.20
35.	Data-Type (REACTION SF9)	5	yes	–
36.	Quantities (REACTION SF5-8)	44*	yes ext	7.20
41.	Conversion table of Quantity (Dict. 14) to REACTION formalism (one-to-one correspondence to Dict. 14)	18	yes	7.21
42.	CINDA Quantities	3	yes	–

*   Additional information given on the following pages.

†   Additions to these dictionaries require NRDC approval

–   No longer used, but codes according to these Dictionaries may still exist in old entries

+   Normally limited to 3-charater code

ext Expansion may extend to follow-up records. In all other cases the expansion is restricted to the length of the explanation field of one record.

6. Additional information on specific dictionaries

Dictionary 2.   Information-Identifier Keywords

The first record for the keyword given in cols. 1-11 has the following format:

```
Cols. 12 - 33: Expansion
      34 - 44: Code designating whether keyword is required
               REQ  - required
               XREQ - required except where not relevant
               AREQ - one of these codes required
               BREQ - each of these keywords is obligatory when relevant,
                      but at least one of them must be present
               OBS  - keyword obsolete; may exist in older entries
      45 - 55: Code defining coded information
               RCODE  - code required
               OCODE  - optional
               OCODE+ - optional; if given, may be repeated in free text
      56 - 66: Pointer to dictionary used, '+' indicating additional coded
               information
```

Following records contain free text information in columns 12-66.

Dictionary 3. Institute ("Lab-codes")

The 7-character code nBBBCCC is constructed as follows:

   n = service-area as agreed among the neutron data centers (1 = USA,
          Canada; 2 = European OECD countries and Japan; 4 = USSR; 3 = all
          other countries) (Compare "Protocol" p.2)
 BBB = country (three characters; the third character may be blank)
 CCC = institution or "lab" (two or three characters, left adjusted)

When the 7-character code identifies a country only, without specifying an
institution, the code in field BBB is duplicated in field CCC as for example,

    1CANCAN   (CANADA).

In CINDA the CCC code alone is used, therefore, the CCC codes must be unique.

An extinct flag 'X' in col. 80 indicates an institution that was either closed
down or continued under a different lab-code. An extinct code remains valid
in TRANS tapes but it can occur only in entries with old data and not with new
data.

The dictionary as included in the Dictionary TRANS tapes, is sorted by the
7-character code. In the printed form, NDS also distributes another version
(Dictionary "3S") sorted by the CCC code; this version includes only one line
per dictionary entry so that part of the explanatory text may be omitted.

The style of the expansion should agree to the following principles:

   1. The expansion has the purpose to enable the user to identify the
      institute. Instructions for compilers (like old names) follow the
      expansions in the free text.
   2. No country code in the expansion.
   3. Do not repeat the city name if already given in the institute's name.
   4. City name should always be present, and should be in the original
      language, if appropriate.
   5. Where necessary, original language name and English translation should
      both be given, separated by an equal sign, with the original language
      name first.
   6. Use commonly known abbreviations where necessary.
   7. Expansions are limited to 2 lines.

Dictionary 4.   Type of reference

This dictionary has normal format except that columns 56-61 of the explanation field are reserved for the term "DICT n" pointing to the dictionary number 'n' which contains the reference codes to be used with the given reference type. Columns 56-61 are blank when no dictionary applies.

Dictionary 5.   Journals

The actual journal code is restricted to 4 characters or less.

Where journals are subdivided into parts, the part is included in the dictionary with the journal code, and separated from it by a slash, as for example:

ND/A = Nuclear Data, Part A.

Such codes have presently a maximum length of 5 characters (with one exception: JNE/AB).

Note: The same journal codes are also used in CINDA (with one exception: the CINDA code of JNE/AB is JNAB).

The country of publication is coded in columns 63-66 in the form nBBB as described above for Dictionary 3.

The "expansion" follows the commonly adopted style of abbreviations for journal titles, in particular "INIS: Authority List for Journal Titles", IAEA-INIS-11. However, too cryptic abbreviations (e.g. "J.Phys."), although commonly used, are avoided and clearer abbreviations are used instead (e.g. "J. of Physics" and "J. de Physique").

An extinct flag 'X' in col. 80 indicates a journal that was either discontinued or continued under a different journal code. An extinct code remains valid in TRANS tapes but it can occur only in entries with old data and not with new data.

The Dictionary included in the Dictionary TRANS tapes is sorted by the journal codes. In printed form, NDS also distributes another version (Dictionary "5S") sorted by country; this version includes only one line per dictionary entry so that part of the explanatory text may be omitted.

Dictionary 6.   Reports

Each code in the dictionary consists of the alphanumeric character string
which precedes the actual report number. The final character of the codes
given in the dictionary is always a hyphen (-), except in a few cases where
the report code is 11 characters and the 12th character is a hyphen. In such
cases the hyphen is dropped in the dictionary.

The explanation field is limited to cols. 12-59 in the main record, and cols.
12-66 in continuation records.

The 7-character institute code (as in Dictionary 3) of the institute at which
the report was issued is given in columns 60 to 66.

An extinct flag 'X' in col. 80 indicates a report series that was discontinued
or continued under a different report code. An extinct code remains valid in
TRANS tapes but it can occur only in entries with old data and not with new
data.

The dictionary as included in the Dictionary TRANS tapes is sorted on this
institute code and, within the institute code, by report code. In the printed
version, NDS also distributes another version (Dictionary "6S") sorted by
report codes; this version includes only one line per dictionary entry so that
part of the explanatory text may be omitted.

Note: The same report codes are also used in CINDA (with some exceptions when
the report code is too long for CINDA).

Dictionary 7.   Books and Conference-Proceedings

Book codes are up to 8 characters long and give a concise short title of the book, or the family name of the first author. (Some older book codes have a length of 10 characters.)

Examples: ABAGJAN for the "Group Constants for Nuclear Reactor Calculations" by Abagjan, et al.
             NEJTRONFIZ for "Nejtronnaja Fizika".

Conference codes are composed of the "year of the conference" given in the first 2 digits of the code, followed by the "place of the conference", which may have up to 6 characters. (Some older conference codes have 2 digits plus 8 characters.)

Examples: 66PARIS
             68COPENHGN

Two conferences at the same place in the same year may be distinguished as shown in the following examples:

    66ANL   and 66ARGONNE
    80BNL   and 80BNL-2
    69WIEN   and 69VIENNA

If the proceedings of a conference can be identified by a report code, then the report code should be used and the conference code will be marked in the dictionary as obsolete.

In the dictionary, books, sorted alphabetically by code, precede conferences, which are sorted by year and alphabetically within year.

Note: The codes in this dictionary are also used in the CINDA file, which has a restriction to 8-character codes. For this reason, additions to this dictionary are restricted to 8-characters. Older 10-charater codes are truncated in the CINDA file. Note that the CINDA book may have longer codes created by the book editing program.

Expansions: In this Dictionary two expansions per code may be given, of which the first is limited to the size of the explanation field of one line (= pos. 12-66) whereas the second may extend over several lines. Both expansions are enclosed in parentheses. This means: Presence of an opening parenthesis in pos. 12 of the second line of a dictionary entry is the indicator that two expansions are given. Which of the two expansions will be used by a computer code will depend on the intention of the center and the space available in the output format. The first expansion will be as descriptive as possible within the limited space: It should include the first author and the (abbreviated) title in the case of books, resp. (abbreviated) title, place and year of the conference. The second expansion, if given, will contain the usual bibliographic information, in full.

Dictionary 9.   Chemical Compounds

The general compound code 'CMP' can be combined with any element in the form (Z-S-CMP) without entry in this dictionary, which lists only special cases.

The actual compound codes (e.g. OXI for oxide) are restricted to a length of three characters.

The codes are sorted by atomic number.

Note: The same chemical compound codes are also used in CINDA.

Dictionaries 10, 11, 12, 14 containing the codes to be used under ISO-QUANT, are no longer used.

Dictionary 24.   Data-heading keywords

These keywords are used in the COMMON and DATA sections as column headings for defining the contents of the columns.

Keywords in Dictionaries 24 and 25 must be unique, i.e. data-heading codes must not be identical to any data unit code.

The keywords, which have a maximum length of 10 characters, are meant to be more or less self-explanatory, so that no expansions are given in the Dictionary. The free text explanation is restricted to cols. 12-65.

Flags in col. 66 of Dict. 24

A flag in col. 66 is used (so far by NNDC only) for checking purposes so that different types of data columns (i.e. variables, error-columns, etc.) can be distinguished easier.

Family of data-heading keywords	Flags in col. 66 of Dict. 24		Category
	Variables	+Associated Quantities	
Incident Energy**	1	B	
Resonance Energy	C	D	
Secondary Energy**	E	F	1
Angle of outgoing particle**	G	H	
ELEMENT	I	*	
MASS, ISOMER	J	***	
MOM	M	R	
NUMBER	N	*	
N-OUT, P-OUT	O,P	*	
THICKNESS	K	*	
FLAG	Z	*	
TEMP	8	9	
HL	6	7	2
SPIN J	4	*	
MOMENTUM L	2	*	
PARITY	0	*	
various others	blank	blank	

*   No headings exist
** Except E-LVL-INI, E-LVL-FIN, EN-NRM, E-NRM, ANG-NRM
*** No headings exist except MASS-RSL which has no flag.
+   Associated quantities are those column-heading keywords which contain the characters ERR or RSL
Category 1 pertains to independent variables
Category 2 pertains to additional information which in certain cases may act as an independent variable

Dictionary 25.   Data-unit Keywords

The data units are entered in the "COMMON" and "DATA" section below the data
heading to define the units for the numerical data.

The format of the dictionary is as follows:

Column   1 - 10   data-unit keyword
         11   blank
         12 - 44   explanation of code (no expansion given)
         45 - 48   dimension code
         49 - 55   blank
         56 - 66   conversion factor

The dimension code provides a cross-link with Dictionary 36, (Quantity
Dictionary) where the dimension code is also given. This facilitates
computerized cross-checks as to whether quantities and units given in a table
are consistent.

The conversion factor is a floating point number which may be used for
transforming units with the same dimension to standard units, namely:

energies	to electron-volts;
angles	to degrees;
time	to seconds;
length	to meters;
cross sections	to barns.

Dictionary 27.   Nuclides

The format of the dictionary is:

Column   1 - 11   nuclide code
         12 - 26   flags in defined positions, enclosed in parentheses.

Free text may be given on successive records, starting in column 12.

1. The nuclide code has the format Z-S-A

    where   Z   is the charge number, up to 3 digits, no leading zeros;
            S   is the element symbol; 1 or 2 characters;
            A   is the mass-number; up to 3 digits, no leading zeros;
                a single zero denotes natural isotopic composition

2. <u>Columns 12-26</u> have the following structure:

Column 12   '('
       13 - 23   Each column contains either a flag or blank:
       13   used for target nuclides in REACTION SF1 when SF2≠0
                      '1' indicates validity,
                      'X' indicates a warning for unusual use.
       14   used for REACTION SF2
                      '2' indicates validity
       15   used for REACTION SF3, REACTION SF4, HALF-LIFE, ·
                   DECAY-DATA, DECAY-MON, RAD-DET, PART-DET and EN-SEC.
                      '3' indicates validity
                      'Z' indicates validity except for REACTION SF3,
                          PART-DET, and EN-SEC: i.e., those cases where the
                          particle codes are used instead of the corresponding
                          nuclide codes
       16   used for nuclides in Reaction SF1 when SF2=0
                      '4' indicates validity
       17 - 21   are presently unused
       22   used for CINDA
                      'C' indicates validity .
                      'T' indicates validity for theoretical work only
       23   used to indicate a stable isotope
                      'S' indicates stability
       24 - 25   isomer field:
                   either blank, idicating that the nuclide has no
                          isomeric states,
                   or   a number, right justified, indicating the
                          maximum number of metastable states,
                          (i.e., number of isomeric states not including
                          the ground state),
                   or   'A' indicating that the nuclide has one or more
                          short-lived (1 sec) isomer(s) but no long-lived
                          (1 sec) isomer. In this case, Z-S-A (without -G)
                          may be used to specify the gound state.
       26   ')'

The flags given in this dictionary cover the normal cases. A number of
special rules as described in Chapter 8 under REACTION, DECAY-DATA, etc., must
also be considered. For some special cases which can hardly be programmed in
a perfect way, see in Lexfor under <u>Nuclide checking</u>.

The dictionary is not intended to act as a Chart of Nuclides. Rare or
short-living nuclides, respectively flags in column 13-25, will be added only
at the time when the nuclide occurs in EXFOR or CINDA.

This Dictionary is not included in the printed version of NDS Dictionaries.

Dictionary 34.   Modifiers (REACTION)

An expansion is only given for those "general-purpose modifiers" at the beginning of the dictionary, which may be included in the REACTION code without entry in Dictionary 36.

Dictionary 36.   Quantities (REACTION)

The format of this dictionary is as follows,

            col. 1 - 18 quantity code (or longer, see item 5. below)
                 19 - 21 dimension code
                      22 special flag
                 23 - 66 expansion and free text.

1.   The quantity code is composed of the codes for the REACTION subfields 5 to 8. All meaningful combinations of the subfield codes that are in use are included. Note, however, that these quantity codes do not include the general modifiers RAW, REL, FCT, AV, SPA, MXW, FIS, A, (A), MSC from the beginning of Dictionary 34.

2.   The dimension code provides a cross-link to Dictionary 25 (units dictionary) where the dimension code is also given. This facilitates computerized checks of whether quantities and units given in a Table are consistent.

3.   In the special flag column, a point indicates that the quantity is a resonance parameter.

4.   The expansion is a short definition of the quantity. It may be used for edited output to customers.

5.   If the quantity code-length is >18 characters, the code is continued on the same record, followed by blanks and '9' in column 66. The dimension-code and the expansion follow on the next record in their assigned fields. - Maximum code-length = 44 characters.

Dictionary 41.   Conversion table of quantities used earlier under ISO-QUANT

This dictionary is used to convert the quantity in the ISO-QUANT formalism as used earlier to the REACTION formalism. The dictionary is supposed to include all quantity codes that may exist in EXFOR in ISO-QUANT formalism.

The format of the dictionary is as follows:

cols.   1 - 18   quantity code in ISO-QUANT formalism as given in the old
                   Dictionary 14;

        19 - 22   Z/A difference between product nucleus and target nucleus;
                   used for computing the product nucleus from the target
                   nucleus, e.g. "-1+0" for the (n,p) reaction);
                   blank when product nucleus is not coded under REACTION.

        23 - 66   equivalent REACTION code enclosed in parentheses, usually
                   excluding target nucleus and product nucleus; of the
                   product nucleus the code -G (or -M etc) is given to
                   indicate an isomeric state extension to be added to the
                   product nucleus.

Chapter 8

INFORMATION-IDENTIFIER KEYWORDS AND CODING RULES

1. Introduction

The information given in the BIB section is structured by means of information-identifier keywords (also called BIB keywords). This chapter gives the coding rules for codes and/or free text under each BIB keyword; it does not give physics definitions for the codes which can rather be found in LEXFOR.

The first part of this chapter (with pages ordered numerically) gives general rules for keywords and coding.

The second part of this chapter (with pages ordered alphabetically by keyword) is devoted to the specific rules for each keyword and the associated coding rules when these rules deviate in any way (restrictions or extensions) from the general format.

2. General coding rules

For each BIB keyword there are specific rules whether information is given in coded form and/or in the form of free text. Compare chapter 4 and in LEXFOR under Free Text.

Codes for use with a specific keyword are found in the relevant dictionary. In the BIB Section, a code is enclosed in parentheses, where the opening parenthesis is positioned in col. 12; compare page 4.2.

In general, more than one code from the same dictionary may be given under a keyword; in this case two possibilities exist:

a) both codes within the same set of parentheses, separated by a comma, for example:

    KEYWORD   (CODE1,CODE2) + free text , or

b) each code enclosed in own set of parentheses followed by free text, with the stipulation that each new code entry start in column 12, for example:

    KEYWORD   (CODE1) + free text ...
                   free text ...
                   (CODE2) + free text

Both of these possibilities, or a combination of the two are allowed, although for some keywords only b) is permitted. See Chapter 4 for the concepts of "codes and "free text".

For some keywords the coded string between the parentheses may include retrievable information other than a code from a dictionary (e.g. author names or numbers).

Embedded blanks are explicitly forbidden in the coding for many information-identifier keywords. With these exceptions, embedded blanks in the coding are tolerated if they follow a code from a dictionary, although this is not recommended. They are not permitted before any code.

Example: STATUS   (DEP   )   Yes
            STATUS   (DEP   ,COREL) Yes
            STATUS   (COREL, DEP)   No
            STATUS   (DEP, 10048007) No

See the detailed coding rules for each keyword!

3. Coding of nuclides

Nuclides appear in the coding of many keywords. The general format is Z-S-A-X, where

Z   is the charge number, up to 3 digits, no leading zeros;
S   is the element symbol; 1 or 2 characters; see Dictionary 8 for the agreed list of element symbols;
A   is the mass-number; up to 3 digits, no leading zeros;
X   is an isomer code denoting the isomeric state. It may have the following values:

G   for the ground state of a nucleus which has a metastable state,
M   if only one metastable state is regarded,
M1 for the first metastable state,
M2 for the second, etc.

If no isomeric state applies, "-X" is omitted and the nuclide is coded in the form Z-S-A.

Exceptions to this coding exist for the following cases:

target nucleus, coded in the first subfield under the keyword REACTION, see page 8.REACTION.2

incident particle and outgoing particle coded under REACTION, see page 8.REACTION.3

product nucleus, coded in the fourth subfield under REACTION, see page 8.REACTION.5.

For checking purposes a list of valid nuclide codes occuring in the EXFOR file, is maintained in Dictionary 27; see page 7.15. Compare also in Lexfor under Nuclide Checking.

4. <u>Keyword categories</u>

The detailed coding rules for each Information-Identifier Keyword are given on the following pages. According to some aspects of the coding rules, the keywords can be grouped in certain categories, which are shown on the next two pages. The table on page 8.4 shows that some of the keywords are

- obligatory: these must be present in either subentry 001 or in all subentries ≥002.

- obligatory, except when not relevant: these must usually be present, however occasionally they are not relevant and may be absent; see the detailed coding rules.

- obligatory for specific data-heading keywords: these must be present when certain data-headings are present in the COMMON or DATA Section: see the detailed coding rules; otherwise they are optional.

- all other keywords are optional.

The table on page 8.5 shows for each keyword a typical coding example and/or the numbers of the relevant Dictionaries. For certain keywords coded information is obligatory, for others optional. In general, the contents of the coded information should <u>not</u> be repeated in free text, since the coded information is either self-explanatory as in the case of AUTHOR, or the codes are expected to be expanded by an editing program as described on page 4.3. For others, the compiler has the option to indicate, as described on page 4.3, whether the editing program should expand the code or not.

It should be noted that the tables on pages 8.4 and 8.5 serve only as an aide-memoire but do not replace the detailed coding rules given on the subsequent pages.

5. <u>Keyword sequence</u>

The sequence of Information-Identifier Keywords is left to the discretion of the compiler. However, it is recommended to give the bibliographic information first (e.g. TITLE, AUTHOR, INSTITUTE, REFERENCE), followed by the physics information (REACTION, METHOD, etc) and book-keeping information (STATUS, HISTORY) in the end.

A keyword must not be repeated within one subentry. A keyword given in subentry .001 may be given again in the following subentries of the same entry, with the exception of the keyword REACTION.

6. Summary of keywords

The presence of the keyword is

Keyword	obligatory	obligatory except when not relevant	obligatory for specific data-heading
Bibliography			
TITLE	X		
AUTHOR	X		
INSTITUTE	X		
EXP-YEAR			
REFERENCE	X		
REL-REF			
MONIT-REF			
Data Specification			
REACTION	X		
Related Data			
MONITOR		X	MONIT etc
ASSUMED			ASSUM etc
DECAY-DATA			DECAY-FLAG
DECAY-MON			
HALF-LIFE			HL1 etc
PART-DET			
RAD-DET			
EN-SEC			E1 etc
EMS-SEC	-		EMS1 etc
MOM-SEC			MOM-SEC etc
ADD-RES			
MISC-COL			MISC etc
FLAG			FLAG
Physics			
INC-SOURCE			
INC-SPECT			EN-DUMMY
SAMPLE			
METHOD		X	
FACILITY	one of them	X	
ANALYSIS	obligatory	X	
DETECTOR		X	
CORRECTION			
ERR-ANALYS		X	...-ERR1 etc
COVARIANCE			
CRITIQUE			
COMMENT			
Book-keeping			
STATUS		X	
HISTORY	X		

Keyword	typical coding and/or Dictionary-number	when keyword present, coded information is ...	coded information should not be repeated in free text
Bibliography			
TITLE	free text only	–	–
AUTHOR	(A.B.AUTHOR)	obligatory	not
INSTITUTE	(3)	obligatory	not
EXP-YEAR	(year)	obligatory	not
REFERENCE	(4,5/6/7,vol,page,date)	obligatory	not
REL-REF	(17,acc#,AUTHOR,Ref.)	obligatory	not
MONIT-REF	(acc#,AUTHOR,Ref.)	obligatory	not
Data Specification			
REACTION	(Z-S-A-X(28,29/30)Z-S-A-X,36,35)	obligatory	not
Related Data			
MONITOR	as REACTION	optional	not
ASSUMED	(ASSUM1,REACTION)	optional	not
DECAY-DATA	(Z-S-A-X,HL,13,E,abund.)		not
DECAY-MON	as DECAY-DATA	obligatory	not
HALF-LIFE	(HL1,Z-S-A-X)	optional	not
PART-DET	(13) or (Z-S-A-X)	obligatory	optional
RAD-DET	(Z-S-A-X,13)	obligatory	not
EN-SEC	(E1,13 or Z-S-A-X)	optional	not
EMS-SEC	(EMS1,13 or Z-S-A-X)	optional	not
MOM-SEC	(M1,13 or Z-S-A-X)	optional	not
ADD-RES	(20)	optional	optional
MISC-COL	(MISC1)	optional	not
FLAG	(1.)	obligatory	not
Physics			
INC-SOURCE	(19)	optional	optional
INC-SPECT	free text only	–	–
SAMPLE	free text only	–	–
METHOD	(21)	optional	optional
FACILITY	(18) or (18,3)	optional	optional
ANALYSIS	(23)	optional	optional
DETECTOR	(22)	optional	optional
CORRECTION	free text only	–	–
ERR-ANALYS	(DATA-ERR1)	optional	not
COVARIANCE	free text only, or (COVAR)	–	–
CRITIQUE	free text only	–	–
COMMENT	free text only	–	–
Book-keeping			
STATUS	(16) or (16,Acc#)	optional	not
HISTORY	(770630X)	obligatory	not

ADD-RES

1. Under this keyword information is given about any additional results which were obtained in the experiment but which are not compiled in the DATA Section of the Exfor entry.

2. This keyword is optional. There may be free text, or coded information with or without free text.

3. If coded information is given it may be in either of the general formats described on page 8.1 using code(s) from Dictionary 20.

8.ANALYSIS

ANALYSIS

1. This keyword is used to give relevant information as to how the experimental results have been analyzed to obtain the values given under "DATA" which actually represent the result of the analysis. See in Lexfor under ANALYSIS.

2. At least one of the keywords METHOD, FACILITY, DETECTOR, ANALYSIS must be present with coded information. Within this restriction, coded information is optional.

3. If coded information is given it may be in either of the general formats described on page 8.1 using code(s) from Dictionary 23.

8.ASSUMED

ASSUMED

1. This keyword is used to define the meaning of columns in the COMMON- or DATA-sections headed by ASSUM and its derivatives. Such columns contain values assumed in the analysis of the data.

2. The keyword is obligatory when such headings are present, and coded information is required. The keyword may be used with free text only, if these headings are not present.

3. The format of the coded information is

    (heading,REACTION-code)

    Where the heading field contains the data-heading to be defined, and the REACTION-code is given in exactly the same way as for the keyword REACTION.

4. If two or more columns of assumed data are given under the headings ASSUM1, ASSUM2 etc., a separate line must be used for each heading.

AUTHOR

1. This keyword is used to give the authors of the work reported.

2. This keyword is obligatory and must have coded information, i.e. the name(s) in some standardized form.

3. All author names are given within one set of parentheses, separated by commas. Names are written according to following conventions:

   Initials and family name are written in the normal way, i.e., A.B.NAME. Hyphenated family names, 2-character initials (as in the transliteration of some Cyrillic characters), and any other deviations from what may be normal, are permitted. For a family name modified by 'Junior', JR is entered following the family name and separated from it by a blank.

   Blanks are permitted between authors' names, i.e. after a comma, but are not permitted following initials.

   The author names may be continued on the next record, but names should not be broken, i.e., the last character on the line to be continued should be a comma.

   Examples:

   | AUTHOR | (A.B.JONES, L.POZA-LOBO, YA.M.IVANOV, NGO-DINH-LONG, A.MORALES AMADO) |

   AUTHOR   (A.B.JONES, L.POZA-LOBO, YA.M.IVANOV, NGO-DINH-LONG,
                  A.MORALES AMADO)

   AUTHOR   (A.B.JONES,L.POZA-LOBO,YA.M.IVANOV,NGO-DINH-LONG,
                  A.MORALES AMADO)

   AUTHOR   (W.W.HAVENS JR)

For further details and, in particular, for transliteration of author names given in Cyrillic characters, see in Lexfor under AUTHOR.

CMPD-QUANT

This keyword was used in pre-1978 entries for neutron data referring to chemical compounds, alloys or mixtures. Since 1977 the Keyword REACTION is used instead.

COMMENT

1. This keyword is used to give pertinent information which cannot logically be entered under another of the keywords available. See also in LEXFOR under Comment.

2. This keyword is optional and contains free text only.

CORRECTION

1. This keyword is used to give information about corrections applied to the data in order to obtain the values given under 'DATA'. See also in LEXFOR under CORRECTION.

2. This keyword is optional and contains free text only.

COVARIANCE

1. This keyword is used to give covariance information provided by the author
    of the data.

2. This keyword is optional and contains covariance information in a free
    format; compare in LEXFOR under Covariance.

3. In the case that the covariance information is too bulky to be included in
    the limited space of the BIB-Section, it may be given in a separate
    Covariance File, whose existence is indicated by the code (COVAR) in col.
    12-18 under the BIB-Keyword COVARIANCE, which may be followed by free text.
    For the format of the Covariance File see in LEXFOR under Covariance.

CRITIQUE

1. This keyword is used to give comments on the quality of the data presented
    in the data table. See also in LEXFOR under Comments.

2. This keyword is optional and contains free text information only.

DECAY-DATA

A.   General items

1.   This keyword is used to give the decay-data for any nuclide occurring in
     the reaction measured, as assumed by the author for obtaining the DATA
     given. See also in LEXFOR under Decay-Data. Decay-data relevant to the
     monitor reaction are coded under the keyword DECAY-MON and not under
     DECAY-DATA.

2.   Keyword is optional, but obligatory when the keyword RAD-DET is present.
     Usually coded information is given with or without free text; free text
     without coded information is also accepted. If the keyword DECAY-DATA is
     present, the keyword HALF-LIFE must not be present. Half-life values
     given under the data headings HL1, HL2, etc. in the COMMON or DATA
     Section, must be explained under the keyword HALF-LIFE, not under
     DECAY-DATA.

3.   If decay data is given in coded form for more than one nuclide, then each
     must be coded separately, starting in col. 12. The coded information can
     then be linked to the corresponding REACTION code by using pointers.

B.   Coding rules

     The general format of the coded information is

          (nuclide,half-life,radiation)

     The coded information may extend over more than one line, but no numerical
     value or code from a Dictionary may extend over two lines. Embedded
     blanks are permitted in the code only at the beginning of a field or
     subfield. Example g) below shows how codes can be arranged as to improve
     the readability.

     When the "Variable Product Nucleus" formalism is used (see pages
     8.REACTION.8 and 6.11), the coding string may be preceded by a
     "decay-flag", which links the DECAY-DATA entry to a line in the DATA
     table, where the product nucleus is coded. The "decay-flag" is coded as
     an integer with a decimal point and enclosed in parentheses as follows:

          ((n.)nuclide,half-life,radiation)

1.   Nuclide field. The general format of the code is Z-S-A-X. See page 8.2.

     Absence of an isomer extension (-X) indicates the ground-state. For
     nuclides having one or more metastable states the isomer extension '-G'
     for the ground state should be given though it is not compulsory.

2. Half-life field. This field contains the actual half-life of the
nuclide specified.

This field may be omitted, in which case the following comma must be
included, unless the radiation-field is also omitted, in which case the
closing parentheses immediately follows the nuclide.

The format is nnnUNIT, where
- nnn is a fixed-point number with decimal point, or an E-format number
with E and without blanks;

- UNIT is a code from dictionary 25 having the dimension TIME. This
code follows the numeric value without a blank in between.

      Examples: 2.45MIN
                   2.412E4YR
                   3.6E+03YR

Unfortunately, the HL-uncertainty can be given only in free text.

3. Radiation field. This field may be omitted, in which case the closing
parenthesis immediately follows the half-life. This field may also be
repeated, each radiation field being separated by a comma. Absence of any
subfield must be indicated by including the separating comma; trailing
commas are not included.

The field consists of three subfields

      (nuclide,half-life,SF3,SF4,SF5)

SF3. Type-of-radiation: A code from dictionary 13.

In the case of two or more simultaneous decays, two or more codes may be
given, each separated by a slash. (See example b).

SF4. Energy: The energy of the radiation in keV. It is coded as a
fixed-point number with decimal point or an E-format number with E
(compare page 5.3), without a blank. No unit is coded.

In the case of two or more unresolved decays, two or more energies or a
lower and upper energy limit may be given, each separated by a slash; see
Example f.

SF5. Abundance: The abundance of the observed radiation per decay. It is
coded as a fixed-point number with decimal-point (compare page 5.3),
without blank. The abundance is usually smaller than 1. or equal to 1.
but may have, e.g., the value 2. if there are two gammas per decay.
Example: Abundance = 1.81 (or 181%) for the 511.keV gamma-line of Na-22.

SF4, SF5. Multiplets: In cases where unresolved doublets (or multiplets)
of gamma-rays were used in the publication, the energies of all involved
gamma-rays, or at least the lowest and the highest energy, should be given
separated by a slash. Thus, two energy values given can mean a doublet or
the borders of an energy range containing all (unresolved) gamma-rays
which were used for analysis on the whole.

Example:

DECAY-DATA (Z-S-A-X,n.nHR,DG,E_1/E_2,I_{12})

Here I_{12} means the total abundance of the two gamma-rays E_1 and E_2, or of all gamma-rays lying between the limits E_1 and E_2, respectively.

In the case of gamma-rays the <u>photon</u> abundance <u>must</u> be given.

C.   Examples of coding for DECAY-DATA

a.   DECAY-DATA   (40-ZR-89-M) (half-life and radiation omitted)
                              in this case information on the decay-data of the
                              nucleus specified is given in free text

b.   DECAY-DATA   (60-ND-140,3.3D) (radiation-field omitted)
                  (59-PR-140,,B+/EC,,0.500)
                              (half-life and radiation-SF2 omitted)

c.   DECAY-DATA   (25-MN-50-G,0.286SEC,B+,6610.) (radiation-SF3 omitted)

d.   DECAY-DATA   (25-MN-50-M,1.76MIN,DG,785.,,B+)
                              (two radiation-fields, the second with SF2 & SF3
                              omitted)

e.   DECAY-DATA   (60-ND-138,5.04HR,DG,328.,0.065)
                              (all fields and subfields present)

f.   DECAY-DATA   (60-ND-139-M,5.5HR,DG,708./738.,0.64)
                              (the abundance given is the total abundance of
                              both gamma rays)

g.   DECAY-DATA   (60-ND-139-G,30.0MIN,B+,,0.257,DG,405.,0.055)
                              (two radiation fields)
                  (60-ND-139-M,5.5HR,DG,738.,0.37,DG,982.,0.29,DG,708.,0.27,DG,
                  403.,0.03,B+,,0.006) (five radiation-fields, extending over
                              2 records)

This last example could also be entered in the following way:

g.   DECAY-DATA   (60-ND-139-G,30.0MIN,B+,,0.257,
                                    DG,405.,0.055)
                  (60-ND-139-M,5.5HR,DG,738.,0.37,
                                    DG,982.,0.29,
                                    DG,708.,0.27,
                                    DG,403.,0.03,
                                    B+,,0.006)

DECAY-MON

1. This keyword is used to give the decay-data for any nuclide occurring in the monitor reaction, as assumed by the author for the monitor value given.

2. Keyword is optional; it may be used only if the keyword MONITOR is present. Coded information is obligatory, with or without free text.

3. The coding rules are identical with those under the keyword DECAY-DATA, except that the flag field is not permitted. See pages 8.DECAY-DATA. DECAY-MON relates to the keyword MONITOR in the same way as DECAY-DATA to REACTION.

DETECTOR

1. This keyword is used to give information about the detector(s) used in the experiment. See also in Lexfor under Measurement Techniques.

2. This keyword must be present except when not relevant. At least one of the keywords METHOD, FACILITY, DETECTOR, ANALYSIS must be present with coded information.

3. Free text may be given or code(s) from Dictionary 22 with or without free text. If this Dictionary contains a relevant code then this should be given.

    Coded information is given in either of the general forms, see page 8.1.

4. If the code 'COIN' is used, then the codes for the detectors used in coincidence must follow within the same parentheses;

        e.g. (COIN,NAICR,NAICR).

    In this case any other detectors used must be coded separately starting in col. 12.

EMS-SEC

1. "EMS" means "effective mass squared". This keyword is used to give
    information about the EMS of outgoing particles, either in free text or in
    "coded" form with or without free text.

    When EMS data are given in the data table under the headings EMS1, EMS2
    etc, the "coded information" under the keyword EMS-SEC defines, to what
    particle or particle system the data headings refer.

2. The use of this keyword is optional. But the keyword must be present when
    the data-heading keywords EMS1, EMS2, etc, are used in the data. Free
    text may be given or coded information, with or without free text.

3. The format of the coded information is:

    EMS-SEC   (heading,particle) ADDITIONAL FREE TEXT IF ANY

    The heading-field EMS-SEC contains the data-heading keyword or the root of
    the data heading to be defined. Root means that the data heading given
    will also define the same heading followed by -MIN, -MAX or -APRX.

    The particle-field contains the particle (Dict. 13) or nuclide (see page
    8.2) to which the data heading keyword refers. Permitted nuclei are
    indicated in Dictionary 27 by a '3' in column 15.

4. If more than one effective mass data-heading keyword is defined, eash is
    coded on a separate record, starting in column 12.

    Example: EMS-SEC   (EMS1,N)
                          (EMS2,P+D)

Note: This was introduced for photonuclear data. For neutron data and CPND
this formalism has not yet been used.

EN-SEC

1. This keyword is used to give information about secondary energies, either in free text or in coded form with or without free text.

   Coded information serves the purpose of specifying, to which particle or nuclide a secondary energy refers which is given in the COMMON or DATA Section under the data-heading keywords E, E1 etc. or Q-VAL, LVL-NUMB etc., or their derivatives.

2. The keyword is optional. But when one of the data-heading keywords En (with n = 1, 2, etc.) is present, then keyword and coded information are obligatory.

   If a data-heading keyword E is not defined under EN-SEC, it refers to the same particle to which the code DE (or PAR or SPC) within the REACTION code refers.

3. The coding format is

   EN-SEC   (heading,particle) ADDITIONAL FREE TEXT Il ANY

   The heading-field   contains the secondary-energy data-heading keyword to be explained,

   the particle-field   contains the particle or nuclide to which the secondary-energy data-heading refers. The code is

   either a particle-code from Dictionary 13

   or a nuclide coded in the standard format as described on page 8.2.

4. More than one secondary-energy column-heading may be explained this way. Each must be coded separately starting in col. 12.

   Example:

   EN-SEC   (E1,G)
               (E2,G)
               (E-EXC,3-LI-7)

5. Different derivatives of the same heading-keyword (e.g. E2, E2-MIN, E2-MAX, E2-APRX) require a single explanation only

   EN-SEC   (E2,G)

6. If under EN-SEC a relative kinetic energy between two particles is given, then the particle codes are not included within the parentheses but given in free text only.

ERR-ANALYS

1. This keyword is used to give free-text explanation of the sources of data
   uncertainties and of the uncertainty values given in the COMMON or DATA
   sections as identified by specific column headings (such as DATA-ERR1,
   ERR-, ANG-RSL, HL3-ERR, etc.).   See also in LEXFOR under Errors.

2. The keyword is obligatory except when not relevant.   Free text may be
   given or coded information with free text.

3. The coded information is of the form:

   > (heading) free text

   where (heading) contains the repetition of the column-heading keyword
   (e.g. DATA-ERR) that occurs in the COMMON or DATA section, and the free
   text following contains the explanatory information.   (Heading) may be
   omitted, if the only heading to be defined is 'DATA-ERR'.

   Permitted column-heading keywords are all keywords from Dict. 24 that
   contain the character sequences 'ERR' or 'RSL' (e.g. EN-ERR-1, ERR-6,
   +ANG-RSL etc.) or 'ER' in pos. 9+10 (e.g. +EN-RES-ER with no space left
   for the second 'R').
   But not permitted are the headings that contain 'EN-RSL' in pos. 1-6 or
   2-7 (e.g. EN-RSL-FW, +EN-RSL, etc.) because these should be explained
   under the BIB keyword INC-SPECT.

4. If two or more error columns are given, then each of the data headings
   must be explained in a separate line.   Example:

   ```
   BIB
   ...
   ERR-ANALYS (EN-ERR) followed by explanation of energy error
              (DATA-ERR1) followed by explanation of first error
              (DATA-ERR2) followed by explanation of second error
   ...
   ENDBIB
   DATA
   EN          EN-ERR      DATA        DATA-ERR1   DATA-ERR2
   MEV         MEV         MB          MB          PER-CENT
   ...         ...         ...         ...         ...
   ```

   DATA-ERR, +DATA-ERR, -DATA-ERR require only a single explanation under
   ERR-ANALYS.

5. In the case of several systematic data uncertainties coded under the
   headings ERR-1, ERR-2, etc., these may be correlated.   In this case the
   correlation factor may be coded in the form

   > (heading,factor) free text

   where factor is the correlation factor coded as a floating-point number.

EXP-YEAR

1. This keyword is used for coding the approximate year in which the experiment was performed if this year differs significantly from the date of the references given. (Example: Classified data that was published only years later).

2. This keyword is optional, but if present coded information must be given with or without free text.

3. The format of the code is (yy) where yy is the two digits of the year, e.g., (65).

FACILITY

1. This keyword is used to define the main apparatus used in the experiment. See also in LEXFOR under Measurement Techniques.

2. This keyword must be present except when not relevant. At least one of the keywords METHOD, FACILITY, DETECTOR or ANALYSIS must be present with coded information. Within this restriction, coded information for FACILITY is optional.

3. If coded information is given it may be in either of the general forms, see page 8.1, with code(s) from Dictionary 18. The facility code from Dictionary 18 may be followed by an institute code from Dictionary 3, which specifies the location of the facility.
   When two or more codes are given under the keyword INSTITUTE, then a facility code must be followed by the appropriate institute code.

4. When the second form of coding is used and more than one facility is given, then each must be coded separately, starting in column 12.

   Example: (CHOPF,1USACOL)
            (SPECC,1USABNL)

FLAG

1. This keyword is used to supply information to specific lines in a data table. See also page 6.11 and in LEXFOR under Flag.

2. The keyword is optional, but if present it must have coded information. It must be present if flags are used in the data table.

3. The format of the code is a fixed point number which appears in the DATA Section under the data heading FLAG. The code must be followed by a free text explanation.

4. If two or more codes are given, they must each start in column 12, followed by a free text explanation of the meaning of the flag.
   Example:
   BIB
   ..
   FLAG   (1.) Data averaged from 2 runs
              (2.) Modified detector used at this energy
   ..
   ENDBIB
   ..
   DATA
   EN   DATA   FLAG
   KEV   MB   NO-DIM
   1.2   123.   1.
   2.3   234.
   3.4   456.   2.
   ENDDATA

5. More than one FLAG column may be given; compare page 5.5

HALF-LIFE

1. This keyword is used to define the nuclide of which the half-life is given
   in the COMMON or DATA sections under the headings HL1, HL2 etc. See also
   pages 5.4, 6.10 and in LEXFOR under Half-Lives.

2. The keyword is optional, with or without coded information. However,
   coded information must be included when the data-heading keywords, HL1,
   HL2, etc. are given in the COMMON- or DATA-sections.

3. The general coding format is

        (heading,nuclide)

   Heading field. This field contains the data-heading keyword to be defined.
   Nuclide field. The general format of the code is Z-S-A-X, see page 8.2

   The coded information must be followed by a free-text explanation of the
   source of the half-life value.

4. If two or more half-life column headings are to be defined, each must be
   coded separately starting in col. 12.

5. Decay-data, including the half-life, should preferably be coded under the
   keywords DECAY-DATA and/or DECAY-MON, as appropriate. If the keyword
   HALF-LIFE is present, neither of the keywords DECAY-DATA or DECAY-MON may
   be present. See also in Lexfor under Half-lives and Isomeric states.

6. NDS compilers should use in this context only the data-heading keywords
   HL1, HL2 etc. The heading HL should be used as an independent variable
   only; compare page 6.10. This distinction is not made in all centers nor
   in old entries.

7. Coding example:

```
BIB
REACTION    ((Z-S-A-M1(N,G)Z-S-A'-M,,SIG)/
            (Z-S-A-M1(N,G)Z-S-A'-G,,SIG))
HALF-LIFE   (HL1,Z-S-A-M1) value taken from handbook ABC (1970)
            (HL2,Z-S-A'-M) value determined by author
            (HL3,Z-S-A'-G) value determined by author
. . . . . . .
ENDBIB
COMMON
HL1         HL1-ERR     HL2         HL2-ERR     HL3         HL3-ERR
MIN         MIN         YR          YR          HR          HR
. . .       . . .       . . .       . . .       . . .       . . .
ENDCOMMON
```

HISTORY

1. This keyword is used to document the handling of the EXFOR entry or subentry. When an entry or subentry is retransmitted, all changes and corrections must be documented under this keyword.
   See also Lexfor HISTORY.

2. This keyword is obligatory and must have coded information.

3. The general format of the code is (yymmddX) or (yymmdd)

   where yymmdd   is a date (year, month, day) on
                  which some action was taken on
                  the entry or sub-entry;
         X   is a code from Dictionary 15 denoting what
                  action was taken. X may be omitted.

4. Each piece of coded information must start on a separate line, starting in col. 12. The HISTORY entries should be in chronological sequence. (However, there is no formal agreement to this effect. There are EXFOR entries in the files where the chronological sequence has not been observed.)

INC-SOURCE

1. This keyword is used to give information on the nuclear reaction producing the incident particles or gammas. (For certain cases, e.g. reactor neutrons used as source, the use of the keywords INC-SOURCE and FACILITY is somewhat overlapping.) See also in LEXFOR under Measurement Techniques.

2. This keyword is optional. There may be either free text or coded information with or without free text.

3. Coded information, if given, may be in either of the general formats described on page 8.1 using codes from Dictionary 19.

4. If the code 'POLNS' is used, the code for the polarized source, if given, must follow in the same parentheses. In this case other sources must be coded separately, starting in column 12.

INC-SPECT

1. This keyword is used to give information on the characteristics and resolution of the incident-projectile beam.

2. This keyword is optional except that it is required when the data-heading keyword EN-DUMMY (or an equivalent keyword) is present in the DATA or COMMON section resp. when the quantity modifier is MXW, FIS or SPA. No coded information.

Compare page 6.8 and Lexfor: Incident-Projectile Energy and Spectrum Average.

INSTITUTE

1. This keyword is used to define the laboratory, institute or university at which the experiment was performed, or with which the authors are affiliated.

2. This keyword is obligatory and must have coded information.

3. Permitted codes are given in Dictionary 3.
   In cases where the institute code is less than 7 characters, trailing blanks may be omitted; however embedded blanks must be included as they are considered part of the code. Examples:

   INSTITUTE   (2FR SAC)
                    (1USAAI)
             or (1USAAI)

4. Two or more codes are coded in either of the general forms described on page 8.1.
   If two or more institute codes are given, and if a facility code is given under FACILITY, then the pertinent institute code must be given also with this facility code, as described on page 8.FACILITY.

   See also in Lexfor under INSTITUTE, where rules are given as to which of several institutes should be coded in ambiguous cases.

ISO-QUANT

This keyword was used for neutron data entries coded before 1978. The keyword is obsolete. See REACTION instead.

METHOD

1. This keyword must be present except when not relevant. At least one of the keywords METHOD, FACILITY, DETECTOR, ANALYSIS must be present with coded information.

2. Free text may be given or code(s) from Dictionary 21 with or without free text. If this Dictionary contains a relevant code then this should be given.

3. Coded information is given in either of the general forms; see page 8.1.

MISC-COL

1. This keyword is used to explain the meaning of the data-heading MISC and its derivatives.

2. The keyword must be present if a MISC heading is present in the given sub-entry.

3. If only one MISC heading is given, (namely MISC) then free text explanation is sufficient. If two or more such headings are given (MISC1, MISC2 etc), then the data-headings are repeated in the BIB-Section under MISC-COL, enclosed in parentheses starting in col.12, followed by free text explanation.

4. Use: The data-heading MISC (or MISC1, MISC2, etc., if more than one is given) is used for supplementary numerical information to be entered in the DATA table. The definition is given in free text under the BIB keyword MISC-COL. A MISC heading must not be used:

   - for any data defined under REACTION,
   - for information for which a data-heading keyword has been defined,
   - for independent variables,
   - in the COMMON section.

If the information under MISC is given in units for which no data-unit keyword exists, the data unit SEE TEXT is entered, and explanation is given in free text under the keyword MISC-COL. This is to avoid introducing data-unit keywords which are unlikely to occur often. The data unit SEE TEXT must not be used for an independent variable or for a DATA (or equivalent) column.

MOM-SEC

1. This BIB-keyword is used to give information about the linear momentum of outgoing particles, either in free text or in "coded" form with or without free text.

   When secondary linear momentum data are given in the data table under the headings MOM-SEC, MOM-SEC1 etc, the "coded information" under BIB-keyword MOM-SEC defines, to what particle or nuclide the data headings refer.

2. The use of this keyword is optional. But the keyword must be present when the data-heading keywords MOM-SEC, MOM-SEC1 etc, are used in the data table. Free text may be given or coded information, with or without free text.

3. The format of the coded information is:

   MOM-SEC   (heading,particle) ADDITIONAL FREE TEXT IF ANY.

   The heading field contains the data heading or the root of the data heading to be defined. Root means that the data heading given will also define the same heading followed by -MIN, -MAX or -APRX.

   The particle field contains a particle code (Dict. 13) or the nuclide (see page 8.2) to which the data-heading keyword refers. Permitted nuclei are indicated in Dictionary 27 by a '3' in column 15.

4. When more than one linear-momentum data-heading keyword is to be defined, each must be coded on a separate record, starting in column 12.

   Example: MOM-SEC   (MOM-SEC1,26-FE-56)
                        (MOM-SEC2,26-FE-57)

Note: This was introduced for photonuclear data. For neutron data and CPND this formalism has not yet been used.

MONITOR

1. This keyword is used to give information about the standard reference data
    (also called monitor data) used in the experiment. In particular it is
    used for defining in coded form the numerical monitor values given in the
    COMMON or DATA section under the heading MONIT. Quantities given under
    MONITOR must be proportional to the DATA (otherwise ASSUMED should be used
    instead).

2. This keyword is obligatory except when not relevant. For the term "not
    relevant" compare in Lexfor under <u>Standards</u>. Information may be entered

    either in free text only or in coded form with or without free text.
    However, coded information <u>must</u> be included when the data-heading MONIT
    (or a derivative) is given in the COMMON- or DATA-Section.

3. The <u>format</u> of the coded information is exactly the same as under REACTION,
    with one exception: If the data-heading MONIT (or a derivative) does not
    occur in the COMMON or DATA sections, subfields SF5 to SF9 may be omitted,
    if only the monitor reaction is known but not the quantity used.

    If coded information is given, the pertinent numerical data should be
    entered in the COMMON- or DATA-Section under the data-heading keyword
    MONIT, MONIT1, etc.

4. If <u>two or more</u> MONITOR codes are given, each must be coded in a separate
    line. The respective MONIT column may then be linked to the MONITOR codes
    <u>either</u> using pointers (see page 6.4 BIB/DATA links)
    <u>or</u>   using the data-heading keywords MONIT1, MONIT2 etc. This formalism
             is used when two or more monitors are given for <u>one</u> reaction.

    Examples:

    <u>with pointers</u>:

    ```
    REACTION   1(AAAAAAA)
               2(BBBBBBB)
    MONITOR    1(CCCCCCC)
               2(DDDDDDD)
    ENDBIB
    DATA
    EN          DATA        1DATA       2MONIT      1MONIT      2
    ...         ...         ...         ...         ...
    ```

    <u>with MONIT1, MONIT2; new formalism introduced in 1985</u>:

    ```
    REACTION   (AAAAAA)
    MONITOR    ((MONIT1)CCCCCC)
               ((MONIT2)DDDDDD)
    ENDBIB
    DATA
    EN          DATA        MONIT1      MONIT2
    ...         ...         ...         ...
    ```

    <u>with MONIT1, MONIT2; old formalism used until 1985</u>:

    ```
    REACTION   (AAAAAAA)
    MONITOR    (CCCCCCC)   ←─┐
               (DDDDDDD)   ←─├─ ──────┬
    ENDBIB                   │        │
    DATA                     ↓        ↓
    EN          DATA        MONIT1   MONIT2
    ...         .  ...       ...      ...
    ```

5. <u>Bibliographic references</u> and Exfor accession number of the monitor data
    given may be entered in free text under MONITOR, or preferably in coded
    form under the keyword MONIT-REF. Items under MONITOR and MONIT-REF may
    be linked by pointers, subject to the restrictions mentioned on page 6.5
    and in Lexfor <u>MONITOR</u>.

MONIT-REF

1. This keyword is used to give informaton about the reference from which the
   standard reference data (monitor data) used in the experiment is taken.

2. Keyword is optional, but if present must include coded information. It
   must only be used when the keyword MONITOR is present.

3. The general format of the code contains 3 main fields:

        (Subacc#,author,reference)

   Embedded blanks are not permitted within the code. (Note however, that
   according to page 8.AUTHOR there may be a blank within the author's name.)
   The coding string may be preceded by a heading field, see below.

   Subacc# is the 8 character subaccession number of the Exfor subentry
   containing the monitor data. Cnnnn001 refers to the entire entry Cnnnn.
   Cnnnn000 (if used at all) refers to a yet unknown subentry within the
   entry Cnnnn. - This field may be omitted but the following comma must be
   included.

   Author: The first author (coded as under AUTHOR), followed by '+' when
   more than one author exists. - This field may be omitted but the following
   comma must be included.

   Reference is coded in exactly the same way as for the keyword REFERENCE.
   This field must be present.

4. Two or more monitor-references

   Each must be coded separately starting in col. 12

   Entries under MONIT-REF and MONITOR may be linked by pointers, subject to
   the restrictions mentioned on page 6.5 and in Lexfor under MONITOR.

   If the data headings MONIT1, MONIT2, etc. are used, these may be repeated
   under MONIT-REF in the format

        ((heading)subacc#,author,reference)

   See the last example below.

5. Examples:

        MONIT-REF   (B0017005,J.GOSHAL,J,PR,80,939,50)
        MONIT-REF   (B0016002,,T,MEGHIR,62)
        MONIT-REF 1(B0019007,A.B.PANONTIN+,J,JIN,30,2017,68)
        MONIT-REF   (,A.B.PANONTIN,J,JIN,30,2017,68)

        MONIT-REF   ((MONIT1)B0017005,J.GOSHAL,J,PR,80,939,50)
                    ((MONIT2),A.G.PANONTIN+,J,JIN,30,2017,68)

N-SOURCE

This keyword is now obsolete. It was used in entries coded before 1984
instead of INC-SOURCE.

NUC-QUANT

This keyword was used for nuclear quantities (spontaneous fission, level
density parameter, nuclear temperature, spin-cut-off factor) in entries coded
before 1978. The keyword is now obsolete. See REACTION instead.

PART-DET

1. This keyword is used to identify the particle(s) actually detected in the experiment, regardless of the quantity given in the data table. See also LEXFOR Particles.

2. This keyword is not compulsory, but should always be present when the particle detected is not evident from the REACTION code, nor from an entry given under RAD-DET and DECAY-DATA. If the keyword is present, coded information is obligatory.

   Example: For a (N,P) reaction one would assume that protons have been detected and no entry under PART-DET is required. In the case of a (N,N+P) reaction the particle(s) detected should be specified under PART-DET (or under RAD-DET and DECAY-DATA).

   The BIB keyword PART-DET is used in the case of prompt particles or gammas. If the compiler wishes to specify not only the detected particle but also its emitting nucleus, he should rather use the BIB keywords RAD-DET and DECAY-DATA.

3. The code is

   either   a code from Dictionary 13

   or   for particles heavier than alpha particles, a nuclide code of
               the form Z-S-A-X as described on page 8.2. However, a nuclide
               should be coded under PART-DET only if this has been detected
               directly, e.g. by a mass-separator; otherwise the keyword
               RAD-DET should be used.

   A "decay-flag" (as can be coded under RAD-DET; see next page) is not permitted under PART-DET.

4. Two or more particles detected

   More than one code may be given in either of the general formats described on page 8.1. Different particles detected may be linked by pointers to different REACTION codes. Particles detected in successive reactions of a reaction combination should be coded on successive lines, in the same sequence as the corresponding reaction units.

5. Particles detected in a monitor reaction must not be coded under this keyword.

RAD-DET

1. This keyword is used to give information about the radiations and/or particles, and nuclides observed in the reaction measured.

2. This keyword is not compulsory, but either RAD-DET or PART-DET must be present when the radiation or particle detected is not evident from the code given under REACTION or DECAY-DATA. Coded information must be given with or without free text. If this keyword is present the keyword DECAY-DATA must also be present.

3. The general format of the code is

       (nuclide,radiation)

No embedded blanks are permitted in the code.

<u>Nuclide field.</u> The general format of the code is Z-S-A-X, see page 8.2.

<u>Radiation field</u> consists of one or more particle codes from Dict. 13, each separated by a comma.

When the "Variable Product Nucleus" formalism is used (see page 8.REACTION.8), the coding string may be preceded by a "decay-flag", which links the RAD-DET entry to a line in the DATA table, where the related product nucleus is coded (see page 6.11). The "decay-flag" is coded as an integer with a decimal point and enclosed in parentheses as follows:

       ((n.)nuclide,radiation)

4. <u>Two or more nuclides.</u> The coded information for each nuclide must be given separately, each code starting in col.12. Pointers may be used to link the RAD-DET codes with the REACTION codes and the DECAY-data codes. Decay-flags (see above) may be used to link RAD-DET codes with variable product nuclei coded in the DATA table and with DECAY-DATA codes.

<u>Examples</u>

      a) RAD-DET (96-CM-240,A)
      b) RAD-DET (25-MN-52-G,DG)
      c) RAD-DET (25-MN-52-M,DG,B+)
      d) RAD-DET (48-CD-115-G,B-)
                    (49-IN-115-M,DG)
      e) RAD-DET 1(94-PU-237-M1,SF)
                    2(94-PU-237-M2,SF)

      f) RAD-DET ((1.)48-CD-115-G,B-)
                    ((2.)49-IN-115-M,DG)

REACTION

A. General information

1. This keyword is used to specify data which is presented in the DATA
   Section in columns headed by DATA, RATIO and SUM (and similar headings
   such as DATA-MIN, DATA-MAX etc.)

2. This keyword is obligatory and must have coded information with or without
   free text following. (Instead of the keyword REACTION, the keywords
   ISO-QUANT, CMPD-QUANT, NUC-QUANT were used for neutron data compiled prior
   to 1978.)

3. A REACTION-unit consists of three major fields,

   > (reaction, quantity, data-type)
   > which are subdivided into 9 subfields,
   > embedded blanks within a REACTION unit are not permitted.

4. More than one REACTION-unit may be given in "REACTION combinations" or in
   "Multiple REACTION" formalism.

   Detailed coding rules are given on the following pages.

B. Coding rules for the REACTION-unit

The REACTION-unit consists of three major fields

(reaction,quantity,data-type)

which are further subdivided as follows:

The reaction field consists of 4 subfields, separated by commas, or parentheses (not interchangeable):

(SF1(SF2,SF3)SF4,quantity,data-type)   SF1 target nucleus
                                         SF2 incident particle
                                         SF3 process
                                         SF4 reaction product

The quantity field consists of 4 subfields each separated by a comma:

(reaction,SF5,SF6,SF7,SF8,data-type)   SF5 branch
                                         SF6 parameter
                                         SF7 particle-considered
                                         SF8 modifier

The data-type field consists of only one subfield:
    (reaction,quantity,SF9)

SF1-4. REACTION field

SF1. Target nucleus: The target nucleus is that to which the data refer; it need not be identical to the target material actually used which may be specified under the keyword SAMPLE. The general format of the code is Z-S-A-X as described on page 8.2, but the following special rules apply:

1. Z-S-0 (A = zero) denotes the natural isotopic composition of an element. Compare in Lexfor under Elements.

2. The isomer code G is not permitted for the target nucleus.

3. The neutron as target "nucleus" (e.g. for neutron-neutron interactions) is coded 0-NN-1.

4. If the data given refer to a target of isotopic mixture other than the natural isotopic composition (e.g. enriched targets), a precise target coding is not possible. See in Lexfor under Target Nucleus.

5. In a few cases "nuclear quantities" that are more or less independent of the incident particle species, may be coded. In such case the "target nucleus" field does not contain the actual target of the experiment but rather the nucleus (e.g. compound nucleus) to which the data are pertinent. See in Lexfor under Nuclear Quantities.

6. Chemical compounds: For thermal neutron data for which the chemical
    or crystalline binding forces are relevant, a chemical compound may
    be coded in SF1 in the form Z-S-CMP. This is either a code from
    Dictionary 9, or, if no code from this Dictionary applies, the code
    'CMP' is attached to the code Z-S- of the predominant element.
    >   1-H-WTR
    >   13-AL-CMP
    For details see in Lexfor under Compounds.

    Note by NDS: A chemical compound may be coded as target nucleus also
    in the case of thick-target yield data when appropriate.

7. Variable nucleus: For "Pn-values" (see in LEXFOR under
    Delayed Fission Neutrons) SF1 may contain the code ELEM/MASS to
    indicate that the nuclei referred to are coded as variables in the
    DATA table under the headings ELEMENT and MASS.

    Example: (ELEM/MASS(O,B-),,PN)

8. Valid nuclei in SF1 are indicated in Dictionary 27 by '1' in column
    13. Furthermore, for "nuclear quantities" (see item 5. above) where
    SF2 contains a zero, valid nuclei in SF1 are indicated in Dictionary
    27 by '4' in column 16.

SF2. Incident Particle. This subfield contains

either   a particle code from Dictionary 28;

or   for particles heavier than an alpha particle, a code in the form Z-S-A (see page 8.2.), at present without an isomer extension. Permitted nuclei are indicated in Dictionary 27 by '2' in column 14.

SF3. Process. This subfield contains

either a) a process code from dictionary 30, e.g. TOT;

or   b) a particle code from dictionary 29, which may be preceded by a multiplicity factor whose value may range from 2 to 99.

            Examples: A
                      4A

            (In the rare case that the multiplicity factor exceeds 99, the formalism of "variable number of emitted nucleons" may be used; see page 6.10.)

or   c) for particles heavier than an alpha particle a code in the form L-S-A (see page 8.2), at present without an isomer extension. In this case no multiplicity factor is allowed; instead the nuclide code must be repeated, if necessary.

            Examples: 8-0-16
                     8-0-16+8-0-16

            Permitted nuclei are indicated in Dictionary 27 by '3' in column 15.

or   d) combinations of a), b) and c) with the codes connected by '+'. Outgoing particles are ordered starting with the lightest at the left of the subfield (i.e. in the same order as in dictionary 29) followed by the Z-S-A formatted codes, in Z,A order, followed by process codes given in the same order as given in dictionary 30.

            The exception to this order is if SF5 contains the code 'SEQ' which indicates that the codes are ordered in the sequence as the reaction proceeds (compare in LEXFOR under Sequence of outgoing particles).

            Examples: HE3+8-0-16
                     A+XN+YP

Special rules for SF3:

In SF3 gammas are coded only

- for a capture process, e.g. (P,G)

- when they are needed to define the partial reaction considered,
  e.g. (N,G+F),SEQ,SIG

In all other cases, gammas are considered as self-evident and are therefore
not coded: write (P,N) and not (P,G+N), even if the gammas from this reaction
have been detected. Compare the "particle-considered" in SF7 below. This
consistency is needed for retrieval purpose: otherwise one has to retrieve
from (P,N) and (P,G+N) if one wants complete information on the (P,N) reaction.

Scattering may be coded as (Z-S-A(P,P)Z-S-A,,SIG), but when elastic, inelastic
or other types of scattering must be distinguished (in particular for neutron
data), the corresponding process codes from Dictionary 30 must be used.
Compare in Lexfor under Scattering.

Sum-of-nucleons formalism (presently applicable to charged-particle reaction
data only): If SF5 contains the branch code 'UND' (undefined), the particle
codes given in SF3 (e.g. 4N+4P) represent the sum of emitted nucleons which
may include the production of alpha particles, deuterons, etc. The code
'(DEF)' in SF5 denotes that the compiler was not sure whether the code 'UND'
applies or not. - In certain cases the number of nucleons produced may be
given as variables in the DATA table; the process code is then XN, YP or
XN+YP. - For details see page 6.10 and in LEXFOR under Particles.

SF4. Reaction product

1. Definition:

In general, the heaviest of several reaction products is defined as the "Reaction Product" (also called "Residual Nucleus") to be entered in SF4. Exceptions or special cases are:

a) If SF5 contains the code SEQ, indicating that the sequence of several outgoing particles coded in SF3 is meaningful, the nuclide to be coded in SF4 is the heaviest of the final products. This may not be the heaviest of all products.

Example: 5-B-10(N,A+T)2-HE-4,SEQ,SIG

b) If SF3 contains one of the process codes TOT, ABS, NON the Reaction Product is not defined.

c) In the following cases the Reaction Product may be undefined, when no specific reaction product is considered:

- if SF3 contains the process code F;

- if SF3 contains the combination of the process code X with a particle code, e.g. (..,G+X),SEQ,... or (..,D+X),SEQ,...;

- if the reaction is measured on a target of natural isotopic composition.

d) If SF3 contains one of the process codes F, X, XN, YP, the product considered is coded in SF4 as Reaction Product, even if this is not the heaviest of several reaction products.

e) In the case of hydrogen and helium isotopes, the term "heaviest" reaction product is defined in the sequence of Dictionary 29.

Example: For n-p scattering, the reaction product to be coded in SF4 is always 1-H-1 and not the neutron.

(SF4. <u>Reaction Product</u>, continued)

2. <u>Coding</u>: This subfield

   either is <u>blank</u>: see a) below

   <u>or</u>   contains a code in the form Z-S-A-X: see b) below

   <u>or</u>   contains the code ELEM and/or MASS: see page 8.REACTION.8
           "Variable Product Nucleus"

a) SF4 is <u>blank</u> only if one of the following cases applies. The subsequent
   comma must not be omitted.

   - if the Reaction Product is not defined
     (see the cases b) and c) above under 'Definition')

   - if the quantity is SF5-SF8 is a resonance parameter as defined in
     Dictionary 36 by a point in col.22, the reaction product is not coded
     (except when it must be coded to identify an isomer)

   - for Nuclear Quantities (see Lexfor) the product nucleus is often not
     coded (although there was no formal agreement to this effect)

   Examples: (92-U-235(N,F),,SIG)
             (26-FE-56(N,EL),,WID) but: (26-FE-56(N,EL)26-FE-56,,SIG)
             (40-ZR-0(N,G),,SIG)

b) SF4 contains the reaction product coded in the form Z-S-A-X as described
   on page 8.2.

   Examples: (92-U-235(N,F)54-XE-124,CUM,FY) = Cumulative yield of Xe-124
                 (92-U-235(N,F)2-HE-4,TER,DA)   = angular distribution of
                                                   ternary fission alphas

             but: (92-U-235(N,F),,DA,FF) = angular distribution of
                                               unspecified fission
                                               fragments

   Special cases:

   - If <u>light particles</u> or gammas are defined as Reaction Product, these are
     coded in SF4 in the Z-S-A form identical to the coding in the
     target-field SF1. In addition, the code

         0-G-0   for gammas

     is used in analogy to the codes

         1-H-1   for protons, or
         0-NN-1 for neutrons

     Thus, the particle codes (A,HE3,T,D,P,N,G) are not used in SF4.

     Example: (28-NI-0(N,X)0-G-0,,SIG) = gamma production cross
                                                section

   - If the target nucleus has A = 0 (= natural isotopic composition) and if
     the process is 'scattering' (compare page 8.REACTION.4), then A = 0
     will occur for the product nucleus in SF4. Otherwise A = 0 is
     forbidden here.

- For isomeric ratios and sums the mathematical operators "/" and "+" are used within the isomer code of the residual nucleus. In this case, the isomer code "T" for "total" may be used in addition to the codes G, M, M1, M2 etc defined on page 8.2.

Examples:

(51-SB-123(N,G)51-SB-124-M2/G,,SIG/RAT)

   = ratio of the cross-section populating the second isomeric state over the cross-section populating the ground state

(51-SB-123(N,G)51-SB-124-M1+M2,,SIG/SUM)

   = sum of the cross-section populating the first and second isomeric state

(51-SN-124(P,N)51-SB-124-G/T,,TTY/RAT)

   = ratio of the thick target yield populating the ground state over the total thick-target yield

See page 8.REACTION.9 for the codes RAT and SUM to be used in SF6. If the branch field SF5 contains a code, e.g. M+, which does not apply to both of the isomeric reactions given, the explicit reaction ratio must be coded as described on page 8.REACTION. 11.

Example: ((...Z-S-A-G,M+,SIG)/(...Z-S-A,,SIG))

(SF4. Reaction Product, continued)

3. Variable Product Nucleus "ELEM/MASS"

In the case of fission (and other processes as specified below) the DATA table
may contain yields or production cross-sections for several product nuclei,
which may be entered in the table as variables (Z and A) under the
column-headings ELEMENT and/or MASS with unit NO-DIM. In this case SF4
contains the code

ELEM -   if the column-heading ELEMENT is used in the DATA table
                (in this case the elemental yield summed over all isotopes
                was determined)

MASS -   if the column-heading MASS is used in the DATA table
                (in this case a mass yield summed over all Z-numbers was
                determined)

ELEM/MASS -   If the column headings ELEMENT and MASS are used in either
                the COMMON section or the DATA table

                Example: 92-U-235(N,F)ELEM/MASS,CUM,FY

A product-nucleus coding in the form "42-MO-MASS" is not accepted. In this
case the code "ELEM/MASS" must be used with the constant 42. under the heading
ELEMENT in COMMON or DATA.

If the column-headings ELEMENT and MASS are present, a third column with the
heading-keyword ISOMER may be given to specify isomeric states:

0. = ground-state (if nuclide has also an isomeric state)
1. = first metastable state
      or: the metastable state when only one is considered
2. = second metastable state
etc.

Decay-data for each entry under the column headings ELEMENT/MASS/(ISOMER) and
their related parent or daughter nuclides can be given in the usual way under
the BIB-keyword DECAY-DATA. Entries under the headings ELEMENT/MASS/(ISOMER)
can be linked to entries under DECAY-DATA (and if present, RAD-DET and
PART-DET) by means of a "decay-flag" (see pages 6.11, 8.DECAY-DATA, 8.RAD-DET,
8.PART-DET). If the half-life is the only decay-data to be given, this can be
entered in the DATA table under the heading HL.

Restrictions of use

The formalism of the "variable product nucleus" may be used only when SF3
contains one of the process codes

X -   production of the product nuclei specified in the DATA section under
        ELEMENT and/or MASS

F -   fission (see also in LEXFOR under Fission)

XN -   variable number of neutrons (see page 6.9 and in Lexfor under Spallation)

YP -   variable number of protons (see page 6.9 and in Lexfor under Spallation)

SF5-8 Quantity field. The coding consists of 4 subfields separated by a comma

    (Reaction,SF5,SF6,SF7,SF8,data-type)

For each subfield there is a dictionary of accepted codes. Any subfield may
contain a combination of codes from the same dictionary, separated by a slash.
If a subfield is omitted, the extra separating comma must be included.

    e.g. (reaction,,SF6,SF7,SF8,data-type)

Only certain combinations of codes in the quantity field are meaningful.
These are listed in dictionary 36. Note that if two or more codes are entered
in a subfield, they must be in the same sequence as in dictionary 36, with the
exception that certain 'general quantity modifiers', which are not entered
into dictionary 36, may be added to SF8 after any other modifier that may be
present in this subfield (see LEXFOR General Quantity Modifiers).

SF5. Branch. Code(s) from dictionary 31
This subfield indicates a partial reaction if, for example, only one of
several energy levels or particle groups has been considered.

SF6. Parameter. Code(s) from dictionary 32
This subfield contains information about the reaction-parameter given, such as
integral or differential cross-section.

Note: The code "SUM" in SF6 is given only and always when the arithmetical
      "+" appears in the isomer extension of the product nucleus in SF4.
      Similarly, "RAT" in SF6 is given only and always when the arithmetical
      "/" appears in the isomer extension in SF4 (or when SF5 contains
      "TER/BIN" or "BIN/TER").

A combination of a sum and a ratio would be coded:
    (51-SB-123(N,G)51-SB-124-M1+M2/T,,SIG/SUM/RAT)

SF7. Particle considered. Code(s) from dictionary 33
This subfield provides particle code(s) indicating to which of several
outgoing particles the quantity refers. Examples:

    (...(N,N+P)...,,DE,N) and (...(N,N+P)...,,DE,P)

The particle-designator is omitted if there is no ambiguity. For integral
data this subfield will usually be empty. Example:

    (...(N,N+P)...,,SIG)

For details see in LEXFOR under Particles.

For a quantity describing the correlation between outgoing particles, two
particle-designators are entered, separated by a slash.

It should be noted that the particle-considered is not necessarily identical
with the particle-detected, if, for example, the angular distribution of an
outgoing particle has been deduced from a recoil particle detected.

SF8. Modifier. Code(s) from dictionary 34
This subfield contains information on the representation of the data, for
example relative data, fitting ceoefficients, etc.

SF9. Data-type field

This field indicates whether the data given are experimental, theoretical, evaluated etc. If the field is omitted, the data are experimental.

This field contains codes from dictionary 35. If two or more codes are given they are separated by a slash.

This field may be omitted, in which case the trailing commas, indicating omitted subfields in the quanty-field, are also omitted.
E.g. (reaction,,SF6).

See also LEXFOR Data Type.

C. REACTION combinations

In most cases a single reaction-unit is sufficient to specify the data.

In order to deal with experimental data sets referring to complex combinations of materials and reactions, the code units defined in this section can be connected into a single machine-retrievable field, with appropriate separators and properly balanced parentheses. In all cases of combined units, parentheses are used in exactly the same manner as in FORTRAN to define algebraic operations.

The permitted separators are:

+(Plus) : Sum of 2 or more quantities.

-(Minus): Difference between 2 or more quantities

*(Times): Product of 2 or more quantities

/(Over) : Ratio of 2 or more quantities

=(Also) : Tautologies (See LEXFOR Tautologies for usage)

The complete REACTION combination must be enclosed in parentheses.

The general form of these combinations are:

```
((------)+(-----))
((------)-(-----))
((------)*(-----))
((------)=(-----))
```

A code unit may not be broken for continuation on the next line.
The separator should appear last on any line, with the first parenthesis of the next code unit beginning in column 12 of the next line. Thus blanks may follow a separator if the reaction combination is continued on the next line.

Examples: ((92-U-235(N,F),,SIG)/(79-AU-197(N,G)79-AU-198,,SIG))

               (((28-NI-58(N,N+P)27-CO-57,,SIG)+(28-NI-58(N,D)27-CO-57,,SIG))/
               (13-AL-27(N,A)11-NA-24,,SIG))

Note that the reaction combination formalism is not used for certain frequently occurring sums, ratios and products for which specific quantity codes have been introduced. (See LEXFOR Ratios, Sums, Products). Isomeric

ratios and sums see page 8.REACTION.7.

For mathematical correctness, certain reaction combinations will require factors (e.g. isotopic abundances) to be coded in SF8:

               ((28-NI-58(N,P)27-CO-58,,SIG,,A)+
               (28-NI-60(N,T)27,CO-58,,SIG,A)

D. Multiple Reaction Formalism

Pointers may be used with this keyword, in which case the code fields associated with each pointer may be a reaction unit or a reaction combination. (See page 6.1 for general information on pointers.)

The use of the multiple reaction formalism is restricted to specific classes of data which are subject to the following restraints.

1)   The incident projectile and the target nucleus are the same.

2)   Quantities are functions of the same independent vairables.

3)   Quantities are integrally related to each other.

For the specific classes of data which may be coded using the Multiple Reaction Formalism, see LEXFOR Multiple Reaction Formalism.

REFERENCE

1. Under this keyword all bibliographic references are coded that contain information on the work of which the data are compiled in the given EXFOR entry resp. subentry. See also in LEXFOR under <u>Reference</u>.

   Other related references must not be coded under this keyword. References containing related information by other authors, may be coded under REL-REF. References containing the standard reference data (resp. monitor data) used, may be coded under MON-REF.

2. This keyword is obligatory and must have coded information.

3. General coding format: Each reference is coded separately with the opening parenthesis in col. 12. An effort should be made to have the main reference the first in the list. The coding consists of up to 6 sub-fields, each separated by a comma, and with no embedded blanks allowed.

   - The first subfield contains the "type of reference": one-character code from Dictionary 4.

   - The second subfield contains the reference code: see Dictionaries 5, 6 and 7 and the following pages.

   - Up to 3 subfields between the second and last subfield, depending on type of reference, giving volume, part or issue number, and page as described on the following pages.

   - The last subfield contains the reference date, coded in the form yymmdd (year, month, day, two digits each). The year must always be present; the month should be present, if known; the day may be omitted at the discretion of the compiler.

   Detailed coding rules for each type of reference are given on the following pages,

Some rules pertaining to all types of reference:

1) The order of the subfields of the code is important and must be
   maintained, even though some subfields may be omitted. If a subfield is
   omitted, the extra separating comma <u>must</u> be included, except in the case:

   a) of parenthesised subfields
   b) when the omitted subfield is a part or page number.

2) The following subfields must <u>always</u> be present:

   first subfield: type of reference
   second subfield: reference code
   last subfield: reference date

3) In the case of more than one reference, each reference must be coded
   separately, starting in Col 12. The main reference is given first.

4) The remaining character positions on the line following the closing
   parenthesis of the coding are reserved for a "mini-comment", giving
   further information about the reference
           e.g. GRAPH ONLY
           or   ABSTRACT

   Compare in Lexfor under <u>REFERENCE.</u>

5) In the few cases, particularly with abstracts, when two works must be
   referenced which appear on the same page of a journal or report, both will
   have identical references. If the compiler considers this as disturbing
   he can distinguish the two references by means of the paper number field:

   (J,PR,104,482(1),5612) first paper on page 482 of Phys. Rev., Vol 104
   (J,PR,104,482(2),5612) second paper on page 482 of Phys. Rev., Vol.104

   Instead of the digits 1 and 2, any available paper number or abstract
   number may be used

6) On the following pages the coding-rules for each subfield are described in
   detail. When it is stated that a subfield "may have any content", this
   exculudes commas and parentheses as these are used as separators between
   subfields.

Journals (Type-of-reference = J)

The reference field may contain up to 4 subfields coded in the form:

    (J,Code,Volume,Page,Date)
or   (J.Code,Volume,(Issue-number),Page,Date)

Code subfield contains a code from Dictionary 5.

Volume subfield contains the volume number; it may have any content,
except commas or parentheses.

Issue-number subfield, if present, contains the issue-number enclosed in
parentheses; it may have any content, except commas or parentheses.
If omitted, the following comma is also omitted.

Special case: In the case of a double issue of a journal, both
issue-numbers may be included, e.g. (2/3) or (2+3) but not (2,3).

Page subfield contains the page number which must be numeric.

Special case: If two papers start on the same page, as for example
abstracts or short letters to the editor, both may be distinguished
in the way described on page 8.REFERENCE.2 item 6).

Examples:

(J,PR,104,1319,5612) = Phys.Rev., Volume 104, page 1319, December 1956.

(J,XYZ,5,(2),89,6602) = Journal XYZ, Volume 5, issue-number 2, page 89,
                         February 1966.

Reports   (Type-of-reference = R or P or S)

Reports may be coded in one of the following formats:

    (Type,Code-Number,Date)
    (Type,Code-Number,Page,Date)
    (Type,Code-Number,(Volume or Part),Page,Date)
    (Type,Code-Number,(Volume or Part),Date)

The Type field contains one of the following codes from Dict.4:

    R = report, also called lab-report, preprint, etc,
         usually containing one or more full size papers.

    P = progress report, usually containing summaries of different
         works done in a lab or country in a given period.

    S = conference proceedings published within a lab-report series.

The Code field contains a code from Dict. 6.

The number field may have any contents, for example:

    3058-39   4648-MS   66-12-9   63-/IX-A/PR   (78)5

but must not contain a comma. The number field must start with a digit or
an opening parenthesis. Compilers should keep a uniform style within a
series, and omit insignificant symbols such as distribution codes if these
are not needed to identify a report.

The Page field, if present, should be numeric.

    Special case: If two papers start on the same page, as for example
    abstracts or brief progress reports, both may be distinguished in the
    way described on page 8.REFERENCE.2 item 5).

The Volume or Part field, if present, is enclosed in parentheses and may
have any content, except commas or parentheses (see example d) below).

For the date field see page 8.REFERENCE.1.

The separators between the fields are commas, except for a hyphen acting
as separator between Code field and Number field. Since the Code field
and the Number field both may contain hyphens, the separator is defined as
the first hyphen which is followed by a digit or an opening parenthesis,
for example:

                          separator
                              ↓
                        AERE-C/R-159-MS
                        code   number

The hyphen acting as separator is included in Dict. 6, except when the
code itself is 11 characters long.

(Reports continued)

Examples:

a) (R,UCRL-5341,5806) = UCRL report number 5351, published in June 1958.

b) (R,JINR-P-2713,6605) = Dubna report, series P, number 2713, published
            in May 1966.

c) (P,WASH-1068,185,6603) = WASH progress report number 1068, page 185,
            published in March 1966.

d) (R,BNL-325,(2.ED/SUPPL.2/VOL.2A),6602) = an extreme but well-known
            example for the Vol. or Part field.

e) (R,CEC-(78)5,7801) = an example where the report "number" starts not
            with a digit but with an opening parenthesis.

When referencing a report which has more than one report-code, it should
be indexed by its primary code, that is the code of the originating
institution which is usually given first on the cover. In case of doubt,
Cinda rules could be followed.

Additional report-codes may be given within a set of parentheses connected
by an = sign: ((...)=(...)=(...)). For continuation records the same
rules apply as for reaction combinations, see page 8.REACTION.11.

Conferences   (Type-of-reference = C)

Books   (Type-of-reference = B)

General coding form: (C or B,Code,Volume,Page,Date)

Frequent cases: (C or B,Code,,Page,Date)
                      (C or B,Code,Volume,Date)

Conference paper numbers or the part (of a volume) may be given in the
following ways:
                 (C,Code,Volume,Page(Paper Number),Date)
                 (C,Code,Volume,(Paper Number),Date)
                 (C or B,Code,Volume,(Part),Page,Date)

Code subfield contains a code from Dictionary 7.

Volume subfield may have any content, except commas or parentheses.

Part subfield, if present, is enclosed in parentheses and may have any
content, except commas or parentheses.

Page (paper number) subfield, if present, contains:

                 the page number which must be numeric

        and/or   the paper number, enclosed in parentheses,
                 which may have any content, except commas or parentheses.

Volume and/or page may be omitted, but see page 8.REFERENCE.2 item 1).

Examples:

a) (C,67KHARKOV,,(56),6702)   = 1967 Kharkov Conference proceedings, paper
                                  number 56, February 1967.
b) (C,66WASH,1,456,6603)   = 1966 Washington Conference proceedings,
                                  Volume No. 1, page 456, March 1966.
c) (B,ABAGJAN,,123,64)   = Book by Abagjan, page 123, published in 1964.
d) (B,MARION,4,(1),157,60)   = Book by Marion, Volume 4, part 1, page 157,
                                  published in 1960.
e) (C,77KIEV,,7704)   = 1977 Kiev Conference, page or paper-number
                                  unknown.
f) (C,78HARWELL,,449,7809)   = Harwell Conference Proceedings page 449.

        Note: Frequently, the last example is coded incorrectly as
        (C,78HARWELL,449,7809). This is interpreted by the Check-Program as
        volume 449 and no error message will appear.

Use of Conference codes:

If conference proceedings are issued within a report series, so that they can be identified with a report number, then the report number must be used - not the conference code. Example: The proceedings of the standards panel 67BRXL were issued as report IAEA-107. In this case, the code 67BRXL must not be used. The code 67BRXL would then be labelled as "obsolete" in Dict. 7.

In practice, the code 67BRXL would be used if the compilation in EXFOR is made from the paper as distributed at the conference. As soon as the proceedings IAEA-107 became available, the compiler should check whether it still contains the same data as reported at the conference, and he should replace the code 67BRXL by IAEA-107 (plus page number).

There are cases where the Proceedings do not include all papers. In this case, the code IAEA-107 would refer to the published proceedings whereas the code 67BRXL could continue to refer to conference papers that were not included in the proceedings.

Publication series for conferences:

There are some series such as

            CONF-...
            NBS-SPEC-PUB-...
            STI/PUB/-... (IAEA)
            (compare the note on top of Dict. 6)

that are used for conference proceedings only and, therefore, are not considered as report series. At the same time, many of these codes are quite long and even too long for use in CINDA. Therefore, Conference codes have been used instead. Example: Use the code 79KNOX and not NBS-SP-594. Note however, that there is no uniform practice in such cases. The Conference Dictionary (Dict. 7) should contain instructions about the code to be used.

8.REFERENCE.2

<u>Private Communications</u> (<u>Type-of-reference</u> = W)

<u>Theses</u> (<u>Type-of-reference</u> = T)

General coding forms: (W or T,Author,Date)
                            (W or T,Author,Page,Date)

<u>Author subfield</u> contains the family name of the (first) author.

<u>Page subfield</u>, if present, must be numeric.

<u>Examples</u>:

a) (W,BENZI,661104)   = private communication from Benzi dated 4 Nov. 1966.

b) (T,MEYER,58,6802)   = Page 58 of thesis by Meyer, published in February
                             1968.

Note by NDS: <u>Private communications</u> should be coded under REFERENCE <u>only</u> if
there is no other reference known. In the frequent case that data mentioned
in a publication are compiled as taken from a data table received from the
author, only the publication is coded under REFERENCE; in addition, the
private communication must be quoted under STATUS as the source of the data
compiled.

REL-REF

1. References related to the data given but originating from another author
    should not be entered under REFERENCE but may be entered under REL-REF.
    Examples are: critical remarks or corrections applied by another author,
    e.g. within a data review or evaluation.

2. The use of the keyword is optional; but when the keyword is present, coded
    information in parentheses is obligatory, with or without free text.

3. The general format of the coding is

        (code,subacc#,author,reference)

    Code and reference must not be omitted. If subacc# and/or author are
    omitted the following comma(s) must be included.

    Code is a code from Dictionary 17, indicating the reason for citing the
    reference.

    Subacc# is an 8 character sub-accession number if the data of the relevant
    reference have been compiled in EXFOR.
    Cnnnn001 refers to the entire entry Cnnnn. Cnnnn000 (if used at all)
    refers to a yet unknown subentry within the entry Cnnnn.

    Author field contains the first author, coded as under AUTHOR, followed by
    + when more than one author exists.

    Reference is coded in exactly the same way as for the keyword REFERENCE.

4. Each relevant reference is coded separately with the opening parentheses
    in col. 12.

5. Examples:

    a) (C,,N.ANON+,J,XYZ,5,(2),90,7701) = Critical remarks by N. ANON et al.
                                           in journal XYZ, Volume 5,
                                           issue-number 2, page 90, January
                                           1977.

    b) (E,B9000002,J.AUTHOR,R,ABC-123,7701) = Data from report ABC-123, of
                                           January 1977 by J. AUTHOR which can
                                           be found in subentry B9000002, was
                                           used in the evaluation.

RESID-NUC

This keyword is obsolete. It had been used in entries coded before 1978 for specifying the residual nucleus, which is now coded under REACTION.

8.SAMPLE

SAMPLE

This keyword is used to give information on structure, composition, shape, etc. of the measurement sample.

The keyword is optional. Information may be given in free text only.

Old entries (1969-1972) may contain under SAMPLE coded information (old Dict. 20) which can be ignored.

8.STANDARD

STANDARD

This keyword is obsolete. In entries coded before 1978 it had been used instead of MONITOR.

STATUS

1. Under this keyword information is given on

    a) the actual source from which the data are taken; e.g. from table nr.
        ... in reference ...; or from private communication corresponding to
        figure ... in reference ...; etc.

    b) the status of the data such as 'preliminary', 'final', 'superseded',
        'derived from another subentry', 'correlated with another subentry',
        'approved by author', etc.

    For further details see in Lexfor under STATUS, and also under
    Interdependent Data and Dependent Data.

2. This keyword is obligatory.
    (Officially it is "obligatory except when not relevant", but according to
    NDS practice this keyword must be present to give at least information on
    the source of the data.)
    Frequently there will be STATUS information in subentry 001 applicable to
    the entire entry, plus additional STATUS information in subentry 00n
    applicable only to this subentry (compare bottom of page 8.3).

3. Under this keyword a code from Dictionary 16 is given followed by free
    text; or free text only if no code applies. Two or more codes may be
    arranged as described on page 8.1.

4. In the following cases a code should be followed, within the parentheses,
    by an eight-character subaccession-number indicating a cross-reference:

    (SPSDD,10048009)   -   this means that the present subentry is
                           superseded by subentry 10048009.

    (DEP,B0001004)   -   this means that the data of the present subentry
                           have been deduced from the data in subentry
                           B0001004.

    (COREL,B0123004)   -   this means that the data of the present subentry
                           are correlated with the data of subentry
                           B01234004 since both were obtained, e.g. by
                           different analysis, from the same experimental
                           raw data (compare page 6.6).

    The Status codes SPSDD, DEP, COREL, OUTDT, RNORM must be followed by a
    subaccession-number, if applicable. The subaccession-number may be
    omitted after the codes SPSDD and OUTDT, when no cross-reference exists.
    It may also be omitted in older entries before introduction of this
    formalism.

    The subaccession-number Cnnnn001 refers to the entire entry Cnnnn.
    Cnnnn000 (if used at all) refers to a yet unknown subentry within the
    entry Cnnnn.

    If a subentry was deduced from two other subentries, this is coded as

    (DEP,12345002)   Not accepted:
    (DEP,23456005)   (DEP,12345002,23456005)

TITLE

1. Under this keyword a title for the EXFOR entry is entered in free text.

2. The keyword must be present. It is usually given at the beginning of subentry 001.

3. The title shall be descriptive for the data given in the EXFOR entry. Where suitable, the title of the bibliographic reference can be used.

4. As for all other BIB information, the title must be given in English using the caracter set defined on page 1.5.

Chapter 9

COMMUNICATIONS, UPDATING, ALTERATIONS

Procedure for tapes received with errors

There are 2 distinct cases.

1. If a tape can physically not be read, in part or whole, then the originating center should be requested to send another identical tape, which it should do with the niminum delay.

2. If there are errors (format, structure, etc.) in one or more entries, then the originating center should be notified of the errors by 4C- or CP-Memos with the usual distribution.

Alterations to EXFOR entries

1. Alterations to EXFOR entries may be transmitted only by the originating center, and are included in the regular EXFOR transmissions.

2. If any entry is altered, those subentries which have been altered should be transmitted to all other centers accompanied by the retransmission of the first subentry. The minimum unit transmitted is a subentry (NOT just the altered records). If individual altered subentries are transmitted, the appropriate ENTRY and ENDENTRY records are included. All corrections should be properly marked with alter flags (see page 2.6) and documented by an appropriate entry under HISTORY.

   The altered subentries should have a "C" in Column 80 of the SUBENT record.

   Serious corrections (for example those involving the COMMON or DATA section, or essential BIB keywords such as REACTION, MONITOR, etc.) should be transmitted as quickly as possible. Less serious corrections could be made and transmitted as workloads permit.

   (Compare in LEXFOR under "HISTORY").

   The ENTRY record should include the revised date in the N2 field and the alter flag "C" in Column 80.

3. Subentries to be added to a previously transmitted entry may be transmitted accompanied only by the retransmission of the first subentry; other unchanged subentries need not be retransmitted.

   The subentries to be inserted should have an "I" in Column 80 of the SUBENT record.

For the procedures to be followed at NDS see in LEXFOR under Alterations to NDS EXFOR entries.

Deletion of Entries or Subentries

An entry or subentry which is superseded can be marked accordingly under the
BIB keyword STATUS (see in LEXFOR under STATUS).
If, for some reason, this is not satisfactory, an entire entry or subentry
can be "deleted". In this case, however, a minimum information must remain in
the EXFOR file in order to

- indicate that the (sub-)entry was not deleted inadvertently,

- indicate the reason for the deletion (e.g. "duplicate entry", or
  "withdrawn by author").

- make sure that the entry number of the deleted entry will not be used
  again for some other data.

The "deletion" is done according to the following procedure on the TRANS
tape. (The resulting action on the EXFOR master file may vary at the
receiving centers.)

1. Any entry or subentry for deletion must have * in Column 80 of the
   relevant ENTRY or SUBENT record.

2. The following keywords must be included in the BIB section of the entry
   or subentry to be deleted:

   REFERENCE
   TITLE
   AUTHOR
   INSTITUTE
   REACTION
   HISTORY

   The ENDBIB record will be followed by NOCOMMON, NODATA.

3. A mnemonic "D" to be attached to the date under HISTORY will indicate the
   date of the deletion. Free text must be with this justifying the
   deletion and, if applicable, giving a cross-reference to a replacing
   entry.

4. Column 80 alter flags must be used throught the "deleted" entry or
   subentry as usual.

5. The accession number of the deleted entry (subentry) should not be used
   for another entry (subentry).

6. When an entire entry is deleted where subentry 001 contains <u>all</u> necessary
    BIB information to be preserved, NOSUBENT records (see page 3.6) may be
    used for subentry 002 and following ones.

    Example:

                                                               <u>col.80</u>

            ENTRY   nnnnn   yymmdd   *
            SUBENT   nnnnn001   yymmdd   *

    BIB-Section as described above with normal use of col. 80 flags

            ENDSUBENT   ##
            NOSUBENT   nnnnn002   yymmdd   *
            NOSUBENT   nnnnn003   yymmdd   *

            ...   .
            ENDENTRY   ##

    <u>Note</u>:   In the first two records of above examples NNDC may use 'C' in
               col. 80 instead of '*'.

<u>Action at NDS</u>: When an incoming TRANS tape contains an ENTRY record having a
'*' in col.80, this causes

    -   that all previous subentries of this entry are removed from the
        master library and replaced by whatever the TRANS tape contains (as
        described in item 2. above). The '*' in col. 80 of the ENTRY record
        is preserved.

    -   that all previous index lines of this entry are removed from the
        Exfor Index without replacement.

    If a '*' in col. 80 is contained in a SUBENT record but not in the ENTRY
record, the same is performed for that subentry only.

<u>Retransmission of Subentries which have been combined into one subentry</u>

<u>Note</u>:   This applies mainly to old neutron data entries compiled before the
           introduction of pointers (see page 6.1)

In the case of a retransmission of a series of subentries (X through Y) which
have been combined into one table, the following simplified flagging system
may be used:

1. Enter under HISTORY in the combined subentry:

    (yymmddA) Subentries X through Y combined

2. For subentries X+1 through Y, transmit NOSUBENT records containing the
    subentry number in the N1 field and * in Col. 80.

Updating of Manual Pages

The updating of Manual pages (EXFOR Manual and LEXFOR) follows the rules outlined in the Protocol, Section I. These are specified and supplemented by the following agreed procedures:

1. Wherever possible proposals affecting the content of the EXFOR-Manual should contain proposals for specific wording to be inserted in the Manual.

2. Suggestions for additions to LEXFOR should be accompanied by adequate explanation and documentation to help in preparing LEXFOR entries.

3. Any proposals for new quantity terms should be supported by the expansion, a full explanation of its use and limits, a list of corresponding Dictionary 36 entries, and a reference.

4. An explanatory LEXFOR entry should be submitted together with a proposed new dictionary code, if appropriate.

5. A change in EXFOR dictionaries, EXFOR or LEXFOR manual should not oblige centers to change existing entries (whether they have been transmitted or not) unless stated explicitly in the proposal and agreed to by the data centers.

6. Updating pages of the EXFOR Manual and of LEXFOR will be issued as soon as possible by means of X4-Memos.

7. The center responsible for updating the Manual may introduce changes for the purpose of editing. However, proposed Manual wordings submitted in CP-Memos are entered in the Manual unchanged, unless an objection is expressed in due time. This center is also responsible for maintaining the internal consistency of the Manual; that means, e.g., to check whether an agreed proposal entails changes (cross-references, etc.) in other parts of the Manual.

8. A change on a Manual page, as compared to its previous version, is marked by a vertical line in the left-hand margin.

Inter-center Memos

Discussion among the cooperating centers on the subjects of data compilation, the EXFOR system and its further development, EXFOR Manual and Dictionaries, and EXFOR transmission tapes, are continued by means of memos, which are called:

    4C-Memos, if dealing with neutron data or other Four-Center matters only;

    CP-Memos, if dealing with CPND and the generalized EXFOR system.

Such memos are sequentially numbered in the form

    Memo 4C-n/m   respectively   Memo CP-n/m

where n is the Originating Center Identification (See page 2.2), and m is the chronological memo number within each n-series.

CP-Memos are distributed to the centers listed on page 9.6. Other compiling groups are informed, according to their needs, by their center of contact.

Such memos should conform to the following general procedure:

1.   Contents of each memo should be summarized in a covering-page index.

2.   Each subject should begin on a new page to facilitate distribution to the appropriate staff at each center for action.

3.   Items requiring agreement of the cooperating centers should be flagged with a special symbol in the index and on the appropriate page.

4.   The Memo number should appear on each page.

5.   All proposed changes and additions to the dictionaries, EXFOR Manual, and LEXFOR should contain (where possible) a revised entry in the format of the appropriate document in addition to usual documentation.

6.   In case of discussion the originating center is responsible for collecting the points of agreement and issuing a final wording in the format of the appropriate document(s).

7.   Proposals which do not evoke discussion should be entered after 4 weeks by the Center responsible for maintenance of manuals, dictionaries, etc.

8.   Updated manual pages documenting changes and additins should issued to all Centers immediately.

The addresses of the cooperating centers and groups are:

CAJaD	Dr. F.E. Chukreev Center for Nuclear Structure and Reaction Data of the USSR State Committee on the Utilization of Atomic Energy I.V. Kurchatov Institute of Atomic Energy Moscow, USSR
CJD	Dr. V.N. Manokhin Centr po Jadernym Dannym Fiziko Energeticheskij Institut Obninsk, Kaluga Region, USSR
NEA-DB	Dr. Nigel Tubbs NEA Data Bank B.P. N° 9 (Bât. 45) F-91190 Gif-sur-Yvette, France EARN/BITNET "username@FRNEAB51"
NDS	Dr. J.J. Schmidt IAEA Nuclear Data Section P.O. Box 100 A-1400 Vienna, Austria EARN/BITNET "username@IAEA1"
NNDC	Dr. S. Pearlstein National Nuclear Data Center Brookhaven National Laboratory Upton, N.Y., U.S.A. 11973 BITNET "NNDC@BNLDAG"
SG	Dr. M. Chiba Hokkaido University Computing Center Kita-11, Nishi-5, Kita-ku Sapporo 060, Japan
RIKEN	Dr. A. Hashizume Nuclear Data Group RIKEN Institute of Phys. and Chem. Res. Wako-Shi, Saitama 351-01, Japan
CDFE	Dr. V. Varlamov Centr Danykh Fotojad. Eksp. Nauchno-Iss. Inst. Jad. Fiz. Moskovskij Gos. Universitet Leninskije Gory Moscow, USSR
IAE-CP	Dr. Cai Dunjiu Institute of Atomic Energy P.O. Box 275 Beijing People's Republic of China

The following center has contributed in the past, but is no longer compiling data.

KaChaPaG   Prof. H. Münzel
Charged Particle Nuclear Data Group
Institut für Radiochemie
Kernforschungszentrum Karlsruhe
Postfach 3640
D75 Karlsruhe, Fed. Rep. of Germany

Other centers or groups which have been represented at meetings and which have expressed interest in cooperation are:

FEI	Dr. A.I. Abramov Photonuclear Data Group Fiziko-Energeticheskij Institut Obninsk, Kaluga Region, U.S.S.R.
FIZ	Dr. H. Behrens Fachinformationszentrum Energie Physik Mathematik D-7514 Eggenstein-Leopoldshafen 2 Federal Republic of Germany
LASL	Dr. E.R. Siciliano Group T-2, MS-B243 Los Alamos National Laboratory Los Alamos, NM 87545, U.S.A. BITNET "ERS@LANL.GOY"
LLNL	Dr. R.M. White Nuclear Data Group, L-298 Lawrence Livermore National Laboratory Livermore, CA 94550, U.S.A. BITNET "WHITE%PD1@LLNL.GOV"
Photon and Charged Particle Data Center	Dr. M.J. Berger Center for Radiation Research National Institute for Standards and Technology Gaithersburg, MD 20899, U.S.A.
SG	Prof. H. Tanaka Sapporo-gakuin University Bunkyoudai 11 Ebetu-shi 069, Japan
Shanghai	Dr. Wang Gongqing Nuclear Data Group Shanghai Inst. of Nuclear Research Academia Sinica P.O. Box 8204, Shanghai People's Republic of China
TUD	Dr. D. Seeliger Sektion Physik Technische Universität Dresden Mommsenstr. 13 DDR-8027 Dresden German Democratic Republic

Physical Structure of Exchange Tapes

1. 9-Track EBCDIC with density 800, 1600 or 6250 bpi
    Each center to decide which it prefers. (See page 9.9).

2. Usually the TRANS tape file will be the only file on the tape. If
    there are more files, this must be indicated clearly on the outside
    of the tape.

3. No multi-volume files.

4. Unlabelled files (in the sense of standard computer labels).

5. No tape-mark at the beginning of the file.

6. Tape-mark at the end of the file.

7. Blocking factor = 10, or up to 40. Because some centers have
    difficulty in processing a physical block of less than the specified
    length at the end of a file, each center must make sure that the
    physical block containing the ENDTRANS record is made up to the full
    block size. Trailing records to fill up the last block should be
    repetitions of the ENDTRANS record.

8. Each tape should have a label attached to the outside with the
    transmission number (TRANS cnnn) written on it, where c is the
    center-identification code and nnn is the sequential transmission
    number (see page 3.3).

Magnetic tape formats

The co-operating data centers wish to receive EXFOR tapes in the format
specified below:

Center	Tape Format
NNDC	EBCDIC 9-track 800, 1600, 6250 bpi
NEA-DB	EBCDIC 9-track 800, 1600 bpi
NDS	EBCDIC 9-track 800, 1600 bpi
CJD	EBCDIC 9-track 800 bpi*
CAJaD	EBCDIC 9-track 800 bpi
Study Group	EBCDIC 9-track 1600 bpi preferred 800 bpi acceptable
RIKEN	EBCDIC 9-track 800 bpi
IAE-CP	EBCDIC 9-track 800 bpi

*Note: Tapes sent to CJD should contain a dummy file of at least
       100 records at the beginning of the tape.

Magnetic tape formats

The co-operating data centers wish to receive EXFOR tapes in the format specified below:

Center	Tape Format
NNDC	EBCDIC 9-track 800, 1600, 6250 bpi
NEA-DB	EBCDIC 9-track 800, 1600 bpi
NDS	EBCDIC 9-track 800, 1600 bpi
CJD	EBCDIC 9-track 800 bpi*
CAJaD	EBCDIC 9-track 800 bpi
Study Group	EBCDIC 9-track 1600 bpi preferred 800 bpi acceptable
RIKEN	EBCDIC 9-track 800 bpi
IAE-CP	EBCDIC 9-track 800 bpi

*Note: Tapes sent to CJD should contain a dummy file of at least 100 records at the beginning of the tape.

Dictionary transmissions

The centers listed above receive from NDS the Dictionary transmissions on tape and in printed form. The same applies to the following NDS customers:

Mrs. Nassiff (Argentina)
Iranian Mission Vienna

Printed versions of the Dictionaries are sent to CDFE, TUD, FIZ. NEA-DB receives 10 copies of the CINDA relevant dictionaries 3, 5, 6, 7, 42.

Interim Dictionary updates are distributed by NDS in the form of listings of the update-records, to

NNDC   (on tape)
NEA-DB
CJD
CAJaD
Study Group
TUD

EXFOR computer codes

NDS sends codes for checking and processing of EXFOR entries, plus documentation, presently to

CJD
CDFE
RIKEN
TUD
IAE-CP

Distribution of EXFOR tapes by NDS

1. TRANS-tapes produced by NDS are sent to:

EXFOR-3 and V series:	NNDC	EXFOR -D and G-series:	NNDC
	NEA-DB		NEA-DB
	CJD		CJD
			CAJaD

   Note: TRANS-D tapes may include revisions to B, P (and perhaps other) CPND files

2. USSR TRANS-tapes corrected by NDS:

   Corrected versions of tapes are identified by 'EXFOR - IAEA NUCL.DATA' in cols. 45 to 66 in the TRANS record, with the date in field N_2 changed to the date of transmission by NDS. These tapes are sent to:

   EXFOR series 4, A, M: NNDC
                                        NEA-DB

   (CJD and CAJaD receive the corrected versions through UPDAT tapes.)

3. UPDAT-N tapes (compare page 3.4):

   Around 1 July, 1 November and 1 March all neutron entries (EXFOR series 1, 2, 3, 4, V) that have been added or altered since the last transmission, are sent to

                   CJD
                   Iranian Mission Vienna

4. UPDAT-CP+PH tapes (compare page 3.4):

   Around 1 July, 1 November and 1 March all non-neutron entries (EXFOR series with all characters except V) that have been added or altered since the last transmission, are sent to

                   CAJaD
                   RIKEN
                   IAE-CP
                   Tanaka, Study Group
                   Mrs. Nassiff, Argentina
                   Iranian Mission Vienna

   On the same tape there should be a second file containing the complete non-neutron EXFOR index

NDS internal Exfor Manual page

Distribution of 4C- and CP-Memos

1. NDS internal distribution, for incoming and outgoing memos:

> D.E. Cullen
> D. Gandarias Cruz
> V. Goulo
> M. Lammer
> H.D. Lemmel
> K. Okamoto
> M. Oshomuvwe
> J.J. Schmidt
> O. Schwerer
> M. Seits

For incoming X-4 Memos: H.D Lemmel (2 copies + original)
                          J.J. Schmidt
                          file X-4 Memos

2. External distribution

a.   for outgoing 4C-Memos:

> S. Pearlstein, NNDC
> N. Tubbs, NEA-DB
> V.N. Manokhin, CJD

> cc. H. Goldstein (only for memos about CINDA)

b.   for outgoing CP-Memos:

> S. Pearlstein, NNDC
> N. Tubbs
> V.N. Manokhin, CJD
> F.E. Chukreev, CAJaD
> H. Tanaka, Study Group
> B.S. Ishkhanov, CDFE
> A. Hashizume, RIKEN
> Zhouang Youxiang

Introduction

LEXFOR is the compiler's part of the EXFOR Manual. Its contents are arranged similar to a lexicon in alfabetic order of subject-headings. As distinct from Chapters 1-9 of the Manual, LEXFOR includes information relevant to the compiling physicists but not to programmers. Therefore, LEXFOR includes the following:

- physical definitions of codes defined in the EXFOR-Manual and its Dictionaries,

- practical examples how to use the EXFOR-system,

- physical background information required for preparing good-quality EXFOR-entries, as well as

- any other information that may be helpful to compilers.

LEXFOR, as a part of the EXFOR Manual, is maintained and updated by NNCSC, following the rules given in Sections F to H of the Protocol, and on pages 9.4-5 of the Manual. In the case that new proposals do not easily find the approval of the cooperating centers, different views on matters of minor importance may all be included in LEXFOR as far as these views are in agreement with the EXFOR rules and do not cause ambiguities in the definitions of codes.

The LEXFOR subject-headings are double underlined. Each subject-heading starts with a new page for the sake of easier updating.

<u>Definition</u>: The sum of all energetically possible interactions excluding elastic and inelastic scattering.

<u>Quantity-Code</u>: ABS - in REACTION SF3

<u>Sum rules</u> (applying to neutron data):

         Absorption = total minus scattering

                = nonelastic minus inelastic

                = capture plus fission in the case of fissile isotopes at thermal energies below reaction thresholds (e.g. n,2n).

<u>Note</u>: Absorption is a <u>sum</u> cross-section. It should only be used where two or more reactions are energetically possible. Where absorption is, throughout an experimental data set, identical with the (n,gamma)-reaction, it should be coded as (N,G). (See also <u>Tautologies</u>)

<u>Examples</u>:

1. The frequently so-called "hydrogen absorption cross-section" must clearly be coded as (N,G), because no other neutron-absorbing reaction besides (n,gamma) is possible.

2. The thermal "absorption cross-section" for gold may well be coded as (N,G) since the energetically possible (n,p) and (n,alpha) cross-sections are negligible in comparison with the measurement uncertainty of the (n,gamma) cross-section. However, this cannot be considered a general guide since there is no Au(n,p) measurement to confirm it.

Activation   Activation

Definition: Activation is the production of a radioactive residual nucleus as
a result of a reaction, which is determined by measuring a specific decay
radiation emitted by the product nucleus.

The activation cross-section can be identified with a specific reaction or
reactions. The data given should then be coded under the appropriate
reaction, e.g., (n,gamma) or (n,p).

ACTIVE (=activation) is entered under the keyword METHOD.

The decay information used in the analysis of the data given should be
specified under the appropriate keywords (see Decay-Data).

See also Isomeric States.

Sum-reaction: Frequently, the activation cross-section is given for an
element with natural isotopic composition, or for some other mixture of
isotopes, where two or more different parallel neutron reactions with
different isotopes lead to the same radioactive residual nucleus. In such a
case, the appropriate sum of reactions should be entered. (See Sums).

Alpha   Alpha

For neutron reaction data only:

Definition: Radiative capture-to-fission cross-section ratio

REACTION coding: (N,ABS),,ALF
     at resonance energy: (N,ABS),,ALF,,RES

See also Single-Level Resonance Parameters.

Note: The reaction code ABS is entered, since capture and fission are
       considered.

Alternations to NDS Exfor entries

First: Check whether the entry to be altered is still in Limbo or whether it has
          already been transmitted to the other centers. If you want to alter an
          entry in Limbo, see that the entry is held back from the next EXFOR
          transmission.

Second: Distinguish important from unimportant alterations (= corrections or
          insertions). Important are the following:

          * alterations in the COMMON or the DATA section or its definitions as
             given under REACTION, MONITOR or elsewhere;
          * alterations submitted by the author, and insertion of the STATUS code
             (APRVD);
          * insertion of an important new reference and of new information
             extracted from it;
          * any other corrections of such mistakes in the BIB-section which the
             responsible physicist considers as misleading to the user of EXFOR.

The alternation is performed in the following way:

1. Staple a new 'Compilation Control Form' into the EXFOR folder, if sufficient
    only the lower half of it; make a big note at the top of this form if the
    EXFOR-entry is still in Limbo; follow the processing steps as usual.

2. The alterations (corrections, insertions, deletions) are entered on coding
    sheets (e.g. EXFOR UPDATE form); columns 67-80 are entered following the rules
    for Dictionary alterations (change, delete, insert) given on pages 7.5+6. In
    the case of several subsequent alterations, take care that record numbers of
    the alteration submitted refer to the file copy of the subentry.

    When a complete section (BIB, COMMON or DATA section) within a subentry is
    replaced, all records on the coding sheet must have accession and sub-accession-
    number in cols. 67-74 and an 'R' in col. 80. The record-number in cols. 75-79
    is entered only in the first line (BIB record, COMMON record resp. DATA record)
    of the section to be replaced; in all subsequent records cols. 75-79 remain
    blank.

    The alterations for each subentry (resp. entry) must be concluded by a line
    containing the keyword "ENDSUBENT" (resp. "ENDENTRY") starting in column 1.

    For all unusual cases consult with the Programming Unit.

3. If a new subentry is to be added to an existing entry, this is coded on an
    EXFOR SUBENTRY form as usual. Add a note on the margin of the entry form that
    an "I" must be punched in column 80 of the SUBENT record.

4. Do not forget to update CINDA if necessary!

5. Do not forget an entry under HISTORY with the code "A" for an important
    alteration or "U" for an unimportant one. In the free text put somewhere your
    initials and explain the alterations performed and the reason, e.g. CORRECTION
    OF MISPUNCHES IN DATA TABLE, or METHOD INFORMATION REVISED BY AUTHOR.

    Note: If the EXFOR entry was still in Limbo at the time of the alteration,
             only revise the existing HISTORY entry and do not prepare a new one!

ANALYSIS   ANALYSIS

Under the information identifier keyword "ANALYSIS" the compiler can enter all
relevant information as to how the experimental results have been analyzed to
obtain the values given under "DATA" which actually represent the result of
the analysis. In particular, this keyword is used for all kinds of deduced
data such as resonance-parameters. If the raw data used for the analysis have
also been entered in EXFOR, a cross-reference to those sets should be given in
the free text. If important assumptions were made (e.g. negative resonance),
these should be specified either directly or by reference. For example,
extrapolation and interpolation should be given only together with appropriate
references. (see also Dependent Data, Assumed Values).

Resonance-parameters require an entry under ANALYSIS explaining how they have
been obtained. "Single level" or "multi-level" must be given in coded form.
A more precise definition of the analysis is desirable in free text, at least
in the form of a cross-reference to the literature where the analysis
description can be found.

The keyword "ANALYSIS" should not be used for information on any analysis made
on the data set to obtain theoretical conclusions. Such information can be
noted under "COMMENT." See also CORRECTION.

See also page 8.ANALYSIS.

Angle   Angle

See also under Differential Data

Data Heading Keyword

The angle may be entered either as angle in degrees or as a cosine (units
given as NO-DIM). An angle given in degrees and minutes must be entered in
two separate columns with the data heading repeated, see page 5.4.

Examples for data heading keywords:

> ANG = angle in lab system
> ANG-CM = angle in center-of-mass system
> COS = cosine of angle in lab system
> COS-CM = cosine of angle in center-of-mass system and
> other codes given in Dictionary 24 with flag G.

Angular Correlation   Angular Correlation

Quantities defining the angular correlation between two or more emitted
particles or radiations are coded with the Parameter code "COR" in SF6 of the
REACTION keyword. The angles given are defined by the particles specified in
the REACTION code.

Example: neutron-proton correlation in the (n,np) reaction:

> (....(N,N+P),,COR)

Exact definition of the data given should always be entered in free text, in
particular in more complex cases such as the correlation function
W(ANG1,ANG2,ANG3) between the angle of the scattered-neutron detector and the
azimuthal and polar angle of the gamma detector.

The DATA table should contain under the column heading keywords DATA, RATIO or
SUM (and their derivatives) only values obtained from the experiment. It is,
however, also important that numerical values used for the derivation of the
experimental results also be given in EXFOR in coded form. Values assumed by
the author including values taken from another source should be entered.

Reference Cross Sections used for normalization should be entered under
the keyword MONITOR. (See Standards).

Decay Data should be entered under the keyword DECAY-DATA. See Decay Data.

Values for which a column-heading keyword exists should be coded under that
column-heading in the COMMON or DATA sections, e.g. spin (SPIN J), resonance
energy (EN-RES), and half-lives, other than those entered under DECAY-DATA,
(HL).

All other assumed values for which a quantity code exists may be entered under
the column heading ASSUM in the COMMON or DATA section and defined in the BIB
Section under the keyword ASSUMED. See page 8.ASSUMED.

Following are some examples of data to be coded using the keyword ASSUMED.

  1. Data on a compound consisting of two elements.
     A cross section is calculated for one of the elements by assuming cross
     section for the other(s).

  2. A cross section is measured for several isotopes. A cross section is
     given for the natural element by assuming a value for those isotopes
     which were not measured.

  3. A resonance width is assumed in order to deduce other resonance
     parameters.

The author(s) of a data set are entered under the keyword "AUTHOR", all names
between one set of parentheses and separated by a comma. The sequence of the
names should be of the same as in the publication. The names are written in a
standard style as described on page 8.AUTHOR.

If a data-set has several references with varying co-authors, all co-authors
may be entered. (NDS will always enter all authors.)

Some East-European authors spell their names and in particular their initials
differently depending on whether they publish in their own language or in
English. Gyulia (Hungarian) = Julius (English). Hristov (Bulgarian) -
Christoph (English). If this is detected at all, the spelling in the author's
own language should be preferred.

The transliteration of cyrillic names follows the US standard.

А	Б	В	Г	Д	Е	Ё	Ж	З	И	Й	К	Л	М	Н	О	П
A	B	V	G	D	E	E	ZH	Z	I	J	K	L	M	N	O	P

Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ъ	Ы	Ь	Э	Ю	Я
R	S	T	U	F	KH	TS	CH	SH	SHCH	´	Y	'	E	YU	YA

Publications in non-English languages are using different transliterations
which the EXFOR compiler should possibly convert to above US standard. In
particular, the old international ISO standard prescribed C instead of TS and
JU and JA instead of YU and YA.

Southeast Asian names

For Southeast Asian names the full name should be quoted. The parts of the name should be given in original sequence with blanks (or hyphen) as separator. In Exfor this will be treated like a family name without initials. (In Cinda, due to space limitations, one may have to select one part of the name, usually the first part.)

China: The name consists of three syllables. The first is the family
          name. The second and third, which may be written in one word, with
          hyphen, or in two words, is the given name. More recently, the
          given name is usually written in one word.
          The given name should not be abbreviated because this would result
          in too many unidentifiable duplications.

Burma: The name consists of two or more syllables of which none is a
          family name. All parts of the name are given names. The syllable
          "U" is a title like "Mr." and should be omitted in Exfor and Cinda.

Indonesia: The name consists of one or more syllables, of which none is a
          family name. Like Burma all parts of the name are given names.

In Western publications one will often find the syllables of Southeast Asian names in inverted sequence. If this is detected by the Exfor compiler, names should be converted back to the original sequence.

Average Resonance Parameters

The following applies primarily to neutron data.

For average resonance-parameters the energy-range of averaging must be
specified under the data-heading keywords "EN-MIN" and "EN-MAX". When
specified, the parameters "1" and "J" are given under the data-heading
keywords "MOMENTUM L" and "SPIN J"; see under Quantum-Numbers.

See Dictionary 36 for quantity codes.

1. Average Widths: The average of the resonance-widths of a specified type in
    a specified energy-range is coded with the quantity-modifier "AV" in SF8
    of the REACTION keyword.

    Example: Average reduced neutron width

            REACTION   (....(N,EL),,WID/RED,,AV)

2. Average Level-Spacing: The average energy distance D between nearest
    neighbor compound-nucleus resonances of total spin J caused by neutrons of
    orbital angular momentum 1, is coded with the quantity-code "D" in SF6
    under REACTION. Example:

            REACTION   (....(N,D),,D)

    If the J and 1 values of the resonances are not specified, then D is
    understood to indicate the observed level spacing.

    Authors may apply statistical tests to evaluate the number of missed
    resonances. This information should be given under ANALYSIS.

3. Fermi-gas model parameters: See under Nuclear Quantities.

4. Strength-Functions: The strength-function S is defined as the ratio of the
    average reduced neutron-width to the average level-spacing for
    compound-nucleus resonances of specified "J" and "1". The quantity code
    is "STF" in SF6 of the keyword REACTION. Example:

            REACTION   (....(N,EL),,STF)

    In general, J and 1 should be specified. However, strength-functions are
    also given without specifying J and 1 or with specifying 1 only.
    Explanation should be given in free text in order to make sure that the
    compiler did not forget to enter J or 1.

Capture   Capture

Definition: A reaction in which the incident projectile is absorbed by the
target nucleus which then emits electro-magnetic radiation.

Quantity code: 'G' in SF3 of REACTION

Note: This process is often called "absorption", which is defined in EXFOR
         as a sum cross-section; see Absorption.

Center-of-Mass System   Center-of Mass System

The indication whether data are given in lab-system or center-of-mass system
is given within the data-heading keywords, not within the REACTION coding.
All quantities are understood to represent the lab-system, unless the
data-headings are labeled with "CM", as for example:

    EN-CM   = incident particle energy in CMS
    E-CM   = energy of outgoing particle in CMS
    COS-CM   = cosine of angle in CMS
    NUMBER-CM   = heading for the coefficient-number, when the (Legendre or
                   cosine) fit refers to an angle given in CMS, independent of
                   whether the fit has been made from an angular distribution in
                   CMS or whether it has first been made from an angular
                   distribution in the lab-system and then converted to CMS.
    DATA-CM   = heading for data which are in CMS with respect to at least
                   one variable.

See the data-heading keywords as given in Dictionary 24.

The compiler may convert data from the centre-of-mass-system to the
lab-system, but should document in free text under INC-SPECT, STATUS or
HISTORY that he did so.

Note: Only one representation (i.e., either lab or center-of-mass) for each
      parameter should be coded as a variable in the data table. The other
      representation may by added under the column heading MISC if considered
      desirable by the compiler. In case of doubt the laboratory system is
      preferred.

Free-text comments are entered in the BIB Section under the appropriate BIB keyword to which the comment refers.

Any information which does not originate with the author must be clearly labelled, e.g., "COMMENT BY THE COMPILER...", and unambiguously separated from author's comments, for example, by including it between stars or by inserting a blank line between author's and compiler's comments.

1. **BIB-Keyword COMMENT**

    Under the keyword COMMENT, free text comments are entered, such as:

    - Miscellaneous information which cannot logically be entered under another available keyword.
    - Author's statements about the data, e.g., whether they agree with theory or with other data.
    - Compiler's or evaluator's comments (see also CRITIQUE, below).

2. **BIB-Keyword CRITIQUE**

    Under the keyword CRITIQUE, free text comments on the quality of the data are entered, as given by the compiler or by an evaluator.

    The reference from which evaluator's comments are taken should be entered under the keyword REL-REF. See under REFERENCE.

    Note: Such comments should be called to the attention of the author, when possible.

3. **BIB-Keyword FLAG**

    The Information-Identifier Keyword FLAG is used to link free text comments in the BIB section with specific lines in the DATA section. See under Flags.

Compounds, chemical   Compounds, chemical

Data compiled in EXFOR normally refer to isotopic targets or elements with
natural isotopic composition. The chemical form of the target, which can be
specified under the keyword SAMPLE, should not be relevant to the EXFOR data
which have normally been corrected for impurities.

Only in those cases where the data measured on a chemical compound cannot be
separated into the contributions of its elements, chemical compounds can be
coded in the "target nucleus" field under the keyword REACTION. The chemical
compound codes provided under REACTION are not meant to give a chemically
correct formula (this must be given under the keyword SAMPLE) but are rather
meant to give a coarse grouping of chemical compounds for retrieval purposes.

Typical nuclear data for chemical compounds are thermal neutron scattering
data for which the formalism described was originally developed. The same
formalism may be used for other data types, when appropriate, such as
(alpha,n) thick target yield data of Be oxide.

For coding chemical compounds under the keyword REACTION see page 8.REACTION.2.

In general, chemical compounds are coded by combining the code CMP with the
element number and symbol of its main component. Example: 26-FE-CMP for iron
oxide or any other iron compound. More detailed information on the compound
is given under the keyword SAMPLE.

For a small number of materials of particular importance in neutron or reactor
physics, special compound codes are used. These are listed in Dictionary 9.
(See also page 7.13).

Example: 1-H-BNZ for benzene (C6-H6).

Note: In CINDA, the compound codes are entered correspondingly in the S-A
           field. A more precise definition of the compound is given in the
           comment field.

Three rules must be kept in mind:

1. A more specific code has priority over a more general code.

    Examples: a.   Zirconium-hydrides are to be entered as 40-ZR-HYD and not
                   as 1-H-CMP nor 40-ZR-CMP.
              b.   Water is to be coded as 1-H-WTR and not as 1-H-CMP.

2. For alloys (or other mixtures) the code CMP is combined with the element
    symbol of the major component, usually the one named first. For chemical
    compounds the code CMP is combined with the symbol of the primary element,
    usually the first code of the formula: CaCO3 is coded as 20-CA-CMP, and
    not 6-C-CMP nor 8-O-CMP.

3. If the compiler feels that two possible codes are equally relevant, the
    REACTION combination using the equal sign (tautology) may be used.

    Examples: a.   Ammonium-hydrocarbon
                   ((7-N-AMM,....)=(1-H-CXX,....))
              b.   brass, if it contains 50% Cu and 50% Sn
                   ((29-CU-CMP,....)=(50-SN-CMP,....))

    (In such cases two CINDA-entries are made, one for each quantity).

Compounds, chemical (page 2)

Typical data on compounds entered are low-energy neutron data, where chemical
or crystalline binding forces affect the neutron cross-sections; an example is
the total cross-section or thermal-scattering data of water. However, thermal
scattering data for H_2 must be entered under the isotope 1-H-1, supplemented
by an entry under the keyword SAMPLE. If, for example, the sample was a
compound, e.g., $PuO2$, and, if the data given refer only to Pu, then the
isotope must be given and not the compound.

CORRECTION   CORRECTION

All relevant information about corrections applied to the measured data to
obtain the values given under DATA should be entered as free text information
under the Information-Identifier Keyword CORRECTION.

Example: Multiple-Scattering correction.

This may include information on:

- corrections that have been applied
- corrections that have not been applied
- corrections that are estimated to be negligible.

Corrections that are not mentioned by the author but are regarded by the
compiler as relevant, are better entered under COMMENT (see Comments) where

they must clearly be labelled as compiler's comments. Partial errors
contributed by the uncertainties of the corrections are entered under
ERR-ANALYS (see Errors).

Consideration, depending on the compiler's judgment: In general, the data are
compiled as resulting from the corrections applied by the author. However,
frequently evaluators re-assess old data using improved corrections, because
they may have better knowledge on the theory of the experiment than that which
was available to the author at the time of the experiment. This may concern
items such as spectra shapes, detector-efficiency curves, etc. In such cases,
the re-assessed data are useful information to the user of EXFOR and should
therefore be compiled. They would be labelled under STATUS as (RNORM).

Compare: Renormalization and STATUS.

Covariance   Covariance

Information-Identifier Keyword COVARIANCE (compare page 8.COVARIANCE)

Covariance matrices, if given by the experimentalist, should be included,
where possible, in structured form as free text under the keyword COVARIANCE.
Only non-zero matrix elements need by given. If the matrices given are too
bulky for inclusion in EXFOR, a reference to where the details can be found is
sufficient.

Example:

```
COVARIANCE VALUES GIVEN ONLY FOR ELEMENTS BELOW DIAGONAL OF
           SYMMETRIC MATRIX ON SAME ENERGY GRID AS DATA.
           1.0
           0.98 1.0
           0.90 0.97 1.0
           0.70 0.82 0.93 1.0
           0.54 0.68 0.83 0.96 1.0
           0.64 0.75 0.85 0.92 0.95 1.0
           0.72 0.78 0.83 0.83 0.83 0.95 1.0
           0.64 0.67 0.69 0.69 0.68 0.83 0.93.1.0
           0.60 0.61 0.60 0.58 0.56 0.74 0.87 0.98 1.0
```

If the covariance information is too bulky for inclusion in the BIB-Section,
it may be given in a separate file. This is indicated by the presence of the
code (COVAR). The separate Covariance File would have the following format.

There are three record types in the covariance file: comment records, data
records and an end record.

Comment Record Format:

Col. 1   'C'
Col. 2- 9   Subentry number
Col. 10   Blank
Col. 11-80   Free text, which must include a description and definition of the
              covariance matrix and a format statement, e.g. FORMAT(9F5.2), for
              the covariance data following.

Data Record Format:

Col. 1   'D'
Col. 2- 9   Subentry number
Col. 10   Blank
Col. 11-80   Covariance data in the format specified above in a comment record.

End Record Format:

Col. 1   'E'
Col. 2- 9   Subentry number

Cross-Sections

For the coding of cross-sections see pages 8.REACTION. See
Dictionary 36 for a complete list of codes. Below, some cases requiring
specific explanation are given.

Fission cross-sections, see Fission.

Cross-sections leading to isomeric states, see Isomeric States.

See also LEXFOR entries for specific processes.

Independent and cumulative cross-sections

The coding of cross-sections requires special care when the formation of
the residual nucleus can occur:

   - by direct (= independent formation), and/or
   - via isomeric transition, and/or
   - via radioactive decay.

The following examples are given in Reaction formalism:

Code	Application
,SIG	Independent formation of the product nucleus can be assumed, but no definitive statement is given by the author.
M+,SIG	Only the activity of the ground state is measured which includes, however, the feeding from a metastable state via isomeric transition. See also under Isomeric States.
IND,SIG	Independent formation of the product nucleus when it is clearly specified by the author that the formation via radioactive decay is excluded.
IND/M+,SIG	Formation of the product nucleus including independent formation and formation via isomeric transition.
(CUM),SIG	The inclusion of the formation via radioactive decay is assumed by the compiler, but no definitive statement is given by the author.
CUM,SIG	The cross-section includes the formation via radioactive decay and isomeric transition.
CUM/M-,SIG	The cross-section includes the formation via radioactive decay but excludes the formation via isomeric transition.
CUM/(M),SIG	The cross-section includes the formation via radioactive decay, the inclusion or exclusion of formation via isomeric transition is uncertain.

November 1982

Cross-section integral between specified energy limits

Definition:

$$\int_{E_1}^{E_2} \sigma dE$$

Coding: coded using the REACTION parameter code INT in SF6.

Example: (-----(N,F),,INT)

The energy limits are specified under the Data-Heading Keywords EN-MIN and EN-MAX.

The units are cross-section x energy, e.g., b*eV.

Such data may be coded only in the following cases:

1. When the data are normalized by means of an integral cross-section over a specified energy range, the integral may be entered under MONITOR.

2. When the differential data are not available.

3. When the energy ranges given are commonly used for intercomparison of the data.

If such data are compiled, it should be clearly stated by whom the data were integrated.   Generally, only data integrated by the experimentalist are compiled.

Compilation of such data is optional.

Note: This code is not to be used for integral measurements.

DATA   DATA

The keyword "DATA" is used in two different functions:

a) System-Identifier

   As such the keyword "DATA" indicates the beginning of the data-table
   section in an EXFOR-entry as distinct from the BIB-section and the COMMON
   section. See the entry in dictionary 1, page 3.9 and chapter 5.

b) Data-Heading

   As such the keyword "DATA" is given on the top of the column in the
   data-table which contains the information defined under the BIB keyword
   REACTION. In certain cases the data-heading keyword DATA may be replaced
   by RATIO or SUM, see in LEXFOR under Ratios and Sums.

Data Type Data Type

The last subfield of the REACTION keyword (SF9) contains a code to indicate whether the data given are experimental, theoretical, evaluated, etc. If the data are experimental this field may be omitted.

Derived Data

Data which are not derived from the experimental data by the most direct method, but are, instead, calculated from other data obtained in the analysis of the experimental data, should be entered using the code 'DERIV' in SF9 (Data type) of the REACTION keyword code.

Only values derived by the experimentalist from his own data should be entered in this way.

Cross reference between 'Derived data' and that EXFOR subentry(ies) from which they were derived, should be given under the BIB keyword STATUS; see in LEXFOR under STATUS.

At present, the following types of derived data may be entered in EXFOR:

-   resonance integrals derived from resonance parameters or energy-dependent cross sections.

-   thermal cross sections calculated from resonance parameters.

-   angular distributions calculated from fitting coefficients.

-   cross-section values (e.g., at 0.0253 eV) derived from a smooth fit to measure points.

DECAY-DATA keyword. The following decay-data pertinent to the table given in the DATA section, are entered in coded form under the BIB keyword DECAY-DATA:

>   decaying nucleus,
>   half-life (value and unit),
>   type of radiation,
>   energy of radiation in keV,
>   abundance of the radiation given.

These data may be given for more than one decay mode. For coding rules see in chapter 8. under DECAY-DATA.

Decay-data are entered

- in order to define a metastable state,
- when used as basic parameters for deducing the data given in the DATA section,
- or as additional information resulting from or related to the experiment.

Rules:

1. The values entered (half-life, radiation-energy, abundance) must be those which have been used for obtaining the DATA given.

2. The compiler must specify in the free text whether these values were measured by the author or whether they were adopted by the author and from what source. If this is not evident, the compiler should point that out, e.g. "Compiler's comment: the origin of the half-life value was not reported by author."

3. If the values that have been used for obtaining the DATA are meanwhile superseded, this should be pointed out by the compiler, e.g. "Compiler's note: The half-life value is superseded, DATA should be revised."

4. If the author does not quote a half-life value, the compiler should take a value from the literature but add in the free text: "Half-life value was not given by the author. The value quoted was taken by the compiler from [reference]."

5. For half-lives there is an alternative coding possibility under the column- heading keyword HALF-LIFE in the COMMON or DATA section; see in Lexfor under Half-lives. However, this is less preferable than the coding under DECAY-DATA.

Decay Data for Variable Product Nuclei

In the case that the column headings ELEMENT and MASS, and (if applicable) ISOMER show up in the DATA (or COMMON) section, more than one string of decay-data information may be given under the keyword DECAY-DATA linked to the pertinent DATA lines by means of "decay-flags" in the following way:

```
DECAY-DATA    ((1.)54-XE-125-G,16.8HR,...
              ((2.)54-XE-127-M,69.SEC,...
              ((2.)54-XE-127-G,36.4D,...
              ((3.)55-CS-127,6.25HR,...
ENDBIB
NOCOMMON
DATA
ELEMENT       MASS         ISOMER       DECAY-FLAG DATA
NO-DIM        NO-DIM       NO-DIM       NO-DIM      ...
54.           125.         0.           1.          ...
54.           127.         0.           2.          ...
55.           127.         (blank)      3.          ...
...
```

It may occur that for one product given in the DATA table, decay data must be specified not only for this product but also for its precursors, for which also branching ratios may have to be considered. In this case one decay-flag given in the DATA table may correspond to two or more entries under the BIB keyword DECAY-DATA (see flag 2. in above example).

If the half-life values are the only type of decay information to be given they may be entered as a data column under the column heading Keyword HL.

DECAY-MON. Under this keyword decay data assumed by the author for the monitor used in the experiment are given. See page 8.DECAY-MON for coding rules.

1.) Theory

In certain cases, a fission-product nucleus may decay by beta-decay to excited levels in the daughter nucleus which lie above the neutron binding energy. In this case, a "delayed" neutron may be emitted whose measured half-life is equal to that of the preceding beta-emitter (delayed neutron precursor). These half-lives are of the order of 0.1 to 60 sec, which is large compared to the period of prompt neutron emission ($<<4 \times 10^{-14}$ sec, see **Fission Yield**).

FISSION PRODUCT: e.g. Br-87

Br-87 = Delayed Neutron Precursor

Fig. Schematic representation of Delayed neutron emission

B^n neutron binding energy
Q^β total β^- decay energy

T 1/2 = 55.4 sec

β^-

β^-

Kr-87* = Delayed Neutron Emitter
T1/2 prompt

n

Kr-86

8.0 MeV = Q^β

γ 5.5 keV = B^n

Kr-87

β^-

DAUGHTER PRODUCT

[Z,N]   [Z+1,N-1]   [Z+2,N-2]   [Z+1,N-2]
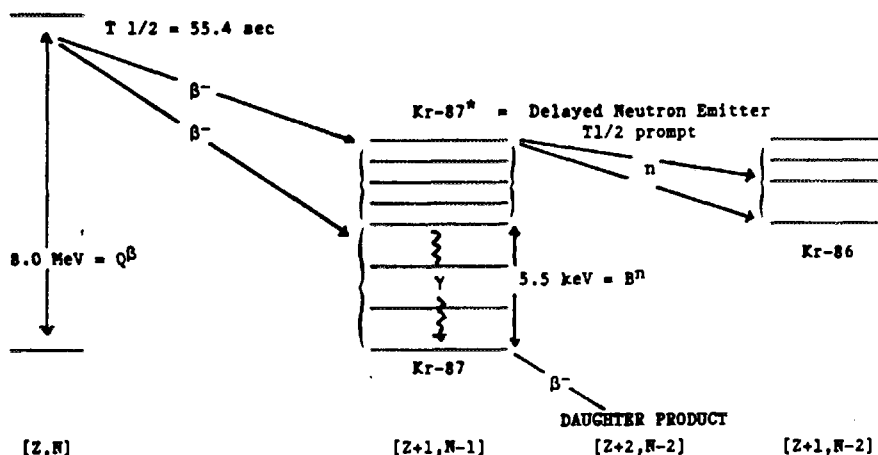
Pn-value

The delayed neutron emission probability (Pn-value) is a decay quantity defined as the fraction of precursor decays leading to delayed neutron emission (decay of Br-87 in the figure above), usually given in percent per decay.

The Pn-value can also be related to the yield data for a given precursor as follows:

$$P_n = \frac{\text{absolute delayed neutron yield}}{\text{precursor fission yield}} \qquad \text{(cumulative or independent)}$$

Sum rule:

$$Pn + \%\text{betas(dn-emitter)} = 100 \qquad \text{(dn-emitter = Kr-87* in the figure).}$$

Delayed neutron groups

Delayed neutron emission is usually represented by 6 delayed neutron groups, distinguished by their half-lives. Each group is associated with, perhaps, several different precursor nuclides with similar half-life values (approximately 55 sec, 22 sec, 6 sec, 2 sec, 0.5 sec and 0.2 sec).

Literature:

S. Amiel, Fission Product Nuclear Data, Vol. II, p. 33 (1973).
G.R. Keepin, Physics of Nuclear Kinetics (1965).
E.K. Hyde, The Nuclear Properties of Heavy Elements, Vol. III (1964).
Amarel et al., J.Inorg.Nuc.Chem., 31, 577 (1969)
Tomlinson et al., J.Inorg.Nuc.Chem., 33, 3609 (1971)
Asghar et al., Nucl.Phys.A, 247, 359 (1975)

2.) Definition and codes of quantities for data to be compiled in EXFOR

Total average delayed fission neutron yield $(\bar{\nu}_d = \bar{\nu}_t - \bar{\nu}_p)$

Coding:

- Absolute delayed neutron yield: (.....(N,F),DL,NU)
  Units: neutrons per fission (entered as NO-DIM)

- Delayed neutron fraction $(\bar{\nu}_d/\bar{\nu}_t)$ – coded as a ratio with the units
  NO-DIM:
  $$((.....(N,F),DL,NU)/(....(N,F),,NU))$$

Partial delayed fission neutron yields

There are two main types of measurements:

Delayed neutron groups

REACTION Coding: (....(N,F),DL/PAR,NU)

Data should be coded using the average half-life of the group as an
independent variable (with data heading HL which need not be explained in
the BTB section).
- Relative abundance (or relative group yield) - coded as ratio with
  units NO-DIM. The values for the goups sum up to 1.
- Absolute group yield-coded with units PC/FIS (neutrons per 100
  fissions) or NO-DIM (neutrons per fission).

Yields of delayed neutrons associated with individual precursors

Data should be coded with the precursor nucleus as an independent variable
given under the data headings ELEMENT and MASS, usually with units PC/FIS,
as above.

a) **Independent delayed neutron yield** of an individual precursor:

   REACTION coding: (....(N,F)ELEM/MASS,DL/IND,NU)

   It is the same as the product of the Pn-value and the independent
   fission yield of the precursor.

b) **Cumulative delayed neutron yield** of an individual precursor:

   REACTION coding: (....(N,F)ELEM/MASS,DL/CUM,NU)

   It is the the same as the product of the Pn-value and the cumulative
   fission yield of the precursor.

Delayed-neutron energy spectrum for a given neutron group

   REACTION coding: (.....(N,F),DL/PAR,DE,N)

   Data are coded using the average half-life of the neutron group and the
   delayed neutron energy or energy range as independent variables.

   The data may be given:

   a) in percent - the data unit PC/FIS is used
   b) as a relative measurement - the quantity modifier REL and data units
      ARB-UNITS are used.

For the preceding quantities the nucleus to be entered is the target nucleus
before the absorption of the incident particle.

For the spontaneous fission enter the fissioning nucleus in the "target" field
and replace the reaction (N,F) by (0,F).

Delayed Fission Neutrons (page 3)

Delayed neutron emission probability (Pn-value)

Definition: Neutron yield per beta decay for a given precursor
                  nucleus.

Reaction coding: (Z-S-A(0,B-)Z'-S'-A,,PN)

Units: either PC/DECAY
                  or NO-DIM if given as a fraction.

The precursor nucleus Z-S-A before beta-decay is coded in the target
field. The neutron-emitting daughter nucleus Z'-S'-A is coded in the
reaction-product field.

If P_n values are given for a series of delayed-neutron emitting fission
fragments ("precursor nuclei"), the formalism of the the "Variable Product
Nucleus" is extended to the target nucleus field SF1 in the following
formalism:

                  REACTION (ELEM/MASS(0,B-),,PN)

with the "precursor nuclei" specified in the DATA table under the headings
ELEMENT and MASS. In this case the Reaction Product is not coded.

3.) Data not presently compiled in EXFOR

The energy spectrum of all delayed neutrons together is time dependent,
due to the contributions from the different half-life groups. This is
presently not coded in EXFOR.

The delayed-neutron equilibrium spectrum as found in a steady-state
reactor is presently not coded in EXFOR.

There are other delayed-neutron quantities which are not properties of the
fissioning nucleus but decay properties of the fission-product nucleus
which is the "precursor" of the delayed neutron. Although such quantities
are closely related to the quantities given above, they are presently not
coded in EXFOR, except for the delayed neutron emission probability (see
above). - The energy spectrum of the neutrons emitted by a specific
precursor is presently not coded in EXFOR.

Dependent Data   Dependent Data

Data that were deduced by a trivial operation from other EXFOR data sets
should be labeled with the code DEP under STATUS. Free text under STATUS
and/or ANALYSIS
should give information as to how the data were deduced. Cross-reference to
the EXFOR entries from which the data were deduced must be coded as an
eight-digit integer following the code, as follows:

    (DEP,10048007)

See also page 8.STATUS.

Examples:

    - Alpha, if it was obtained from the ratio of two independent EXFOR
       sub-entries for fission and capture.

    - Radiation width, if it was obtained from a subtraction of two
       independent EXFOR sub-entries of total width and elastic width.

    - Legendre- (or Cosine-) coefficients are considered as dependent data,
       if the originally measured differential cross-sections are also given
       in EXFOR.

    - If the same data are given in two subentries in different
       representations, e.g., cross-section and cross-section times
       square-root of energy, one of them should have the status code (DEP).

The status code DEP should not be used when some data sets are mutually
interdependent, as for example:

       An experiment (Cabell, AERE-R-5874,68) may yield simultaneously
       absorption and capture cross sections, and alpha, where all three
       interdependent quantities were derived from a common set of raw
       data. None of them should be labeled with the status code "DEP".

Compare: Interdepent Data and Data Type

Differential Data   (page 1)   **Differential Data**

See also **Fitting Coefficients**, **ANGLE**

1. Differential with respect to angle of emitted particle or radiation

Quantities defining the angular distribution of an emitted particle or radiation are coded with "DA" in SF6 of the REACTION keyword. The angle given as variable in differential cross sections, is the angle of the emitted particle or radiation against the incident particle beam.

Example: angular distribution of protons emitted in the (n,np) reaction:

$$\text{REACTION} \quad (....(N,N+P),,DA,P)$$

Relative Angular Distributions (quantity modifiers coded in REACTION SF8)

a) The values given represent the shape of the angular distribution given in arbitrary units.

      Quantity Modifier: REL
      Data-unit Keyword: ARB-UNITS

b) Ratios to the value at one angle:

$$\frac{d\sigma}{d\Omega}(\theta) \Big/ \frac{d\sigma}{d\Omega}\left(\theta_o\right) = 1, \text{ when } \theta = \theta_o$$

    Quantity Modifier:

        when $\theta_o = 90$: RSD

        when $\theta_o \neq 90$: REL

      Data-unit Keyword   : NO-DIM

c) Ratios to the integrated cross section:

$$\frac{1}{\sigma} \frac{d\sigma}{d\Omega}(\theta)$$

    Code as a ratio with Data-units 'NO-DIM'

Example: REACTION ((-----(N,EL),,DA)/(----(N,EL),,SIG))

d) Values normalized such that their value over the integral equals 4π:

$$\frac{4\pi}{\sigma} \frac{d\sigma}{d\Omega}(\theta)$$

      Quantity modifier: RS
      Data-unit Keyword: NO-DIM

2. Differential with respect to energy of emitted particle or radiation

Quantities defining the energy spectrum of the outgoing particle or radiation
are coded with 'DE' in SF6 (Parameter) for the REACTION keyword.

Example: energy spectrum of gammas from inelastic neutron scattering:

REACTION (----(N,INL),,DE,G)

3. Differential with respect to energy and angle of emitted particle or radiation

Quantities defining the energy spectrum of the outgoing particle or radiation
as a function of angle are coded with 'DA/DE' in SF6 (Parameter) for the
keyword REACTION.

Example: Double differential inelastic scattering cross section

REACTION (------(N,INL),,DA/DE)

4. Triple Differential Data

Triple differential data with respect to the energy and angle of one outgoing
particle or radiation and the energy of another outgoing particle or radiation
are given with the code 'DA/DE/DE' in REACTION SF6 (Parameter).

REACTION (------(N,2N+P),,DA/DE/DE,N/N/P)

5. General

If it is not evident from the quantity-code which outgoing particle is
referred to, this is indicated in the fourth quantity-subfield.

The indication whether the differential cross-section, the angle, or the
energy is given in the lab-system or centre-of-mass system is not entered
within the quantity-code but in the data-headings; see under
Centre-of-mass System.

Dissapearance   Disappearance

The disappearance or removal cross-section is defined in CINDA as the cross-section for all neutron-induced processes producing no emergent neutron, that is $(n,\gamma) + (n,p) + \dots$ It differs from the absorption cross-section by not including $(n,2n)$, (n,np), etc.

Note other meanings of "removal" in reactor physics and shielding-physics.

Dosimetry Reactions Dosimetry Reactions

Priority should be given to the compilation of cross section data for use in neutron dosimetry by foil activation.

A list of the 'most-needed' reaction data identified follows.

Activation Reactions (for use with neutron threshold detectors)

3-LI-6(N,X)HE PROD
5-B-10(N,X)HE PROD
7-N-14(N,P)6-C-14
9-F-19(N,2N)9-F-18
11-NA-23(N,G)11-NA-24
11-NA-23(N,2N)11-NA-22
12-MG-24(N,P)11-NA-24
13-AL-27(N,A)11-NA-24
13-AL-27(N,P)12-MG-27
15-P-31(N,P)14-SI-31
16-S-32(N,P)15-P-32
21-SC-45(N,G)21-SC-46
21-SC-45(N,2N)21-SC-44
21-SC-45(N,2N)21-SC-44-M
22-TI-46(N,P)21-SC-46
22-TI-47(N,N+P)21-SC-46
22-TI-47(N,D)21-SC-46
22-TI-47(N,P)21-SC-47
22-TI-48(N,P)21-SC-48
22-TI-48(N,N+P)21-SC-47
25-MN-55(N,2N)25-MN-54
25-MN-55(N,G)25-MN-56
26-FE-54(N,P)25-MN-54
26-FE-54(N,A)24-CR-51
26-FE-56(N,P)25-MN-56
26-FE-58(N,G)26-FE-59
27-CO-59(N,P)26-FE-59
27-CO-59(N,A)25-MN-56
27-CO-59(N,2N)27-CO-58
27-CO-59(N,G)27-CO-60

28-NI-58(N,P)27-CO-58
28-NI-58(N,2N)28-NI-57 → 27-CO-57
28-NI-60(N,P)27-CO-60
29-CU-63(N,A)27-CO-60
29-CU-63(N,2N)29-CU-62
29-CU-63(N,G)29-CU-64
29-CU-65(N,2N)29-CU-64
30-ZN-64(N,P)29-CU-64
30-ZN-64(N,2N)30-ZN-63
40-ZR-90(N,P)39-Y-90
40-ZR-90(N,2N)40-ZR-89
41-NB-93(N,INL)41-NB-93-M
41-NB-93(N,2N)41-NB-92-M
42-MO-98(N,G)42-MO-99 → 43-TC-99-M
45-RH-103(N,INL)45-RH-103-M
47-AG-109(N,G)47-AG-110-M
49-IN-115(N,INL)49-IN-115-M
49-IN-115(N,G)49-IN-116-M
53-I-127(N,2N)53-I-126
73-TA-181(N,G)73-TA-182
74-W-186(N,G)74-W-187
79-AU-197(N,G)79-AU-198
79-AU-197(N,2N)79-AU-196
79-AU-197(N,3N)79-AU-195
79-AU-197(N,4N)79-AU-194
80-HG-199(N,INL)80-HG-199-M
90-TH-232(N,2N)90-TH-231
90-TH-232(N,G)90-TH-233 → 91-PA-233
92-U-238(N,G)92-U-239 → 93-NP-237

Fission Reactions

90-TH-232(N,F)
92-U-235(N,F)
92-U-238(N,F)
93-NP-237(N,F)
94-PU-239(N,F)
95-AM-241(N,F)

Naturally occurring elements are, in general, entered with A=O. However, for monoisotopic elements, the atomic weight of the naturally occuring isotope is used.

A list of mono-isotopic elements follows:

Z-S-A	Z-S-A
4-BE-9	45-RH-103
9-F-19	53-I-127
11-NA-23	55-CS-133
13-AL-27	59-PR-141
15-P-31	65-TB-159
21-SC-45	67-HO-165
25-MN-55	69-TM-169
27-CO-59	79-AU-197
33-AS-75	83-BI-209
39-Y-89	90-TH-232
41-NB-93	

Nearly Mono-isotopic elements may be entered with the A-number of their main isotope in the case where there is no noticeable influence from trace isotopes on the data presented. This generally is the case for total and elastic scattering cross sections. However, special care should be taken in the case of the capture cross section or in the case of partial cross sections which may lead to levels in one of the trace elements.

Following is a list of nearly mono-isotopic elements:

```
1-H-1
2-HE-4
6-C-12
7-N-14
8-O-16
23-V-51
57-LA-139
73-TA-181
```

Note: Elements which do not occur naturally must be entered with the isotope number:

```
43-Tc
61-Pm
84 ≤ Z ≤ 89
91-Po
93 ≤ Z
```

Superheavy elements which do not have an element symbol are coded using an * for the element symbol (e.g., 107-*-270). See Dictionary 8.

See also Target Nucleus.

The hydrogen isotopes are coded as 1-H-2 and 1-H-3.
The symbols D and T should not be used.

Emission Cross-Sections

See under Production Cross-Sections

Errors   Errors

For coding rules see pages 6.10 and 8.ERR-ANALYS. - Errors as referred to
here, are estimates of experimental uncertainties.

Table of contents

A.   Standard procedure

Information on data-errors and experimental uncertainties is entered in the
DATA section under specific data headings as given in Dictionary 24. These
headings require free text explanation.

a)   Numerical 'error' values are entered in the "COMMON" or "DATA" section
     under data-heading keywords containing the characters 'ERR' as given in
     Dictionary 24, for example:

     EN-ERR = error of monochromatic incident-neutron energy or uncertainty of
               the central energy in an incident neutron spectrum. This is not
               to be confused with energy-resolution "EN-RSL" (see Resolution).

     DATA-ERR= error of data given under the data-heading keyword "DATA"

     If two or more errors of different type are given that refer to the same
     data, data-heading keywords of the type"DATA-ERR1" and "DATA-ERR2" are
     used. Unsymmetric errors are identified with "+DATA-ERR" and "-DATA-ERR".

b)   Free text explanation of the error-sources and of the numerical
     error-values is given under the keyword "ERR-ANALYS". In order to link
     the explanations to the numerical data given, the relevant "error-headings"
     are given in parentheses, starting in column 12, followed by free text.
     (When only one data-error is given, the code (DATA-ERR) need not be given
     under the keyword "ERR-ANALYS".) Free text should contain a statement of
     error-types included in the quoted error, and also those error-types which
     are not included in the quoted error. Note that explanatory information
     on the energy-resolution and on errors referring to the incident neutrons
     are more likely to be described under "INC-SPECT".

Errors (page 2)

The numerical uncertainty values quoted in the COMMON or DATA section are of relevance only in context with an appropriate entry under ERR-ANALYS, explaining the type of uncertainty and percentage of contributing uncertainties. Therefore, the compiler should be most careful in defining the information given and should be aware of the following aspects which are required for a precise definition of the uncertainty:

1. error-type, such as:

   - statistical or random uncertainty (always uncorrelated)
   - systematic uncertainties (often correlated)
     sample related: mass, geometric effects, multiple scattering, self-absorption.
     detector related: efficiency, calibration.
     normalization: uncertainty of the monitor cross section, flux determination.

2. total error or partial error

   For example, the statistical uncertainty, which is most often a partial along with other uncertainties, may be the total uncertainty if other sources of uncertainty are negligible.

3. shape of error-function, such as

   - Gaussian, symmetric
   - triangular, symmetric
   - unsymmetric, for example $8.5^{+0.5}_{-0.2}$

4. error measure, such as

   standard deviation = half-width at half-maximum of Gaussian error distribution function.

   = 2/3 probability that the true value is within error bars.

   confidence limits = when the errors are given as confidence limits, various definitions exist, for example 95% probability which corresponds to approximately two standard deviations.

   errors "supposed not to exceed ..." = approx. 100% probability value is within error bars.

5. error given in absolute units or percent; see Units.

6. error correlations, see in Lexfor under COVARIANCE, Interdependent Data and on page 8.COVARIANCE.

B. More sophisticated procedure for precision data

General Comments

1. First priority should be given to the compilation of detailed information on statistical and systematic errors for experimental data on neutron cross sections of standards and dosimetry reactions. For such data, error types such as statistical systematic, total, should be coded in computer intelligible form as specified further below.

2. When the required information is not given in the puclication, every effort should be made to obtain the information from the authors.

3. The keyword COVARIANCE is introduced. All correlation factors and covariances if given by the authors, are given in free text, where possible in structured form. If this becomes too bulky for inclusion in EXFOR, a reference where details can be found is sufficient.

4. Errors should be broken down into statistical and systematic errors.

5. Errors will be given as one standard deviation (or the equivalent for systematic errors).

6. Systematic errors should be broken down into individual independent components and these components should be given as a function of energy. They should not be combined into a final variance-covariance matrix (V-C matrix) as this represents a significant loss of information.

7. The breakdown of systematic errors into major components by source should be "fine" enough so that the correlations between sub-components at different energies within a given major component may be reasonably set equal to a constant lying between +1.0 and -1.0. Correlation factors may be given in the format specified on page 8.ERR-ANALYSIS item 5.

8. In the case of systematic errors where the preceding is not satisfied, e.g., background determination in a time-of-flight experiment with black filters, the quantitative information on the energy dependence of the correlations should be given in "comments" which include the appropriate algebraic expressions.

9. The preceding two proposals avoid the problem of having to give a gigantic V-C matrix in the files and allow the evaluator construct the V-C matrix of the data from the information given. They also allow for the inclusion of new information on any major error component obtained at a later date.

10. Measured ratios should always be given when they are available.

11. Data measured in different experimental runs with changes in experimental parameters, e.g., sample, flux monitor, etc., should be given as separate sets.

Coding

1. Error fields will be identified as statistical or systematic (or total, if that is all that is given). The definition of the different systematic errors will be given in free text comments.

2. Only errors which are one standard deviation or the equivalent will be entered using this format. If authors give 2- or 3-sigma-errors, EXFOR compilers will convert them to 1-sigma-errors. Other types of error information will usually be given in free text only.

3. Constant errors, such as in sample thickness, etc., will be entered in the COMMON data section or in free text under ERR-ANALYS, others will be given as a function of energy.

4. The data will be tabulated as follows:

ERR-1	ERR-2						
$\varepsilon 1$	$\varepsilon 2$						

EN	EN-ERR	EN-RSL	DATA	ERR-S	ERR-3	ERR-4	...
E_1	ΔE_1	$E_R(E_1)$	$B(E_1)$	$\Delta_{stat}(E_1)$	$\varepsilon_3(E_1)$	$\varepsilon_4(E_1)$	...
E_2	ΔE_2	$E_R(E_2)$	$B(E_2)$	$\Delta_{stat}(E_2)$	$\varepsilon_3(E_2)$	$\varepsilon_4(E_2)$	...
.	.	.	.	.	.	.	...
.	.	.	.	.	.	.	...
E_i	εE_i	$E_R(E_i)$	$B(E_i)$	$\Delta_{stat}(E_i)$	$\varepsilon_3(E_i)$	$\varepsilon_4(E_i)$	...
.	.	.	.	.	.	.	...
.	.	.	.	.	.	.	...
E_n	ΔE_n	$E_R(E_n)$	$B(E_n)$	$\Delta_{stat}(E_n)$	$\varepsilon_3(E_n)$	$\varepsilon_4(E_n)$	...

where   EN   = Lab energy of incident particle
        EN-ERR = energy uncertainty
        EN-RSL = resolution (a Gaussion distribution is assumed; (EN-RSL) defines the variance of the distribution)
        DATA   = the measured data (B)
        ERR-S   = statistical error (δ_{stat})
        ERR-1   = constant 1st major component of systematic error (ε_1)
        ERR-2   = constant 2nd major component of systematic error (ε_2)
        ERR-3   = 3rd major component of systematic error (ε_3)
        ERR-4   = 4th major component of systematic error (ε_4) etc.

The following are assumed:

$$\langle \Delta_{stat}(E_i)\ \Delta_{stat}(E_j)\rangle = 0 \quad \text{if } i \neq j$$
$$\langle \Delta_{stat}(E_i)\ \varepsilon(E_j)\rangle = 0$$
$$\langle \varepsilon_l(E_i)\ \varepsilon_m(E_j)\rangle = 0 \quad \text{if } l \neq m.$$
$$\langle \varepsilon_l(E_i)\ \varepsilon_l(E_j)\rangle = \varepsilon_l(E_i)\ \varepsilon_l(E_j)\ \rho_{ij}$$

where ρ_{ij} is a constant between -1.0 and +1.0
See General Comment 8, when ρ_{ij} is energy dependent.

Example : Error Coding.

```
SUBENT        10921002       821014
BIB                  3           25
REACTION   ((29-CU-63(N,A)27-CO-60,,SIG)/(92-U-238(N,F),,SIG))
ERR-ANALYS UNCERTAINTY IN NEUTRON ENERGY ABOUT 10 KEV.
           (ERR-T) TOTAL ERROR
           (ERR-S) STATISTICAL ERROR
           SOURCES OF SYSTEMATIC UNCERTAINTIES (CORRELATION
              FACTORS IN PARENTHESIS AFTER HEADING)
           (ERR-1,1.0) GAMMA-RAY DETECTION EFFICIENCY.
           (ERR-2,0.0) IRRADIATION GEOMETRY.
           (ERR-3,1.0) URANIUM DEPOSIT, MASS, AND ISOTOPE CONTENT.
           (ERR-4,1.0) EXTRAPOLATION CORRECTION FOR FISSIONS AND
                       CORRECTION FOR FINITE THICKNESS OF DEPOSIT
           (ERR-5,1.0) CORRECTION FOR NEUTRON ABSORPTION IN
                       CU SAMPLE
           (ERR-6,1.0) CORRECTION FOR NEUTRON SCATTERING BY THE
                       SAMPLE AND FISSION CHAMBER COMPONENTS
           (ERR-7,0.5) NEUTRON SOURCE CHARACTERISTICS.
COVARIANCE ONLY ABOVE DIAGONAL ELEMENTS OF SYMETRIC MATRIX ARE
           GIVEN IN PERCENT ON SAME ENERGY GRID AS DATA.
                           100   17   19   29   23   14   13
                                100   37   39   45   28   23
                                     100   42   48   29   26
                                          100   50   31   26
                                               100   35   30
                                                    100   22
                                                         100
ENDBIB               25            0
COMMON                3            3
ERR-1      ERR-6      ERR-7
PERCENT    PER-CENT   PER-CENT
 1.5        2.2        1.5
ENDCOMMON             3            0
DATA                  9            7
EN         EN-RSL-HW  DATA        ERR-T       ERR-S       ERR-2
ERR-3      ERR-4      ERR-5
MEV        MEV        NO-DIM      PER-CENT    PER-CENT    PER-CENT
PER-CENT   PER-CENT   PER-CENT
 3.800      0.081      2.42    -04 13.        12.         3.3
 1.0        0.2        1.8
 3.800      0.082      1.84    -04 22.        21.         2.6
 1.0        0.2        1.8
 4.065      0.041      5.142   -04  6.5        4.7        2.0
 1.0        1.5        1.8
 4.361      0.041      9.769   -04  5.7        3.8        2.0
 1.0.       0.7        1.8
 4.656      0.042      1.475   -03  5.6        3.6        2.0
 1.0        1.0        1.8
 4.954      0.043      2.409   -03  5.0        2.4        2.0
 1.0        1.2        1.9
 5.268      0.045      3.912   -03  8.7        7.5        1.7
 1.3        1.0        1.9
ENDDATA              18            0
ENDSUBENT            52            0
```

Errors (page 6)

C. Example: Unsymmetric errors and error limits

A data table may contain different notations as follows:

```
        20.    ± 5.
        21.    + 3./-1.
     ≃ 22.
     < 23.
```

This must be split into several columns.

DATA	DATA-APRX	DATA-MAX	DATA-ERR	+DATA-ERR	-DATA-ERR
MB	MB	MB	MB	MB	MB
20.			5.		
21.				3.	1.
	22.				
		23.			

D. Errors of independent variables, standards, half-lives, etc.

Most of what was said above applies to the dependent variables, i.e. to the data given under the heading DATA and defined under REACTION.

Errors of independent variables (energies, angles, etc), of standard cross-sections, half-lives or other parameters, are coded in a similar manner using appropriate data-heading keywords as defined in Dictionary 24. For these cases the more sophisticated procedure as above under B. cannot be used.

Fission (page 1) **Fission**

See also **Fission Yields, Fission-Neutron Specta, Delayed Fission Neutrons.**

Theory

Fission can occur either spontaneously or by the capture of an incident particle. In spontaneous fission, a nucleus exists in a highly excited and deformed state. In the case of capture, a particle is absorbed forming a highly excited nucleus which then undergoes deformation. If the nucleus is excited with sufficient energy such that the electrostatic repulsion will be greater than the surface forces holding the nucleus together, it may undergo scission.

At the scission stage the nucleus generally divides into two deformed and excited fission fragments having a mass greater than the mass of the incident projectile but not less than 7. This process is called **Binary Fission.**

Much less frequently, the nucleus divides into three fragments, where the size of the third fragment varies between a 'scission neutron' and a fragment similar in size to the other two fragments. This process is called **Ternary Fission**

For further detail see:

E.K. Hyde, The Nuclear Properties of Heavy Elements, Vol. III (1964)

N. Feather, 'Ternary Fission', Physics and Chemistry of Fission, page 33, Vienna (1969)

At higher energies (neutrons above about 50MeV) there are other mechanisms such as spallation; compare under **Reaction Mechanisms.**

Coding

The fission process is coded using the process code 'F' in REACTION SF3. The reaction-product field SF4 is left blank (except when a specific product is referred to; see further below).

Example: (....(N,F),,SIG) Neutron fission cross-section

Special rules apply for the coding of the **Reaction Product** (see pages 8.REACTION.5 and 8.REACTION.8.

Spontaneous Fission is coded using '0' in REACTION SF2 and 'F' in SF3.

Example: (....(0,F),,NU) spontaneous fission nu(bar)

Ternary Fission

Ternary fission is coded by using the modifier 'TER' in REACTION SF5 (branch).

Examples:

    (....(N,F),TER,SIG)   Ternary fission cross-section
    (....(N,F),TER,DA,LCP)   Angular distribution of light charged
                                 particles in ternary fission

Frequently, the ternary fission is further specified by the accompanying light
particle, e.g., 'alfa-particle accompanied ternary fission'. Such information
should be coded by specifying the light particle in REACTION SF4.

Example: (...(N,F)2-HE-4,TER,SIG)   Cross-section for alpha-accompanied
                                     ternary fission.

Note: This is a partial cross section for only those ternary fissions
      accompanied by the light charged particle specified.

The ratio of binary to ternary fission may be coded by combining the codes
'BIN' and 'TER' in REACTION SF5 (branch) and the code 'RAT' in SF6 (data type).

Example: (....(N,F),BIN/TER,SIG/RAT)

Fission Products

The fission-product for which data are given (e.g. yields, kinetic energies,
etc.) can be coded

    -     either in REACTION SF4
    -     or as a variable in the DATA table (variable product-nucleus
          formalism, see page 8.REACTION.8).

Examples:

(92-U-235(N,F)54-XE-124,,FY)   = Yield of the fission-product Xe-124
(92-U-235(N,F)54-XE-125-M,,FY)= Yield of Xe-125m
(92-U-235(N,F)ELEM/MASS,,FY)   = Yield of the product nuclei specified in the
                                 DATA table under the headings ELEMENT and MASS.

For details see under Fission-yields.

For quantities related to the bulk of heavy or light fission products the
codes HF (heavy fragment) and LF (light fragment) are used in REACTION SF7
(particle considered).

Example: (....(N,F),,AKE,HF)   Average kinetic energy of heavy fragments

Decay Data for the fission-product nuclei considered are coded as usual. See
the Lexfor entry "Decay-Data" where an example is given for coding decay-data

in the case of "variable product nuclei".

Partial fission cross sections

The fission cross section is a sum cross section, for example:

(n,f) = direct fission + (n,n'f) + (n,2nf) + ... + (n, f) + ...

The partial fission cross sections are coded under the keyword REACTION as follows:

|	
(n,n'f)	(N,N+F),SEQ,SIG
(n,2nf)	(N,2N+F),SEQ,SIG
(n,gamma f)	(N,G+F),SEQ,SIG

Note: For the coding of a "direct fission only" cross section a new branch code (e.g., DIR) could be introduced for SF5 as soon as such a case occurs and is to be coded in EXFOR.

Fission through fission isomers

Prompt fission may have to be distinguished from delayed fission via a fission isomer with measurable lifetime. This can be coded as follows:

(D,P+F),PR,SIG   prompt fisson

(D,P+F),DL,SIG   delayed fission via a fission isomer which must be further specified under the BIB keyword DECAY-DATA.

Fission (page 4)
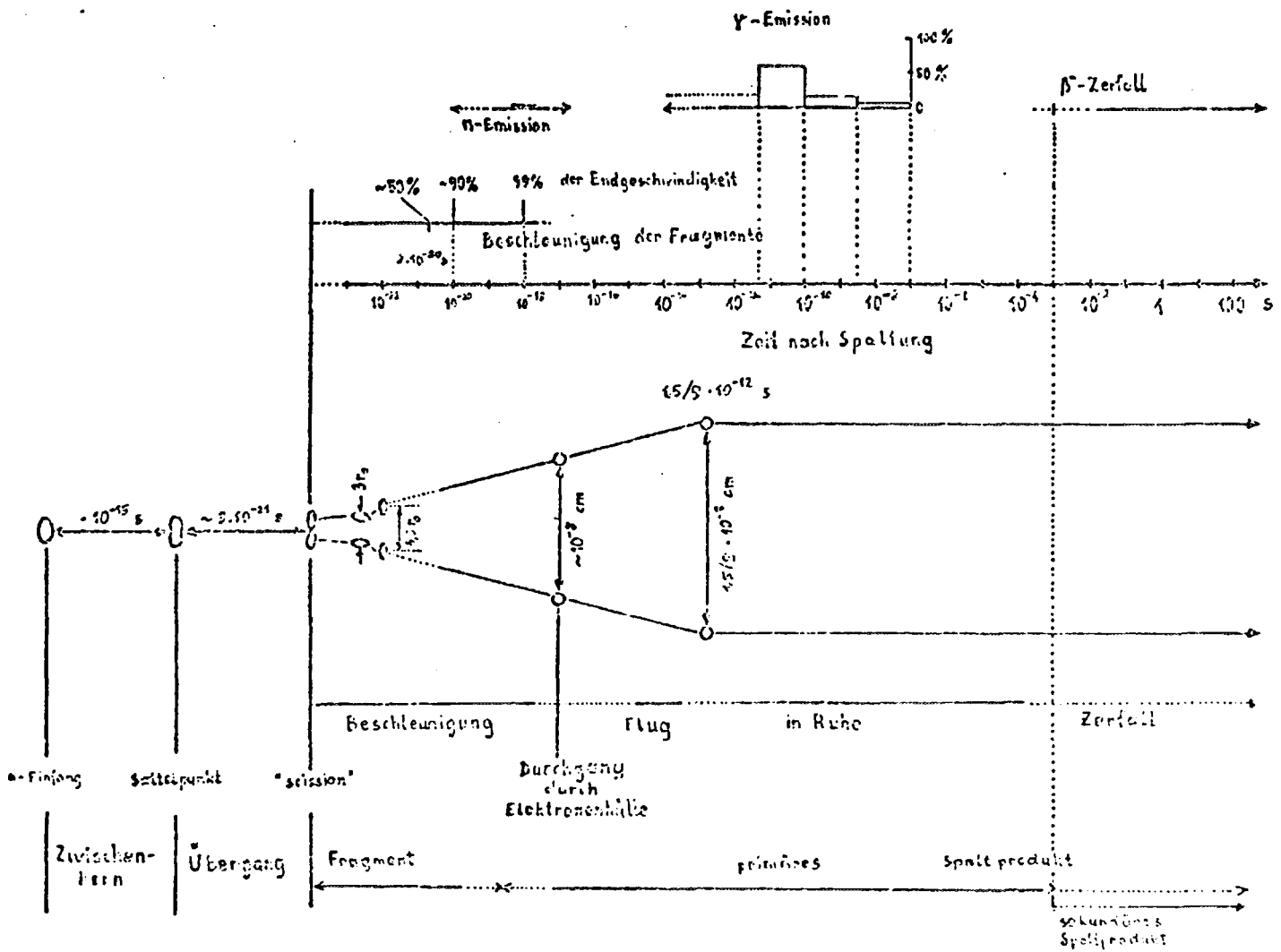
Zeitlicher Verlauf der Kernspaltung
reproduced from Thesis M.Lammer

Fission-Neutron Spectra Data

Theory

Fission-neutron spectrum data are fitted either to a Maxwellian or to a Watt spectrum or to one of several other defined spectra.

The Maxwellian spectrum has the shape:

$$N(E) \sim \sqrt{E} \, \exp(-E/T)$$

where E is the energy of the fission neutron and T is the spectrum temperature given in Mev. Also often given are the average kinetic energy E and the most probable energy E_p which are defined as:

$$\overline{E} = 3T/2$$

$$E_p = T/2 = \overline{E}/3$$

The Watt spectrum is based on the assumption that fragments emit neutrons with a Maxwellian spectrum in the center-of-mass system. The shape of the Watt spectrum is:

$$N(E) \sim \exp(-E/T) \, \sinh(\frac{2}{T} \sqrt{E \, E_f} \,)$$

where T is the spectrum temperature given in Mev but deviating from the temperature defined in the Maxwellian fit; E_f is a theoretical "fragment kinetic energy per nucleon". The average kinetic energy $\overline{E}$ is defined here as:

$$\overline{E} = E_f + 3T/2$$

The numerical value of $\overline{E}$ should be approximately the same disregarding the spectrum shape to which the data were fitted.

Fission spectrum average cross-sections are defined as:

$$\sigma = \frac{\int \sigma(E) N(E) \sqrt{E} dE}{\int N(E) \sqrt{E} dE}$$

Fission-neutron spectra data (page 2)

The knowledge of the shape of the fission spectrum is developing, and Maxwellian and Watt spectra are now considered only as rough approximations. Presently preferred is a "double Watt spectrum". The Cf-252 spectrum, which is more accurately known, suggests that none of the presently used fits is sufficient. Therefore, it is most important to compile point data of the energy distribution of fission neutrons. However, it is also desirable to compile mean-energy values because they are rather independent of the spectrum shape assumed and frequently needed for measurement analysis (detector response, etc.).

References

James Terrell, "Fission Neutron Specta and Nuclear Temperature". Phys. Rev. 113, p. 527 (1959)

"Prompt Fission Neutron Spectra", Vienna, 1979

Data to be compiled in EXFOR

1. **Energy spectra of fission neutrons**

   In the literature, these data are usually called X(E). Data are usually given in arbitrary units, which requires the REL modifier in the quantity code. In the normalized form $\int X(E)dE = 1$, (or $\int X(E)dE = $ nu-bar), data have the units of a reciprocal energy.

   The data are functions of the outgoing-neutron energy (E), and incident-projectile energy (EN).

   Examples:

---(-,F)PR,DE,N	Energy spectrum of prompt fission neutrons
---(-,F),DL,DE,N)	Energy spectrum of delayed neutrons
---(-,F),DL/PAR,DE,N)	Energy spectrum for a specific delayed neutron group

2. **Fitting parameters of fission-neutron spectra**

   Since the average kinetic energy $\bar{E}$ is the only quantity which is comparable in all fits, EXFOR entries should be made for this quantity.

   Example:

---(-,F),PR,AKE,N	Average kinetic energy of promp fission neutrons.

   Details of the fit and of the spectrum shape assumed should be given under ANALYSIS.

Fission-neutron spectra data (page 3)

3. **Fission neutron spectrum averaged cross-sections** are entered with the modifier FIS.

   It must be evident in the EXFOR entry whether the data were:

   - measured directly. The method should be specified under METHOD. Under INC-SPECT, the kind of spectrum and the nuclide and incident-projectile energy from which the fission-neutron spectrum is produced should be specified.

   - calculated by integrating a measured cross-section curve over an assumed fission-neutron spectrum. This is specified using the code 'DERIV' in REACTION SF9. An entry should also be made under ANALYSIS. It is essential to give the assumed spectrum type and its parameters, as well as how the fit was made (e.g., in a N(E)-versus-E scale or in a N(E)/√E-versus-E scale.

   Note: More recently, the use of the modifier MXW (previously used for Maxwellians near 0.0253 eV only) was extended to Maxwellian spectra of higher temperatures. Consequently, one could use

   - FIS   for cross-sections measured directly in a fission-neutron spectrum; and for cross-sections calculated in a non-Maxwellian approximation of the fission-neutron spectrum.

   - MXW   for cross-sections calculated in a Maxwellian approximation of the fission-neutron spectrum.

   So far, there is no formal agreement on this matter.

Review-article see e.g. A.C. Pappas, J. Alstad, 69VIENNA,,669,6907.

Fission-process: The capture of the incident neutron creates a highly excited
compound-nucleus showing large deformation which leads to scission or to other
competing reactions like neutron-evaporation or gamma-emission. At the
scission-stage the nucleus generally devides into two deformed and excited
fission fragments. In a small fraction of the scissions the nucleus devides
into three fragments, where the size of the third fragment varies between a
scission-neutron and a fragment similar in size to the other two. These
fragments are called primary, initial, or pre-neutron emission fragments.

The primary fragments repel each other, obtain their full kinetic energy (e.g.
90 MeV), emit prompt neutrons (4 x 10^{-14}sec) and gamma-rays (10^{-11}sec), are
slowed down in the surrounding medium and stopped. These fragments are called
secondary, final, post-neutron emission fragments, or primary fission-products.
(The emitted gamma-rays may cause conversion betas and X-rays.)

The primary products undergo (after 10^{-2} sec and more) a series of beta-decays
forming secondary products and end up in stable nuclei. For certain products
the emission of delayed neutrons is competing with the beta-decay process.

In most of these stages mass-yields and charge-dispersion are measured as well
as energy-distributions. The terms "fragments" and "products" are not clearly
distinguished. Most frequently "fission-fragments" are meant as primary
fragments and "fission-products" are the end-products. However, the
border-line between fragments and products is varying, and often the word
"fragments" is used as overall term including all stages of decay. Often
fission-fragments are specified by their mass only including all Z-numbers, so
that the fragment-yield remains constant during beta-decay. Fission products
are usually specified by Z and A. A specified fission-product is obtained in
two ways: either immediately from fission (primary yield) or from the decay of
another fission product. Thus, the total amount of a specified fission-product
varies in time. Very short-living fission-products may nevertheless be most
important, because some have extremely high capture cross-sections (10^6b).
Finally, all decay to stable end-products, partially via metastable states.
For odd A-numbers there exists only one stable end-product, that is
significantly formed in fission, for even A-numbers one or two.

Units: A mass-yield or fission-product yield, when measured absolutely, is
given in per-cent per fission (code: PC/FIS). Fissions and fragments must
then be counted independently. If only relative yields are given, the
modifier REL should be used with the REACTION code and the DATA-Unit code is
ARB-UNITS. Since in ternary fission more than two fragments are formed per
fission, the yields for all fragments sum up to a bit more than 200%.
However, emission of light particles in ternary fission does not change the
sum of yields in the binary fission mass range usually measured, and other
mass splits in ternary fission are negligible. Therefore relative yield
measurements (ARB-UNITS) may be normalized to 200%, if the measurement was
made for a sufficient large number of fragments; if this is done, the
data-table may include some values that have not been measured but obtained by
interpolation; such values must be labelled by flags.

Primary fission-fragment-yield. This is the primary yield per fission of
fission-fragment mass A before prompt neutron-emission. It may also be called
pre-neutron-emission fragment-mass distribution. Quantity-code: (N,F)MASS,PRE,FY.
In all experimental techniques corrections for some prompt neutrons already
emitted cannot be avoided.

Secondary fission-fragment yield. This is the secondary yield per fission of
fission-fragment mass A after prompt-neutron emission, but before beta-decay
and delayed neutron-emission. It may also be called post-neutron-emission
fragment-mass distribution. Quantity-code: (N,F)MASS,SEC,FY.

Independent fission-product yield. This is the direct or independent yield per
fission of a primary fission-product specified by Z and A, after prompt neutron
emission, but before beta-decay and delayed-neutron emission, including only
the direct yield and not the yield obtained from decay of other fission-products.
Quantity-code: (N,F)ELEM/MASS,IND,FY.

Sum-rule: (N,F)ELEM/MASS,IND,FY summed over all Z for given A
            = (N,F)MASS,SEC,FY for given A

Note: Experimental data of independent yields of the product Z.A include a
portion yielding from the delayed neutron-emission of the product Z.A+1 or
from the beta-decay of the product Z-1.A, if separation times are not short
against the relevant decay-times. Corrections are required which should be
mentioned under "CORRECTION". Fragment-mass yields are not affected by
beta-decay but only by delayed neutron-emission.

Cumulative fission-product yield. This is the cumulative yield per fission of
a fission-product specified by Z and A, after prompt neutron-emission,
including the independent yield plus the yield from decay of other
fission-products. Quantity code: (N,F)ELEM/MASS,CUM,FY.

Sum-rule: (N,F)ELEM/MASS,CUM,FY for the beta-decaying product Z-1.A
          + (N,F)ELEM/MASS,IND,FY for product Z.A

          = (N,F)ELEM/MASS,CUM,FY for product Z.A, if the products Z-1.A and
                                   Z.A+1 are not delayed neutron-emitters.

The following events may add to the cumulative yield of the fission-product
Z.A in its ground state:

    independent yield from fission
    beta-decay from product Z-1.A in ground state
    beta-decay from product Z-1.A in a metastable state
    delayed neutron-emission from product Z.A+1
    internal transition from a metastable state of product Z.A

In addition, the product Z.A may be formed from neutron capture in the product
Z.A-1, which is not included in the "cumulative yield".

The cumulative yield is often given for a metastable state of a fission-product
Z.A; this is entered in EXFOR by means of flags.

Total chain-yield. The total chain-yield per fission of fission-fragment mass
A is the sum of the cumulative yields of all stable fission-products having
the same mass A. In the case that only one stable fission-product per mass A
exists, the total chain-yield for mass A is identical with the cumulative
yield of the stable end-product Z.A.

Fractional yields. The fractional independent fission-product yield is
defined relative to the cumulative fission-product yield or relative to the
total chain-yield.

Fission Yields (page 3)

The fractional cumulative fission-product yield is defined relative to the total chain-yield.
In all cases the data are entered as REACTION ratios.

```
((92-U-235(N,F)ELEM/MASS,IND,FY)/(92-U-235(N,F)ELEM/MASS,CUM,FY))
((92-U-235(N,F)ELEM/MASS,IND,FY)/(92-U-235(N,F)ELEM/MASS,CHN,FY))
((92-U-235(N,F)ELEM/MASS,CUM,FY)/(92-U-235(N,F)ELEM/MASS,CHN,FY))
```

Fragment charge. The distribution of charge Z within a given fragment mass-chain A is called charge-dispersion. It can empirically be approximated by a Gaussian distribution with a most probable charge Zp. The fractional independent yield of a fission product (after prompt neutron emission) is given by

$$P(Z) = (\pi c)^{-\frac{1}{2}} \exp [- (Z-Zp)^2/c],$$

whereas the fractional cumulative yield is given by

$$\sum_{0}^{Z} (P_n) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{Z+\frac{1}{2}} \exp \left\{ \frac{-(n-Zp)^2}{2\sigma^2} \right\} dn$$

The parameters c and σ are widths of the distributions, related by $c = 2 (\sigma^2 + \frac{1}{2})$
For charge dispersion, fractional yields are defined only as ratios to total chain yield.
Reference: A.C. Wahl et al. Phys. Rev. 126, 1112 (5/62)

Note: The Gaussian width parameter has been assumed to be approximately constant for all A chains, as given by Wahl et al. Therefore Zp has sometimes been determined from a single fractional yield measurement. However, there is evidence for a variation of c and with mass A and they may be determined together with Zp. Therefore in a comment the Gaussian width parameter used should be explained (value or reference).

The following definition of charge distribution (primary charge function) is now generally accepted: distribution of primary charge as a function of primary mass. This quantity is deduced, either from other quantities (charge dispersion, mass distribution), or from instrumental measurements of fragment mass (kinetic energy) and X-rays, both methods involving uncertain corrections for prompt neutron emission. As this quantity is mainly of interest for studies of the fission process, but not in applied fields, no codes are proposed.

Coding example:
    (N,F)MASS,,ZP = most probable charge of fragments with given mass A

Similarly, the most probable mass is coded:
    (N,F)ELEM,,AP   = most probable mass of fragments of given element

Fission Yields (page 4)

In the case of binary fission where the fissioning nucleus divides with high probability into two unequal fragments, the ratio of the mean mass of the heavier fission fragment to that of the light fission fragment is called the fission asymmetry.

Coding: ((...(N,F),,AP,HF)/(...(N,F),,AP,LF))

Angular distributions and energy-spectra of fission fragments are coded as

(N,F),,DA,FF and (N,F),,DE,FF

and similar codes given in Dictionary 36.

For Methods of Yield Measurements see the review paper by W.H. Walker, IAEA Panel on Fission-Product Nuclear Data, Bologna, Italy, 26-30 Nov. 1973. (Lammer).

Fission Yields (page 5)

Coding examples

a) Primary fission-fragment yield:
```
REACTION    (92-U-235(N,F)MASS,PRE,FY)
...
COMMON
EN
EV
0.0253
ENDCOMMON
DATA
MASS        DATA
NO-DIM      PC/FIS
...         ...
```

The secondary fission-fragment yield is entered as above; only the quantity-modifier PRE is replaced by SEC. The total chain-yield has the modifier CHN instead.

b) Independent fission-product yield:
```
REACTION    (92-U-235(N,F)ELEM/MASS,IND,FY)
COMMON
EN
EV
0.0253
ENDCOMMON
DATA
ELEMENT     MASS        DATA
NO-DIM      NO-DIM      PC/FIS
...         ...         ...
```

The cumulative fission product yield is entered as above; only the quantity-modifier IND is replaced by CUM.

c) Fractional yields:
```
REACTION    ((92-U-235(N,F)ELEM/MASS,IND,FY)/(92-U-235-(N,F)MASS,CHN,FY))
...
COMMON
EN
EV
0.0253
ENDCOMMON
DATA
ELEMENT     MASS        DATA
NO-DIM      NO-DIM      NO-DIM
...         ...         ...
```

Fission Yields (page 6)

(coding examples continued)

Fission-product charge: charge dispersion

a) Fractional yields:
    REACTION   ((92-U-235(N,F)ELEM/MASS,IND,FY)/(92-U-235(N,F)MASS,CHN,FY))
    ...
    COMMON
    MASS   EN
    NO-DIM   EV
    135.   0.0253
    ENDCOMMON
    DATA
    ELEMENT   DATA
    NO-DIM   NO-DIM
    53.   ...
    54.   ...
    55.   ...
    ...   ...

    Fractional cumulative yields are entered as above, with IND replaced by
    CUM. For Charge dispersion the second reaction of the ratio must always
    have the modifier CHN.

b) Most probable charge:
    REACTION   (92-U-235(N,F)MASS,,ZP)
    ...
    COMMON
    EN
    EV
    0.0253
    ENDCOMMON
    DATA
    MASS   DATA
    NO-DIM   NO-DIM
    ...   ...

Fission Yields (page 7)

(coding examples continued)

Relative cumulative yields of metastable fission-products

```
BIB
REACTION (92-U-235(N,F)ELEM/MASS,CUM/REL,FY)
...
ENDBIB
COMMON
EN
EV
0.0235
ENDCOMMON
DATA
```

ELEMENT	MASS	ISOMER	HL	DATA
NO-DIM	NO-DIM	NO-DIM	D	ARB-UNITS
50.	118.			...
50.	119.	0.	...	...
50.	119.	1.	...	...
50.	120.			...
50.	121.	0.	...	...
50.	121.	1.	...	...
50.	122.			...
50.	123.	0.	...	...
50.	123.	1.	...	...
51.	123.			...
...	...	...	...	...

```
ENDDATA
```

Note that for isomers always their half-life must be given as in above example. If, in addition, decay radiation and its energy shall be specified, use the "DECAY-FLAG Formalism" as shown in Lexfor under Decay Data.

Fission Yields (page 8)

Fission-Yields Standards

1) Often yields of some specific nuclei are given in arbitrary units.
   Add the REL modifier to the REACTION code and give the unit ARB-UNITS.

2) Yields of some specific nuclei (58-CE-144,60-ND-147,etc) may be given
   relative to the yield of another nucleus (42-MO-99). This can be entered
   as:

ELEMENT	MASS	DATA
NO-DIM	NO-DIM	ARB-UNITS
42.	99.	1.
58.	144.	0.977
60.	147.	0.423
etc.		

3) Same as 2) above, but a reference value for the yield of 42-MO-99 is
   assumed:

   REACTION (92-U-235(N,F)ELEM/MASS,CUM,FY)
   MONITOR (92-U-235(N,F)42-MO-99,CUM,FY)
   ...
   COMMON
   MONIT
   NUC/100F
   6.14
   ENDCOMMON
   DATA

ELEMENT	MASS	DATA
NO-DIM	NO-DIM	NUC/100F
58.	144.	5.2
60.	147.	2.45
etc.		

4) Same as 3) above, but U-238 yield data in a fission spectrum are given
   relative to a U-235 yield in a thermal spectrum

   REACTION (92-U-238(N,F)ELEM/MASS,CUM/FIS,FY)
   MONITOR (92-U-238(N,F)42-MO-99,CUM/MXW,FY)
   ...
   COMMON   MONIT
   EN-NRM   NUC/100F
   0.0253   6.14
   ENDCOMMON
   DATA

EN-DUMMY	ELEMENT	MASS	DATA
EV	NO-DIM	NO-DIM	NUC/100F
2.0E+6	42.	99.	6.2
2.0E+6	58.	144.	4.2
2.0E+6	60.	147.	2.75
etc.			

Fission Yields (page 9)

(Fission yield standards continued)

5) The R value is given

$$R = \frac{(\text{Activity Ce-144 from fast U-238}) * (\text{Activity Mo-99 from thermal U-235})}{(\text{Activity Ce-144 from thermal U-235}) * (\text{Activity Mo-99 from fast U-238})}$$

R is measured in order to determine the Ce-144 yield from fast U-238 assuming the other three yields as known, i.e.

(Yield Ce-144 from fast U-238) =

$$= R * (\text{Yield Ce-144 from thermal U-235}) * \frac{(\text{Yield Mo-99 from fast U-238})}{(\text{Yield Mo-99 from thermal U-235})}$$

```
REACTION    (92-U-238(N,F)ELEM/MASS,CUM/FIS/FCT,FY)
COMMENT     UNDER DATA THE R-VALUE IS GIVEN WHICH IS DEFINED AS ...
...
...
DATA        ELEMENT     MASS        DATA
EN-DUMMY    NO-DIM      NO-DIM      NO-DIM
2.0E+6      58.         144.        1.234
```

Fitting Coefficients

Coefficients obtained from a fit to a differential cross section may be coded into EXFOR by entering the type of expansion used to fit the data in REACTION SF8 and specifying the representation used.

The data for a given energy is entered with the coefficient number given under the data heading NUMBER or NUMBER-CM (compare Center-of-Mass System).

Where the first coefficient (l=0) is either unity or another constant, it need not be coded in the data table.

In the case where the first coefficient is identical to the cross-section, it should be coded as a separate subentry. In this case, each subentry should have a cross-reference under the STATUS code COREL to the other subentry.

Example: STATUS   (COREL,10234002) Zeroth-order coefficient x 4 pi given
                   as elastic scattering cross section

Note: If the directly measured differential cross sections are also coded in EXFOR, the fitting coefficients need not be compiled. If compiled, the coefficients should be marked as dependent data under STATUS, with a cross-reference to the subentry number of the cross section from which they were derived.

Reference:

M.Abramowitz and I.A.Stegun, Handbook of Mathematical Functions, Dover
    Publications, 1970.

———

The following pages contain examples of data to be coded in EXFOR. For a complete list of fitting coefficient codes, see Dictionary 36.

Fitting Coefficients (page 2)

1. ### Cosine Coefficients

   Definition: Coefficients obtained by fitting a differential cross section by an equation containing a sum in powers of cosine.

   Quantity Codes: COS in REACTION SF8 plus a code indicating the representation used.

   Representations:

   DA,,COS = a_ℓ (dimension, e.g., b/sr) where:

   $$\frac{d\sigma}{d\Omega}(E,\theta) = a_o + \sum_{\ell=1}^{n} a_\ell(E)\cos^\ell\theta$$

   DA,,COS/RS = a_ℓ (no dimension) where:

   $$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{\sigma}{4\pi}\left[1 + \sum_{\ell=1}^{n} a_\ell(E)\cos^\ell\theta\right]$$

   DA,,COS/RSO = a_ℓ (no dimension) where:

   $$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{d\sigma}{d\Omega}(E,0^o)\sum_{\ell=0}^{n} a_\ell(E)\cos^\ell\theta$$

   DA,,COS/1K2 = a_ℓ (no dimension) where:

   $$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{1}{k^2}\sum_{\ell=0}^{n} a_\ell(E)\cos^\ell\theta$$

   DA,,COS/RSD = a_ℓ (no dimension) where:

   $$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{d\sigma}{d\Omega}(E,90^o)\left[1 + \sum_{\ell=1}^{n} a_\ell(E)\cos^\ell\theta\right]$$

---

* k= wave number

2. Legendre Coefficients

Definition: Coefficients obtained by fitting a differential cross section by an equation containing a sum of Legendre polynomials.

Quantity Codes: LEG in REACTION SF8 plus a code indicating the exact representation used.

Representations:

DA..LEG = A_ℓ (dimension, e.g., b/sr) where:

$$\frac{d\sigma}{d\sigma}(E,\theta) = a_o(E) + \sum_{\ell=1}^{n} a_\ell(E)P_\ell(\cos\theta)$$

DA..LEG/RS = W_ℓ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{\sigma}{4\pi}\left[1 + \sum_{\ell=1}^{n} W_\ell(E)P_\ell(\cos\theta)\right]$$

DA..LEG/RSL = B_ℓ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{\sigma}{4\pi}\left[1 + \sum_{\ell=1}^{n}(2\ell+1)B_\ell P_\ell(\cos\theta)\right]$$

DA..LEG/2L2 = a_ℓ (dimension, e.g., b/sr) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{1}{2}\sum_{\ell=0}^{n}(2\ell+1)a_\ell(E)P_\ell(\cos\theta)$$

DA..LEG/L4P = a_ℓ (dimension, e.g., b/sr) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{1}{4\pi}\sum_{\ell=0}^{n}(2\ell+1)a_\ell(E)P_\ell(\cos\theta)$$

DA..LEG/1K2 = a_ℓ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{1}{k^2}\sum_{\ell=0}^{n}a_\ell(E)P_\ell(\cos\theta) \qquad k = \text{wave number}$$

DA,, LEG/RSO = a_ℓ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{d\sigma}{d\Omega}(E,0°)\sum_{\ell=0}^{n} a_\ell(E) P_\ell(\cos\theta)$$

DA,,LEG/RSD = a_ℓ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E,\theta) = \frac{d\sigma}{d\Omega}(E,90°)\left[1 + \sum_{\ell=1}^{n} a_\ell(E) P_\ell(\cos\theta)\right]$$

Fitting Coefficients (page 4)

The following codes were proposed but not yet adopted. The code FM stands for 'figure od merit' which corresponds to a product of polarization and cross-section.

3. **Associated Legendre Polynomials of the First Kind**

   Definition: Coefficients obtained by fitting

   - a differential cross section
   - or the product of a differential polarization and a differential cross section
   - or the product of a differential polarization and the square of a differential cross section

   by an equation containing a sum of associated Legendre polynomials of the first kind (see, for example, Chapter 8 of Reference 1 for the relationship between Legendre functions). See also Polarization.

   Quantity Codes: AL1 in REACTION SF8.

   Examples:

   FM/DA,,AL1 = a_ℓ (dimension, e.g., b/sr) where:

   $$P(E,\theta) \times \frac{d\sigma}{d\Omega} = \sum_{\ell=0}^{n} a_\ell P_\ell^1 (\cos\theta)$$

   FM2/DA,,AL1 = a_ℓ (dimension, e.g., $(mb/sr)^2$) where:

   $$P(E,\theta) \times \frac{d\sigma^2}{d\Omega}(E,\theta) = \sum_{\ell=0}^{n} a_\ell(E) P_\ell^1 (\cos\theta)$$

4. **Sine-Squared Coefficients**

   Definition: Coefficients obtained by fitting

   - a differential cross section
   - or the product of a differential polarization and a differential cross section
   - or the product of a differential polarization and the square of a differential cross section

   by an equation containing a sum in powers of sine . See also Polarization.

   Quantity Codes: SN2 in REACTION SF8.

   Examples:

   FM/DA,,SN2 = a_ℓ (dimension, e.g., b/sr) where:

   $$P(E,\theta) \times \frac{d\sigma}{d\Omega}(E,\theta) = \sum_{\ell=0}^{n} a_\ell \sin^{2\ell}\theta$$

   FM2/DA,,SN2 = a_ℓ (dimension, e.g., $(mb/sr)^2$) where:

   $$P(E,\theta) \times \frac{d\sigma^2}{d\Omega}(E,\theta) = \sum_{\ell=0}^{n} a_\ell(E) \sin^{2\ell}\theta$$

October 1980

Flags   Flags

Keyword FLAG

Flags are used to supply information to specific lines in a DATA Section. For
this purpose, the keyword "FLAG" is used in two different functions

a) Data-heading: the column in the data-table in which the flags are given,
    is headed with the keyword "FLAG" and the unit "NO-DIM". The actual flags
    must have the form of fixed point numbers with a decimal-point. (Note:
    there may be more than one column with this data heading, compare p. 5.5)

b) BIB keyword: the meaning of the flags is explained under the BIB keyword
    "FLAG", where the actual flags are given in parentheses, each on a
    seperate line starting in column 12, followed by free text information.
    See pages 8.FLAG and 6.11.

Note: Flags must not be used for entire subworks. Obviously, the
data-heading "FLAG" cannot occur in the COMMON-Section. In general, a flag
should not be given in a DATA-Section which has only a single data-line;
however there are cases that, for example, a certain flag is given in several
subentries of an entry, of which one subentry, incidentally, contains only one
data-line.

Keyword DECAY-FLAG

When the "variable product nucleus" formalism is used, flags may be given in
the DATA table under the heading "DECAY FLAG" to link specific lines in the
DATA table to specific entries in the BIB-Section under DECAY-DATA (resp.
RAD-DET or PART-DET). See page 6.11.

Free Text

Be short and precise!

For general rules see page 4.2. The free text in EXFOR should be clear enough
so that users who are not familiar with the system, can easily understand it.
No abbreviations should be used that are not self-explanatory. No codes from
dictionaries are allowed in the free text.

Some examples:

1. Write NUCL.PHYS., and not NP
2. Separate a number and its unit by a blank for clarity.
3. Element symbols and their Z and A values should be written in free text as
    for coded information (see page 8.2). The Z-value can be omitted. The O
    for natural elements should be omitted. Write U-235, and not 235U.

Free text information should be entered under the keyword to which it
pertains. In particular, comments which refer to any of the REACTION subfield
codes or which are necessary to understand a special coding or reaction type,
should be given in the free text under REACTION rather than under COMMENT.

Standard values, parameters and other numerical values should, if suitable, be
entered under DATA or COMMON, although they may be given also in free text.

When writing formulae in free text, the compiler should attempt to use the
FORTRAN conventions, when they apply, with liberal use of parentheses for
clarity.

Blank lines should be used with great discretion. Free text following codes
can start right after the closing parenthesis. However, for clarity, they may
be indented. Continuation lines may start in column 12.

Parentheses () can be used in the free text except in column 12 where the
opening parenthesis marks a code.

The language of the free text is English. However, names of journals or other
names should not be translated into English. Write "Yadernaya Fizika", and
not "Nuclear Physics" which applies to another journal.

Any free text comments not originating with the author must be clearly
labelled e.g. "COMMENT BY THE COMPILER", and unambiguously separated from
authors comments, e.g., by including it between quotation marks or by
inserting a blank line between authors and compilers comments.

For character set permitted in the free text see page 1.5.

The REACTION coding of gamma spectra was inconsistent in old EXFOR entries.
When the quantity code SPC was introduced it was used as an abbreviation for
DE,G,REL, but thereafter clear definitions for gamma spectra quantities had
not been introduced.

In 1984 the following conventions were approved:

Data coded as DE,G (or DE, see below) should have the unit MB/MEV (or another
unit in the same dimension) to be consistent with similar data such as DE,N.
Consequently, DE,G would apply to a continuous spectrum of unresolved gammas,
where the gamma-energy is a variable coded under the column-heading E.

Data coded as SPC should have the unit GAM/100N. This would apply to spectra
of discrete gamma-lines whose energy-values are coded under the column-heading
E.

Examples of REACTION codes:

          (Z-S-A(N,INL)Z-S-A,,DE,G)
          (Z-S-A(N,INL)Z-S-A,,SPC)
          (Z-S-A(N,G)Z-S-A',,DE)
          (Z-S-A(N,X)0-G-0,,DE)

Note that in the latter two cases the "particle-designator" G is redundant
and, therefore, omitted. The code SPC always refers to gammas so that no
particle-designator is given.

Note: Instead of coding the energies of gamma-lines under the column
          heading E, it would be nicer to code them under a specific REACTION
          string such as

          (28-NI-58(N,P)27-CO-58,,E,G)

          in analogy to the coding of neutron-resonance energies. However,
          such a proposal had not found the approval of the co-operating data
          centers.

The intensity of gamma-lines can be normalized and given in mb as partial
cross-sections for the production of the gamma lines. This would be coded as,
e.g.,

          (Z-S-A(N,G)Z-S-A',PAR,SIG,G)

Data to be compiled in EXFOR

Neutron capture gamma-ray spectra are not given high priority and whether they are coded in EXFOR is left to the discretion of the individual data centers.

1. **Intensities of gamma lines**

   REACTION code: (----(N,G)----,,SPC)
   Unit type: SPC (e.g., GAM/100N)

   The gamma-ray energies are discrete values coded under the data heading 'E'.

   Relative measurements require the addition of the modifier 'REL' and units 'ARB-UNITS'.

2. **Continuous spectra of unresolved gammas**

   REACTION code: (----(N,G)----,,DE)
   Units type: DE (e.g., MB/MEV)

   The gamma-ray energy is a continuous variable coded under the data heading 'E'.

3. **Partial radiation widths**

   REACTION code: (----(N,G),PAR,WID)
   Unit type: E (e.g., EV)

   The independent variable is

   - either the gamma-ray energy coded under the data heading 'E'.
   - or the final level energy coded under the data heading 'E-LVL-FIN'.

   The data for both cases may differ by a factor due to gamma multiplicities.

General Quantity Modifiers   General Quantity Modifiers

The general quantity modifiers are AV, SPA, FIS, MXW, FCT, REL, RAW, A, (A),
MSC. They can be added to any quantity without requiring an entry in
dictionary 36. Some of them require clarification:

1. The RAW modifier is used for raw or uncorrected data such as transmission
    data, reaction yields, raw gamma spectra, etc. A centre is free to
    transmit or not to transmit this data but if it decides not to do so, a
    dummy entry with NODATA should be transmitted stating under STATUS under
    what reference the data is available at the centre. This data should be
    made available in some format to the other centres upon request. · The need
    for compilation and transmission of such data has been expressed
    repeatedly (Geel 1977, see Memo 4C-2/103).

    The RAW-modifier should always be explained in free text. See also under
    Raw data and NODATA.

2. The FCT modifier is used if the data has been multiplied by a defined
    factor not containing another quantity (e.g. a mathematical factor or a
    branching ratio). Explanatory free text is compulsory. If the factor
    contains another quantity, the appropriate REACTION combination is to be
    used, except in the case of a ratio of the same quantities (see
    REL-modifier). The FCT modifier must not be used for factors for which
    specific codes have been introduced in the pertinent dictionaries, such as
    isotopic abundance.

3. The REL modifier is used in case of relative data that were not
    normalized, i.e., the data are proportional to the quantity given. For
    such data the data unit ARB-UNITS is used.

    The REL modifier always needs explanation in free text. For relative
    angular distributions compare under Fitting Coefficients.

4. The MSC modifier is used for unusual data types, indicating that the exact
    definition of the quantity is given in free text following the REACTION
    code. This modifier should be used with discretion because the data will
    not be fully machine retrievable. Currently, the MCS modifier is used
    only for photonuclear data.

The "General quantity modifiers" in the check program (HDL)

If REL, RAW or FCT are present, print warning message "Modifier explained in
text?"

If REL is present, check that DATA are in "ARB-UNITS". If not, print error
message "REL modifier requires ARB-UNITS"

If MXW, FIS, or SPA are present, check that keywords INC-SPECT and EN-DUMMY
are present. If not, print error message "Modifier requires explanation under
INC-SPECT" resp. "Modifier requires EN-DUMMY".

If AV is present, check that EN-MIN or EN-MAX are present in the data table.
If not, print error message "AV modifier requires EN range".

Half-lives <div style="float:right">Half-lives</div>

Half-life values in EXFOR entries serve a double purpose: they may define a metastable state; and they may be, like a standard, basic parameters for deducing the cross-section value from the experiment.

Consequently, the half-life should be coded in computer-intelligible form

- whenever a code indicating a metastable state occurs in target-nucleus, quantity or residual nucleus;
- when a target nucleus or residual nucleus is not stable and its half-life is an essential parameter in the analysis of the experimental data.

Half-lives may be coded in computer-intelligible form in one of the following ways:

1) In the BIB section using the keyword DECAY-DATA; see Decay Data.

2) In the COMMON or DATA section under the column-heading HL, HL1, etc., which usually requires explanation under the BIB keyword HALF-LIFE.

Furthermore, for certain data types the half-life functions as an independent variable to be coded under the data heading HL without an explanation under the BIB keyword HALF-LIFE. Compare Delayed Fission Neutron Data.

The BIB keyword HALF-LIFE is used to explain, to which nucleus a half-life value, which may be given in the COMMON or DATA section, refers. For coding-rules see pages 8.HALF-LIFE, 6.10 and 5.4.
If more than one half-life is given, the relevant nuclei must be coded under this keyword. If only one half-life value is given under the data-heading keyword HL and no explanation is given under this keyword, then the half-life of the residual nucleus is meant, or it is an independent variable.

The free text must include the source of the half-life value, in particular whether it was determined by the author in the same experiment, or whether the author used the half-life value from some other source.

Compare pages 5.4, 6.10, 8.DECAY-DATA, 8.DECAY-MON, and 8.HALF-LIFE.
See in particular the "Rules" given in Lexfor under Decay Data.

The keyword "HISTORY" is used to document chronologically the handling of the
EXFOR entry within the data center. The information to be given consists of a
date and a one-character code in parentheses followed by free text. See page
8.HISTORY for coding rules and Dictionary 15 for permitted codes.

In particular it is desirable to document under HISTORY important corrections
or revisions to an entry or subentry. Such important alterations are flagged
with the code "A" following the data. The purpose of this flag is to automate
as far as possible follow-up actions resulting from the alteration, such as
updating of an index, or informing data users who had received the earlier
version.

The following items are considered sufficiently important to be flagged with A:

- any change in the numbers given under COMMON or DATA;
- any change of the meaning of these numbers (e.g. due to change of the
  REACTION coding, units, MONITOR, etc.);
- any other change that the compiler considers important enough that
  earlier recipients of the entry should be informed.

Less important changes are documented following the code "U".
Compilers are urged to document all changes under HISTORY.
(Compare also Lexfor: Alterations to NDS Exfor entries)

Examples of possible entries entered under the HISTORY keyword:

(671119R)	Data received from author on tape ND1234
(701003T)	Data converted from SCISRS-I, and checked for agreement with table 3 in Phys. Rev. 56, p. 78
(691223)	Proof-copy sent to author
(680220L)	Data entered into library
(690411C)	
(721130A)	Some mispunches in data table corrected
(721130U)	Spelling error in BIB corrected

Note: The origin of the numerical data may be given in free text under this
      keyword (see use of code R in the above examples) or under "STATUS".

Note to NDS compilers: When entering or revising an Exfor entry, always put
your initials in an appropriate place under HISTORY. - No entry or revision
without a HISTORY entry!

In subentry 001 an alteration entry under HISTORY (codes "A" or "U")
- should refer to all of the following subentries, as ususal,
- but may, of course, also indicate that a change was made in subentry
  001 only.
The free text should make it clear which of these two cases applies. A "U"
HISTORY entry in subentry 001 is tolerated also in the case that it refers
only to some but not all of the following subentries.

Incident-Projectile Energy

The energy of the incident particles is, in general, entered under the data-heading keyword "EN". Some other relevant data-headings can be found in Dictionary 24 flagged with an A in column 66 of the Dictionary.

If the incident-particle energy is given only indirectly, the following headings are used to facilitate a data-retrieval by energy:

1. If the energy is given as "MU-ADLER" (equivalent to resonance-energy in Adler-Adler formalism), the energy-range of the data-set is given explicitly in the "COMMON" section under the data-headings "EN-MIN" and "EN-MAX".

2. If the data are averaged over an incident neutron spectrum, an equivalent energy is given under the heading "EN-DUMMY", "EN-MEAN" or "KT"; see under Spectrum Average.

No incident energy is entered for Nuclear Quantities (see there) where the incident particle field SF2 under REACTION is 0 (zero).

For nuclear properties such as the Nuclear Temperature, for which the incident projectile energy is not quite irrelevant, the incident projectile energy may be given in free text but should not be coded under "EN".

Information on the characteristics of the resolution and the spectrum of the incident-particle beam is entered in free text under the keyword "INC-SPECT". See page 8.INC-SPECT.

Compare under Secondary Energy for which the data-heading code is "E" as distinct from "EN". Secondary energies are flagged in Dictionary 24 with "E" in column 66 of the Dictionary.

Note: For wave-length of incident particles see under Wave-lengths

Inelastic Scattering   Inelastic Scattering

Definition: Two-body interaction in which the incident projectile re-emerges
with an energy lower than its initial energy by the amount of energy deposited
in the target nucleus. The residual nucleus is left in an excited state which
then decays, primarily, by gamma-ray emission, occasionally by e^+ e^- emission.

In rare cases the scattering particle can be accelerated by de-excitation of
an isomeric state (see e.j. Petrov et al, NP/A 292, 88, 7711). In the term
"inelastic scattering" it is not distinguished whether the gammas come from an
isomer or another excited state.

The term "inelastic scattering", as used here, covers only inelastic nuclear
scattering. Inelastic slow-neutron scattering, where molecular or crystalline
forces are involved, is called "thermal scattering", see Scattering.

Method of Measurement

Inelastic scattering may be measured by detecting the inelastically scattered
particle or by detecting the de-excitation gamma radiation. Due to gamma-ray
cascades, the production of a specific gamma-ray may differ from the
excitation of its state of origin. They will be equal, however, if gamma-ray
cascades to and from the level can be excluded.

Coding

Inelastic scattering is coded with INL in REACTION SF3 (Process). For
inelastic gamma emission, G is coded in REACTION SF7 (Particle considered).

For partial reactions due to the excitation of a discrete level or the
production of a specific gamma ray, the code PAR is entered into REACTION SF5
(Branch).

For the excitation of a discrete level or group of levels, the level energy or
excitation energy must be given under the Data-Heading Keyword E-LVL or E-EXC.

For the production of a discrete inelastic-scattering cascade gamma or range
of gammas, the gamma-ray energy must be given under the Data-Heading Keyword E.

See page 5.4 for the coding of two or more unresolved levels.

Inelastic Scattering (page 2)

Examples:

(--,INL)---,,SIG)	total inelastic-scattering cross section
(--,INL)---,,SIG,G)	total inelastic gamma-emission cross section ($\geq$ inelastic-scattering cross section)
(--,INL)---,PAR,SIG)	partial inelastic-scattering cross section for the excitation of a discrete level or range of levels
(--,INL)---,PAR,SIG,G)	partial cross section for the production of a discrete inelastic gamma or range of gammas
(--,INL)---,,DA)	angular distribution of inelastically scattered particles
(--,INL)---,,DA,G)	angular distribution of inelastic gammas
(--,INL)---,,DE)	energy distribution of inelastically scattered particles
(--,INL)---,,DE,G)	energy spectrum of inelastic gammas
(--,INL)---,,DA/DE)	double differential inelastic-scattering cross section

Note: "Inelastic gammas" means gamma rays following the inelastic scattering of particles.

See page 8.INSTITUTE for coding rules under this keyword.

When more than one institution is entered for a given work, the one which contains the measurement facility should in general be entered first. Exceptions are:

a) If an itinerant group uses the facility of another institution, the institution of the itinerant group should be given first;

b) In an ambiguous case, the compiler may enter first that institution from which one is most likely to obtain further information on the experiment.

In the case of neutron data the digit of the institute code determines the centre responsible for compiling the data. If two institutions of different service areas are involved, the institute to be coded first according to above rules, shall determine the centre responsible; but the centres involved must inform each other of their intention to code the work in order to avoid duplication.

Interdependent data   Interdependent data

Data that have been measured by the same technique, have certain systematic
error-sources in common and are therefore interdependent. Their uncertainties
are correlated.

Examples:

1. nu-bar for U-233 amd U-235, both measured in the same manganese bath.

2. Absorption, capture and alpha all obtained simultaneously in the same
    experiment (Cabell, AERE-R-5874, 68).

Uncertainty correlations must be considered carefully by evaluators.
Therefore, the compiler should enter all required information on common error
sources and cross-references between interdependent data-sets or subentries.
This is particularly worthwhile in the case of private communications; in
other cases evaluators will rather use published references.

For correlated data, e.g. sigma1 and sigma2, it is essential to compile in
EXFOR also the ratio sigma1/sigma2 and its uncertainty.

If the author gives a covariance matrix for his data, see in Lexfor under
COVARIANCE. Covariance information should be given primarily for neutron
cross-sections of standards and dosimetry reactions.

Different results for the same quantity obtained in the same experiment by two
different methods of analysis may be coded in the same subentry, see 6.6.
Such data may be entered in separate subentries, in which case, the subentries
should be linked to each other using the STATUS code 'COREL'. (See page
8.STATUS for coding details).

Definition:

An isomeric state is defined as a long-lived energy state, where long-lived is, generally, accepted to mean having a measurable half-life. For practical applications, a Metastable state shall be defined in EXFOR as an energy state having a half-life of the order of 0.1 milliseconds or longer.

The term isomeric states shall refer to the ground and known metastable states.

1. Isomeric states of nuclei are indicated with an isomer code following the nucleus code, e.g. 95-AM-242-M1. See page 8.2 for coding rules.

   These isomer codes are used wherever a nucleus is coded, e.g. under REACTION, HALF-LIFE, DECAY-DATA, etc. However, when nuclei are coded within a data table, using ELEMENT and MASS as column headings, numerical isomer codes are used under the column heading ISOMER, as defined on page 8.REACTION.8.

2. Partial reactions leading to isomeric states are identified by the isomer code of the product nucleus coded in SF4 under REACTION, e.g.:

   (Z-S-A(P,N)Z-S-A-M1,,SIG)

   Isomeric ratios (and other combinations) are usually coded by using mathematical operators within the isomer codes of the product nucleus as described on page 8.REACTION.7.

3. Decay data: In all cases an unambiguous identification of the respective isomer, e.g. by its half-life and/or other decay properties is obligatory.

   It should be noted that the assignment of isomeric states (ground, first, second) for a given nucleus may vary in the literature according to the growing knowledge about this nucleus. In order to define an isomeric state uniquely, compilers must include in the EXFOR entry also the decay properties of the isomer under the keywords DECAY-DATA or HALF-LIFE (compare in Chapter 8 under DECAY-DATA and HALF-LIFE).

4. Isomeric branches: The following branch codes are used in REACTION subfield SF5 when the ground state was measured and isomeric transition to the ground state is possible:

   M+ - Including formation via isomeric transition
   M- - Excluding formation via isomeric transition
   (M) - Uncertain whether formation via isomeric transition is included

   In the case of isomeric branches it must be clearly distinguished between the sum-coding and the usage of the "branch" code M+.

The sum coding

    (target(,)Z-S-A-M+G,...)

is used only in cases where the <u>total</u> formation cross section $_{M^+}$ $_G$
was obtained from <u>separate</u> measurements. If only the activity of the
ground-state was measured which inlcudes the feeding from the metastable
state via the isomeric transition, the branch code M+ is used:

    (target(,)Z-S-A,M+...).

Accordingly, $(\sigma_M + \sigma_G)$ is greater or equal to $(\sigma, M+)$.

<u>Exception</u>: In cases where the formation cross-section of a nucleus is
determined from a <u>daughter</u> activity ensuring a 100% inclusion of the
produced isomer, the sum-code must be used, since the branch-code M+
stating formation via isomeric γ-transition in the residual nucleus does
not apply unambiguously to this case.

When the sum cross-section (target(,)Z-S-A-M+G,...) is identical to the
total reaction cross-section (target(,)Z-S-A,...), only the latter code
without isomer codes should be used. When retrieving data from EXFOR, one
should realize that the same data

    (target(,)Z-S-A,...)

to be retrieved may have been coded under the (less preferable!) codes

    (target(,)Z-S-A-M+G,...)   or   ...M1+G...

or   ((target(,)Z-S-A-M,...) + (target(,)Z-S-A-G,...))

Compare also Dictionaries 31, 36 and under <u>Cross-Sections</u>

If it is uncertain, which of 2 isomers is the ground state (e.g. Sb-116,
where recent issues of Lederer or Charts of Nuclides do not give an
assignment), NDS compilers should make a decision but add a comment
indicating that the "assignment of ground and metastable state as done by
the compiler is uncertain". (Compare entry 30517)

5. <u>Fission isomers</u>: A 'fission isomer', also known as 'shape isomer', is
    defined as an energy state whose primary mode of decay is spontaneous
    fission. They are coded in the same way as other metastable states with
    the fission decay mode specified under the keyword DECAY-DATA.
    See in LEXFOR under <u>Fission</u> for the coding of reaction data through
    fission isomers.

The neutron reactions on light-target nuclei (Z 6) require special care, because many different notations exist. For example, the notations

   Li-6(n,d)   Li-6(n,nd)   Li-6(n,n alpha)

may all describe the identical reaction, Li-6(n,nd alpha).

In EXFOR, data retrievals for light-nuclei reactions would be made rather difficult if the notations for these reactions were not standardized. This is easily solved by the following rule: the heaviest of the reaction products is defined as the residual nucleus, and the remaining reaction products are sorted in REACTION SF3 in ascending order of Z and A. For details see page 8.REACTION.3.

In angular or energy distributions the particle considered must be given in REACTION SF7 when not self-evident. See LEXFOR Particles. The following examples show different angular distributions for the reaction Li6(n,2np)He4. Angular distribution of

gammas:	(3-LI-6(N,2N+P)2-HE-4,,DA,,G)
neutrons:	(3-LI-6(N,2N+P)2-HE-4,,DA,,N)
protons:	(3-LI-6(N,2N+P)2-HE-4,,DA,,P)
alphas:	(3-LI-6(N,2N+P)2-HE-4,,DA,,A)

To aid the compiler, the following table lists all possible light-nuclei reactions, together with their thresholds and REACTION codes. The threshold energies were taken from R.J. Howerton, et al, "Thresholds of Nuclear Reactions", UCRL-14000, (1964). Note that the table gives only the end products and that in some cases competing reactions exist that lead to the same end products.

For neutron reactions, no REACTION codes other than those listed on the following pages should be used in EXFOR for the light-nuclei reactions except when the modifier SEQ is given, as described in LEXFOR under Sequence of outgoing particles. In addition to the processes listed below, only scattering processes as well as sum cross-sections, such as charged-particles emission, alfa-emission, etc., exist for these nuclei.

n-p scattering is coded as (1-H-1(N,EL)1-H-1 . . .). It should not be coded as (1-H-1(N,P) . . .) though when retrieving from EXFOR one should realize that such wrong coding may exist in the file.

Reaction	Threshold (MeV)	REACTION	Comments
H (n,gamma)D	0	1-H-1(N,G)1-H-2	
D (n,gamma)T	0	1-H-2(N,G)1-H-3	
D (n,2n p)	3.34	1-H-2(N,2N)1-H-1	
T (n,2n d)	8.35	1-H-3(N,2N)1-H-2	
T (n,3n p)	11.31	1-H-3(N,3N)1-H-1	
He3(n,gamma)He4	0	2-HE-3(N,G)2-HE-4	
He3(n,p t)	0	2-HE-3(N,P)1-H-3	
He3(n,2d)	4.35	2-HE-3(N,D)1-H-2	
He3(n,n p d)	7.32	2-HE-3(N,N+P)1-H-2	
He3(n,2n 2p)	<14.	2-HE-3(N,2N+P)1-H-1	(PL,23,477,66)
He4(n,d t)	21.97	2-HE-4(N,D)1-H-3	
He4(n,n p t)	24.76	2-HE-4(N,N+P)1-H-3	
He4(n,2n)He3	25.72	2-HE-4(N,2N)2-HE-3	
He4(n,n 2d)	29.80	2-HE-4(N,N+D)1-H-2	
Li6(n,gamma)Li7	0	3-LI-6(N,G)3-LI-7	
Li6(n,t alpha)	0	3-LI-6(N,T)2-HE-4	
Li6(n,n d alpha)	1.71	3-LI-6(N,N+D)2-HE-4	
Li6(n,p)He6	3.19	3-LI-6(N,P)2-HE-6	
Li6(n,2n p alpha)	5.43	3-LI-6(N,2N+P)2-HE-4	
Li6(n,n t)He3	18.42	3-LI-6(N,N+T)2-HE-3	

Reaction	Threshold (Mev)	REACTION	Comments
Li7(n,gamma)Li8	0	3-LI-7(N,G)3-LI-8	
Li7(n,n t alpha)	2.81	3-LI-7(N,N+T)2-HE-4	via He5,Li7*,H-4 or three-particles break-up (NP/A,98,305,67)
Li7(n,2n)Li6	8.29	3-LI-7(N,2N)3-LI-6	
Li7(n,d)He6	8.87	3-LI-7(N,D)2-HE-6	
Li7(n,2n d alpha)	11.06	3-LI-7(N,2N+D)2-HE-4	
Li7(n,n p)He6	11.41	3-LI-7(N,N+P)2-HE-6	
Li7(n,3n p alpha)	14.76	3-LI-7(N,3N+P)2-HE-4	including search for bound trineutron
Be9(n,gamma)Be10	0	4-BE-9(N,G)4-BE-10	
Be9(n,alpha)He6	0.67	4-BE-9(N,A)2-HE-6	
Be9(n,2n 2alpha)	1.85	4-BE-9(N,2N+A)2-HE-4	
Be9(n,t)Li7	11.59	4-BE-9(N,T)3-LI-7	
Be9(n,p)Li9	14.74	4-BE-9(N,P)3-LI-9	
Be9(n,d)Li8	16.28	4-BE-9(N,D)3-LI-8	
Be9(n,n d)Li7	18.54	4-BE-9(N,N+D)3-LI-7	
Be9(n,n p)Li8	18.76	4-BE-9(N,N+P)3-LI-8	
Be9(n,n t)Li6	19.66	4-BE-9(N,N+T)3-LI-6	
Be9(n,3n)Be7	22.85	4-BE-9(N,3N)4-BE-7	
Be9(n,n He3)He6	23.54	4-BE-9(N,N+HE3)2-HE-6	

Reaction	Threshold (MeV)	REACTION	Comments
B10(n,gamma)B11	0	5-B-10(N,G)5-B-11	
B10(n,p)Be10	0	5-B-10(N,P)4-BE-10	
B10(n,t 2alpha)	0	5-B-10(N,T+A)2-HE-4	via Be8,Li7(2nd exc.st), or three-particle break-up
B10(n,alpha)Li7	0	5-B-10(N,A)3-LI-7	to ground state and 1st exc.state; (2nd exc. st. decays to t+alpha)
B10(n,d)Be9 g	4.79	5-B-10(N,D)4-BE-9	to ground state; Be9* decays to n + 2α
B10(n,n alpha)Li6	4.90	5-B-10(N,N+A)3-LI-6	
B10(n,n d 2alpha)	6.62	5-B-10(N,N+D+A)2-HE-4	
B10(n,n p)Be9	7.24	5-B-10(N,N+P)4-BE-9	
B10(n,2n p 2alpha)	9.28	5-B-10(N,2N+P+A)2-HE-4	
B10(n,He3)Li8	17.32	5-B-10(N,HE3)3-LI-8	
B10(n,n He3)Li7	19.56	5-B-10(N,N+HE3)3-LI-7	
B10(n,n t)Be7	20.54	5-B-10(N,N+T)4-BE-7	
B10(n,3n)B8	29.72	5-B-10(N,3N)5-B-8	
B11(n,alpha)Li8	7.23	5-B-11(N,A)3-LI-8	
B11(n,n alpha)Li7	9.44	5-B-11(N,N+A)3-LI-7	
B11(n,d)Be10	9.82	5-B-11(N,D)4-BE-10	
B11(n,t)Be9	10.42	5-B-11(N,T)4-BE-9	
B11(n,p)Be11	11.70	5-B-11(N,P)4-BE-11	
B11(n,n p)Be10	12.25	5-B-11(N,N+P)4-BE-10	
B11(n,n t 2alpha)	12.25	5-B-11(N,N+T+A)2-HE-4	

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Reaction	Threshold (MeV)	REACTION	Comments
B11(n,2n)B10	12.50	5-B-11(N,2N)5-B-10	
B11(n,n d)Be9	17.25	5-B-11(N,N+D)4-BE-9	
B11(n,3n p 2alpha)	21.70	5-B-11(N,3N+P+A)2-HE-4	
B11(n,He3)Li9	25.73	5-B-11(N,HE3)3-LI-9	
B11(n,n He3)Li8	29.68	5-B-11(N,N+HE3)3-LI-8	
C12(n,gamma)C13	0	6-C-12(N,G)6-C-13	
C12(n,alpha)Be9 g	6.17	6-C-12(N,A)4-BE-9	to ground state; Be9* decays to n + 2α
C12(n,n 3alpha)	7.98	6-C-12(N,N+2A)2-HE-4	
C12(n,p)B12	13.63	6-C-12(N,P)5-B-12	
C12(n,d)B11	14.87	6-C-12(N,D)5-B-11	
C12(n,n p)B11	17.29	6-C-12(N,N+P)5-B-11	
C12(n,t)B10	20.50	6-C-12(N,T)5-B-10	
C12(n,2n)C11	20.28	6-C-12(N,2N)6-C-11	
C12(n,He3)Be10	21.09	6-C-12(N,HE3)4-BE-10	
C12(n,n He3)Be9	28.47	6-C-12(N,N+HE3)4-BE-9	
C12(n,n d)B10	27.28	6-C-12(N,N+D)5-B-10	
C12(n,n p t 2alpha)	29.65	6-C-12(N,N+P+T+A)2-HE-4	
C12(n,3n)C10	34.47	6-C-12(N,3N)6-C-10	

Measurement Techniques   Measurement Techniques

Physics information on the experimental measurement techniques is entered
under several keywords (see Chapter 8 for coding rules).

*METHOD: The description of experimental technique(s) employed in the
experiment, e.g., activation, is entered under this keyword.

Information which can rather be entered under one of the more specific
keywords, below, should not be entered under METHOD.

*FACILITY: The keyword FACILITY is used to identify the main apparatus or
machine used in the experiment, e.g., rector or cyclotron.

When there is more than one institute code for an entry, the code for the
institute at which the facility is located should be entered following the
facility code, if known.

INC-SOURCE: Under the keyword INC-SOURCE, the source of the incident-projectile
beam used in the experiment is entered.

This keyword is used exclusively for the nuclear reaction used as an incident-
projectile source. The apparatus in which this reaction took place is entered
under FACILITY, and the quality of the resulting particle beam is entered under
INC-SPECT (see under Incident-Projectile Energy). (For certain cases, e.g.,

reactor neutrons used as source, the use of the keywords INC-SOURCE and
FACILITY is somewhat overlapping).

SAMPLE: The keyword SAMPLE is used to identify information on sample material
characteristics.

*DETECTOR: Information on detectors used in the measurement may be entered
under the keyword DETECTOR.

Detector used as monitors are also entered under this keyword.

For particles detected and the keyword PART-DET see Particles; for their
energies and the keyword EN-SEC see Secondary-Energy.

*Note: One of the following keywords must be present: FACILITY, DETECTOR,
ANALYSIS, or METHOD. It is advisable that all four of these keywords be
given, except when not relevant. For example, FACILITY is not relevant with
respect to spontaneous fission.

MONITOR   see   Standards

1. Neutron average resonance-parameters:

    Angular momentum for strength-functions, average level spacings, reduced
    resonance-width, col. heading MOMENTUM L, quantity ...,L, <u>see p. 6.9</u>.

2. Linear momentum of incoming particles:

        col. heading MOM

3. Photonuclear data:

    Linear momentum of outgoing particles BIB keyword MOM-SEC and column
    heading M, see p. 8.MOM-SEC.

Compare <u>Single-Level Resonance Parameters</u>, <u>Quantum Numbers</u>.

In analyzing resonance structure for fissile nuclides, it is necessary to use a multilevel formalism to account for interference effects from neighboring resonances and also those due to distant resonances.

Three different multilevel formalisms are generally used: Vogt, Reich-Moore and Adler-Adler. All three are derived from R-matrix theory of Wigner and Eisenbud.

Reich-Moore and Vogt Resonance Parameters

In Vogt and Reich-Moore formalisms, cross sections are expressed in terms of R-matrix level parameters. Cross sections due to resonance levels of the same spin and parity are related to the elements U_{nn} of the collision matrix by relations of the form:

Total cross section: $\quad \sigma_{nT} = 2\Pi\, \lambdabar_n^2\, g\, \text{Re}(1 - U_{nn})$

Other cross sections: $\quad \sigma_{nr} = \Pi\, \lambdabar_n^2\, g\, \left| \delta_{nr} - U_{nr} \right|^2$

> where: $\lambdabar_n$ = neutron wave length in the center-of-mass system
>
> g = statistical weight factor
>
> δ_{nr} = Kronecker delta

and Re stands for the real part of the expression in parenthesis.

The collision matrix U is related to the nuclear level properties by means of the derivative matrix R, in the following form:

$$R = \sum_\lambda \frac{\vec{\gamma}_\lambda \times \vec{\gamma}_\lambda}{E_\lambda - E}$$

> where: $\vec{\gamma}_\lambda \times \vec{\gamma}_\lambda$ is the vector product of the vectors γ_λ and λ refers to levels. The diagonal elements of γ_λ are reduced with parameters.

The collision matrix U can be related to the derivative matrix R through the matrix:

$$(1 - RL^0)^{-1}R$$

> where: $L^0 = L-B$; B is a constant diagonal matrix; L is a complex matrix with elements being a function of momentum ℓ.

Both the Vogt and the Reich-Moore formulas require that off-diagonal matrix elements describing interference in the radiative capture channels must vanish.

The Reich-Moore formula involves summation over levels and a matrix inversion with respect to channels.

The matrix (1 - RL) is partitioned into a 2x2 matrix, each element of which leads to a definition on the matrix

$$K_{cc'} = \frac{i}{2} \sum_{\lambda} \frac{\Gamma_{\lambda c}^{1/2} \, \Gamma_{\lambda c'}^{1/2}}{E_{\gamma} - E - \frac{i}{2} \Gamma_{\lambda \gamma}}$$

The fission cross section can be expressed by:

$$\sigma_{nf} = \sum_{c=2}^{\ell+1} 4\pi \, \lambda_n^2 \, g \left| (\ell - K)_{nc}^{-1} \right|^2$$

where ℓ = number of fission channels

Similar expressions are obtained for other partial cross sections.

Reich-Moore Resonance Parameters are entered under the quantity codes:

(N,O),,EN	E_{λ}	Resonance energy; units of energy (e.g., eV)
(N,TOT),,WID,,RM	Γ_{λ}	Total width; units of energy
(N,G),,WID,,RM	$\Gamma_{\lambda\gamma}$	Capture width; units of energy (including all primary gamma decays not followed by a neutron or charged-particle emission).
(N,F),1,WID,,RM	$\Gamma_{\lambda f_1}$	*Fission width for channel 1; units of energy
(N,F),2,WID,,RM	$\Gamma_{\lambda f_2}$	*Fission width for channel 2; units of energy
(N,F),,WID,,RM	$\Gamma_{\lambda f}$	Total fission width: $= \left\| \Gamma_{\lambda f_1} \right\| + \left\| \Gamma_{\lambda f_2} \right\|$
(N,EL),,WID,,RM	$\Gamma_{\lambda n}$	Neutron width; units of energy
(N,EL),,WID/RED,,RM	$\Gamma_{\lambda n}^{(\ell)}$	Reduced neutron width; units of energy

* The relative phases of $\Gamma_{\lambda f_1}$ and $\Gamma_{\lambda f_2}$ are either 0 or 180 degrees, therefore, the parameter values are given with either a positive or negative sign.

The Vogt Formula involves summation of channels and matrix inversion with respect to levels, and requires that level interference in the neutron channel be equal to zero.

The inversion of the channel matrix $(1-RL^o)$ leads to the definition of the level matrix A, which is given by:

$$(A^{-1})_{\lambda\lambda'} = (E_\lambda - E)\,\delta_{\lambda\lambda'} - \frac{1}{2}\sum_c (\Gamma_{\lambda c})^{\frac{1}{2}}(\Gamma_{\lambda'c})^{\frac{1}{2}}$$

where c is channel number.

A Reduced neutron width for an s wave resonance is defined as:

$$\Gamma_{\lambda n}^o = 2g\,\Gamma_{\lambda n}\,E^{-\frac{1}{2}}$$

Vogt Resonance Parameters are entered under the quantity codes:

(N,0),,EN	E_λ	Resonance energy; units of energy (e.g., eV)
(N,TOT),,WID,,VGT	Γ_λ	Total width; units of energy
(N,G),,WID,,VGT	$\Gamma_{\lambda\gamma}$	Capture width; units of energy (including all primary gamma decays not followed by neutron or charged-particle emission)
(N,F),1,WID,,VGT	$\Gamma_{\lambda f_1}$	Fission width for channel 1; units of energy
(N,F),2,WID,,VGT	$\Gamma_{\lambda f_2}$	Fission width for channel 2; units of energy
(N,EL),,WID,,VGT	$\Gamma_{\lambda n}$	Neutron width; units of energy
(N,EL),,WID/RED	$\Gamma_{\lambda n}^{(\ell)}$	Reduced neutron width; units of energy * sqrt of energy
(N,0),,PHS,,VGT	$\theta_{\lambda_i\lambda_j}$	Relative phase of channel λ_i and λ_j; units of angle

Adler-Adler Resonance Parameters

The Adler-Adler formalism is a generalized Kapur-Peierls formalism in which cross sections are given in terms of Kapur-Peierls poles and and residues G and H.

The resonance part of the reaction cross section (without Doppler Broadening) in the Adler-Adler formalism is given by:

$$\sigma_\lambda (E) = \frac{1}{\sqrt{E}} \sum_k \frac{G_{r_k} \nu_k + H_{r_k} (\mu_k - E)}{(\mu_k - E)^2 + \nu_k^2}$$

where: G, H, μ, ν are treated as constants, since they have only a weak energy dependence.

Adler-Adler coefficients are entered under the quantity codes:

(N,0),,EN,,AA	μ_λ	Resonance energy; units of energy (e.g., eV)
(N,TOT),,WID,,AA	ν_λ	Corresponding to half the total width; units of energy
(N,F),,AG,,AA	$G_{\lambda f}$	Fission symmetry coefficient; in B*EV*RT-EV
(N,F),,AH,,AA	$H_{\lambda f}$	Fission asymmetry coefficient; in B*EV*RT-EV
(N,G),,AG,,AA	G_λ	Capture symmetry coefficient; in B*EV*RT-EV
(N,G),,AH,,AA	H_λ	Capture asymmetry coefficient; in B*EV*RT-EV
(N,TOT),,AG,,AA	G_γ	Total symmetry coefficient; in B*EV*RT-EV
(N,TOT),,AH,,AA	H_λ	Total asymmetry coefficient; in B*EV*RT-EV

The parameters are functions of μ which corresponds to the resonance energy. Since this representation of the energy causes trouble in a data retrieval by energy, the energy limits of the Adler-Adler fit must be entered explicitly in the COMMON section under the Data-Heading Keywords EN-MIN and EN-MAX

R-Matrix Resonance Parameters

The R-Matrix reduced width is given by:

$$\Gamma = 2\gamma^2 P$$

where: P = penetrability

These may be entered under the Reaction keyword using the modifier code 'RMT' in SF8.

For further details see:

M.S.Moore, IN-1222, p. 199 (1969)
D.B.Adler, F.T.Adler, ANL-6792, p. 695 (1963)
E.Vogt, Phys. Rev. 112, 203 (1958)
C.W.Reich, M.Moore, Phys. Rev. 111, 929 (1958)

At present, the following classes of data may be coded using the Multiple Reaction Formalism (compare page 8.REACTION.9).

1.) resonance parameters of the same isotope
        e.g. REACTION 1(92-U-235(N,TOT),,WID)
                    2(92-U-235(N,EL),,WID)
                    3(92-U-235(N,0),,J)

with the pointers being repeated in the data-headings DATA 1, DATA 2, DATA 3, respectively, and perhaps elsewhere.

2.) multiple representations of the same reaction
        e.g. REACTION 1(92-U-235(N,F),,SIG,,REL)
                    2(92-U-235(N,F),,SIG)

with the pointers being repeated in the data-headings DATA 1 and DATA 2, and perhaps elsewhere.

        or   REACTION 1((92-U-235(N,F),,SIG)/(79-AU-197(N,G),,SIG))
                    2(92-U-235(N,F),,SIG)

with the pointers being repeated in the data-headings RATIO 1 and DATA 2, and perhaps elsewhere. (Instead of the heading RATIO the heading DATA may be used as well).

3.) partial cross-sections of the same reaction (i.e. REACTION subfields SF1 to SF3 are equal)

    a) isomeric data (branches, ratios, etc.) of the same reaction
        e.g. REACTION M(39-Y-89(P,2N+P)39-Y-87-M,,SIG)
                    G(39-Y-89(P,2N+P)39-Y-87-G,,SIG)
                    S(39-Y-89(P,2N+P)39-Y-87-,,SIG) DEDUCED
                    R(39-Y-89(P,2N+P)39-Y-87-M/G,,SIG/RAT) DEDUCED

with the pointers being repeated in the data-headings DATA M, DATA G, DATA S, DATA R, and perhaps elsewhere.

    b) compound-nucleus and direct interaction parts for the same reaction.
    c) high-energy fission and spallation parts for the same reaction.
    d) binary and ternary parts for fission measured.
    e) light and heavy fragment parts for fission-yield data.

4.) data measured simultaneously for the production of specific particles or nuclides where the author has assigned values to given reactions based on systematics or theoretical considerations.

        Example 1:   (P,2N)   Example 2:   (N,A)
                     (P,3N)   (N,NA)
                     (P,4N)

Note: In the case of a variable product nucleus for a given reaction (i.e., for the REACTION keyword, SF1, SF2 and SF3 are constant) the Variable Product Nucleus Formalism is used.

5.) alternative results

Data for the same reaction obtained by different types of analysis of the same experiment, or by different experiments reported in the same paper, may be entered in the same subentry, but in this case the same REACTION code must be repeated for each type of analysis resp. experiment; see the example on page 6.6.

STATUS: In the case that one of the reactions given has been deduced from the other (e.g. if absolute U-235(N,F) data were deduced from relative data using standard reference data from another author), the appropriate status code is entered with the relevant pointer, e.g.:

STATUS   2(DEP)   free text.

Explanation in free text may be given behind the status code and/or behind the reaction code.

Multiplicity

Definition: Particle yield per event.

Quantity Code: MLT in REACTION SF6.

Examples:

(-----(P,A)-----,,MLT,G) gamma yield from (p,alpha) reaction

(-----(N,X)0-G-0,,MLT) gamma yield from all neutron-induced reactions

Partial Multiplicity

In many cases the experimental arrangement will be such that not all of the particles produced will be detected. In such cases, the branch code PAR must be used in REACTION SF5.

The most common experimental occurrence of this will be limits on the energies of the particle detected.

Authors will also often deduce the multiplicities as a function of spin or momentum transfer; these deduced results should not be coded.

Neutron Multiplicity

The neutron multiplicity should be coded as given above only for those reactions for which special codes do not exist. For neutron multiplicity from neutron-induced reactions or from spontaneous fission, see Neutron Yield.

Neutron Yield   Neutron Yield

The following special terms are defined for neutron yields from neutron-induced reactions or from spontaneous fission. For other neutron yields, see Multiplicity.

Nu-bar ($\bar{\nu}$)

Definition: Average number of fission-neutron emitted per fission event

Coding:

(————(N,F),,NU)	neutron-induced fission nu-bar
(————(0,F),PR,NU)	spontaneous fission prompt nu-bar
(————(N,F),DL,NU)	neutron-induced fission delayed nu-bar
(————(N,F+XN),,NU)	probability for the emission of x neutrons fron neutron-induced fission ; see page for the formalism for a variable number of emitted nucleons.

For further related quantity codes see Dictionary 36. A special example is

$$(N,F)MASS,PR/PAR,NU$$

which means: partial prompt neutron yield as function of incident neutron energy, fragment mass, and fragment energy.

Sum-rule: total nu-bar = prompt plus delayed nu-bar.

See also Delayed Fission Neutrons

Eta (η)

Definition: The average neutron yield per nonelastic event.

For the thermally fissile isotopes, where fission and capture are, up to a certain threshold, the only nonelastic processes, eta is defined as average neutron yield per absorption.

Coding:

for thermally fissile nuclei: (N,ABS),,ETA
in general: (N,NON),,ETA
eta at resonance: (N,ABS),,ETA,,RES

In the case of thermal neutron fission, where fission and capture are, up to a certain threshold, the only nonelastic processes, Eta is related to Nu-bar by:

$$\eta = \bar{\nu}\frac{\sigma_f}{\sigma_a}$$

NODATA

In the following cases 'NODATA' EXFOR entries may be transmitted which do not contain numerical data in the DATA section;

1. Unobtainable data: In the case where a center is aware that data exist, but the center is unable to obtain the data, a 'NODATA' entry should be made in EXFOR to inform the other centers (and their users) of the status of the data. This will eliminate many repeated requests for the same data and needless bookkeeping concerning data which will be entered into the system with extensive delays or not at all. Under STATUS the code (UNOBT) is entered followed by free text giving, if known, the date when the data may be expected to be released, or the reason why the data cannot be obtained.

2. "Raw" data:
Voluminous files of "raw" data may be stored on special archival tapes. A 'NODATA' EXFOR entry is then transmitted giving under STATUS a cross-reference to the special archival tape, the approximate number of records, and information on how to obtain the data upon request. If the author so wishes, a warning is given in free text that the raw data should be used only after consultation with the author. See LEXFOR Raw Data.

The BIB section of the 'NODATA' entry should be prepared as usual, containing at least the obligatory keywords (see page 8.4).

The COMMON section should contain minimum and maximum of the incident-projectile energy, if known.

The DATA section is replaced by the system identifier NODATA (compare page 3.9). The system identifier NODATA cannot occur in subentry 001 so that, as usual, an entry consists of a minimum of two subentries.

(page 2)
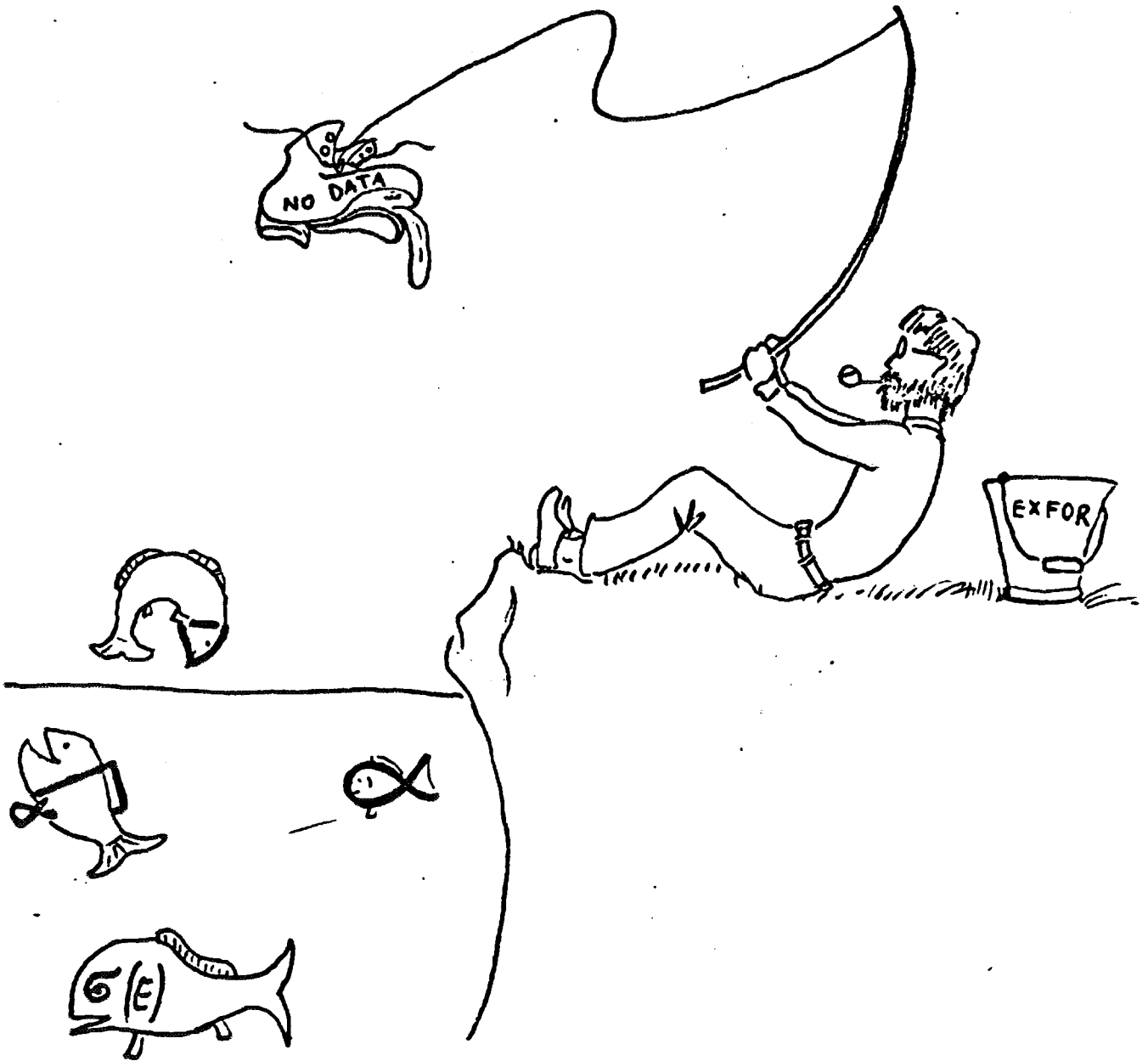
Nonelastic   Nonelastic

Definition: The sum of all energetically possible interactions, except elastic scattering.

Coding: Process code 'NON' in REACTION SF3

      Example: (-----(N,NON),,SIG)

Sum-rules: Nonelastic   = Total minus Elastic
                      = Absorption plus Inelastic.

Note: The nonelastic cross-section is a sum cross-section and should only be used when two or more of the relevant interactions are possible.

EXFOR is designed for nuclear reaction data referring to a target nucleus and an incident projectile. In the case of neutron reaction data, some derived "nuclear quantities" that are independent of an incident projectile are included in the scope of EXFOR because they are important for neutron data evaluation. For the coding of such data in EXFOR the following rules apply:

- in SF1 under REACTION that nucleus (e.g. compound nucleus) is coded to which the quantity refers

- in SF2 under REACTION a zero is entered to indicate that the quantity does not refer to an incident projectile; correspondingly, no incident energy (EN) is given.

At present, the following nuclear quantities are coded in EXFOR.

1. Spontaneous fission, coded as (0,F), see Fission.

2. Level-Density Parameter – proportional to single-particle level-spacing at top of Fermi-sea in the Fermi-gas model of the nucleus, in specified formalism, coded as (Z-S-A(0,0),,LDP). See note below.

3. Nuclear Temperature – from Fermi-gas model of the nucleus, coded as (Z-S-A(0,0),,TEM).

4. Spin-cut-off factor, coded as (Z-S-A(0,0),,SCO).

Note on STATUS: Subentries with nuclear quantities should, if applicable, contain under STATUS the code "DEP" with cross-reference to the subentry containing the reaction data from which the nuclear quantity was derived. Although nuclear quantities should be independent of the incident projectile energy, it is recommended to mention projectile and energy in the free text.

Note on Level-Density Parameters: For nuclei around A=208, neutron emission spectra can be interpreted only by assuming a variable level-density parameter (increasing density with increasing excitation energy). In this case the level-density parameter is a function of the incident neutron energy and it is justified to code it as

        (Z-S-A(N,INL),,LDP)

with Z-S-A = target nucleus, and with the neutron energy coded as usual under EN.

Note on incorrect EXFOR entries: Several EXFOR entries were transmitted where nuclear quantities are coded incorrectly, e.g. in the form (Z-S-A(N,2N)Z-S-A',,SCO), or with the wrong nucleus entered in SF1 under REACTION. This must be remembered when retrieving such data from the EXFOR library.

The NDS check program uses dictionary 27 to take care of the normal cases of nuclide coding. In addition it takes care of many special cases such as the codes 'O-G-O' or 'ELEM/MASS' in REACTION SF4, etc.

The following special cases are known where the check program may produce error messages although the entry may be correct.

1. Short living nuclides or isomers may occur correctly as a target nucleus. Such rare target nuclei will not be entered in dictionary 27, because it seems more likely that such nuclides show up as a misspelling of a stable nuclide.

2. Many nuclides have short living isomers which do not show up in Charts of Nuclides. In such cases compilers will often code 'Z-S-A' under DECAY-DATA where, strictly speaking, 'Z-S-A-G' would be more adequate.

3. For several nuclides it is uncertain whether they have an isomer. In such cases, the dictionary should <u>not</u> indicate an isomer, although this may correctly exist in the Exfor file.

4. For several nuclides it is uncertain, which of two isomers known is the ground-state. For this case entries exist where the nuclide is coded without an isomer extension, although the dictionary may indicate the isomer. The isomer meant can be identified with the half-life given.

5. When SF5 contains the code M+, the product-nucleus may eventually be coded without an isomer extension, because neither -G nor -M+G do apply.

6. A <u>stable</u> product-nucleus may be detected by its characteristic X-rays. In this case a stable nuclide may show up under RAD-DET or DECAY-DATA, although usually stable nuclides are forbidden here.

1. Partial reactions are usually coded with the code "PAR" in REACTION
    subfield 5. The code PAR is restricted to partial reactions leaving the
    residual nucleus in a specific level or emitting a specific gamma or
    particle group. (See examples under Inelastic Scattering.) The partial

    reaction must be specified further by coding one of the following
    secondary energies under an appropriate data heading from Dictionary 24
    (Family E):

    > Level energy, excitation energy, reaction Q value, energy of the
    > outgoing particle, or energy gain (resp. degradation) of the outgoing
    > particle.
    > Compare page 8.EN-SEC.

2. The code PAR is not used:

    a) for partial reactions leaving the residual nucleus in an isomeric
        state. See under Isomeric States and page 8.REACTION.5.

    b) for certain partial reactions due to competing reaction mechanisms;
        see under Reaction Mechanisms.

    c) for partial reactions specified by a defined sequence of outgoing
        particles. See Sequence of outgoing particles.

3. The code PAR may also be used for partial reactions leading through
    different mechanisms to the same endproduct. Example: The reaction

        6-C-12(N,N+3A)

    may proceed through any of the following mechanisms

        6-C-12(N,A)4-BE-9*(N)4-BE-8*(2A)
        6-C-12(N,A)4-BE-9*(A)2-HE-5*(N+A)
        6-C-12(N,N')6-C-12*(A)4-BE-8*(2A)
        6-C-12(N,N')6-C-12*(3A)

    All these partial reactions may be coded as

        (6-C-12(N,N+2A)2-HE-4,PAR,SIG)

    with free text explanation such as "PARTIAL REACTION VIA...". The
    intermediate states should be specified in the data table and explained
    under the BIB Keyword EN-SEC as clearly as possible, e.g.

        EN-SEC   (E-LVL,4-BE-8)

    In some cases, however, a more accurate way of coding is possible using
    the SEQ code in SF5 (see Sequence of outgoing particles). The first 3

    reactions of the above example could e.g. be coded as follows:

        (6-C-12(N,A+N+A)2-HE-4,SEQ,SIG)
        (6-C-12(N,A+A+N)2-HE-4,SEQ,SIG)
        (6-C-12(N,N+A+A)2-HE-4,SEQ,SIG)

    Compilers should try to achieve this way a unique identification of the
    partial reaction, as far as this is possible.

4. If ratios of partial reactions are given, it may occur that both units of
    the ratio have identical codes, both using the code PAR, with explanation
    given in free text.

1. Particles participating in a reaction
    The incident projectile is coded in REACTION SF2. Particles resulting
    from the REACTION to be defined are given in SF3 and SF4 as specified on
    the pages 8.REACTION.

    The nuclear reaction to be coded under the keyword REACTION usually
    specifies the endproducts without specifying the sequence of the outgoing
    particles. For the convenience of data retrievals, several outgoing
    particles are coded in the reaction parenthesis always sorted by ascending
    Z and A number. If the sequence of the outgoing particles is needed for
    defining the data given, see in Lexfor under Sequence of outgoing particles.

    The term "particles" in this Manual usually includes gamma rays. However,
    in the REACTION coding string gammas are usually not coded; the code for
    gammas is given only when it is needed for defining the reaction or the
    quantity given.

2. **Particles Considered/Particle Designator**
   For differential data it may be necessary to specify within the REACTION
   coding string, to which of several outgoing particles the quantity given
   refers (= "particle considered"). The "particle considered" is not
   necessarily identical with the "particle detected" (see below). When the
   "particle considered" must be specified, it is coded in subfield SF7 of
   the REACTION string. If SF7 is blank the "particle considered" is the one
   referred to in SF3.

Examples:

(----(P,P+A)----,PAR,SIG,A)	Partial cross-section for a specific alpha group
(----(P,A)----,PAR,SIG)	Partial cross-section for a specific alpha group (Here SF7 is left blank, because there is no ambiguity)
(3-LI-6(N,T)2-HE-4,,DA,A)	Angular distribution of alpha particles
(3-LI-6(N,T)2-HE-4,,DA,G)	Angular distribution of gammas

If the code given in REACTION SF3 is a process code, and the reaction refers
to a specific particle, the particle considered is determined as follows:

INL: The particle considered is assumed to be the same as the incident
projectile, gammas must be entered in REACTION SF7.

(----(N,INL)----,,DA,G)	Angular distribution of gammas from inelastic neutron scattering
(----(N,INL)----,,DA)	Angular distribution of inelastic neutrons

F: The particle considered is ambiguous and must be entered in REACTION SF7

(----(N,F),,DA,FF)	Angular distribution of fission fragments
(----(N,F),PR,DA,N)	Angular distribution of prompt fission neutrons
(----(N,F),IND,FY/DE)	Independent fission yield of fragments of a specified kinetic energy. Note that FF in SF7 is not coded because it is redundant due to the presence of the code FY.

X: The particle considered is assumed to be the particle for which the
production is measured. Compare under Production Cross-Sections

(----(N,X)0-NN-1,EM,DA)	Differential neutron emission cross-section

Particles (page 3)

3. Particles/Radiations Detected

Particles actually detected in the experiment may be identified using the keyword PART-DET (see page 8.PART-DET for coding rules). This keyword need not be given in those cases where the particle detected is obvious from the quantity given.

If the particle detected may be attributed to the decay of a specific nucleus, it may be coded using the keyword RAD-DET. (See page 8.RAD-DET for coding rules).

The particles detected in a monitor reaction should not be included under the keywords PART-DET or RAD-DET.

See Dictionary 13 for list of permissible codes.

Distinguish the different codes for decay-gamma (DG) and other gammas (G), and also for the different beta-particles: decay-electrons (B-), decay-positrons (B+) and other electrons (E).

4. Variable number of emitted nucleons

When a mass or element distribution of product nuclei is given and their Z and/or A values act as independent variables, a variabel sum of outgoing nucleons may be indicated in REACTION SF3 using the process codes XN, YP or XN+YP. The numerical values of the multiplicity factors X and Y are entered in the DATA table under the data-heading keywords N-OUT and P-OUT, respectively. If, in this formalism, the "emitted nucleons" are 2 neutrons and 2 protons, it is not distinguished whether these nucleons are emitted in the form of an alpha, or of 2 deuterons, or what ever. See also chapter 6 and pages 8.REACTION.

This formulation is only permitted if all REACTION subfields but SF3 and Sf4 remain unchanged.

This formulation should not be used for frequently occurring reactions such as (n,2n); otherwise retrievals for such important reactions would become difficult. If data for only a few reactions are given, e.g. (n,2n), (n,3n), etc. the Multiple Reaction Formalism (see there) should be used instead.

The code 'XN' must not be confused with the term 'neutron emission' (compare Production Cross-Sections).

5. Undefined/Defined Reaction Channels

Note: For the present, this formalism is used only for charged particle data.

In some cases a given residual nucleus may be produced by more than one reaction channel, e.g. (P,A) and (P,2N+2P), but only the residual nucleus has been investigated. If it is clear that more than one channel contributes [e.g. for energies well above the threshold for (P,2N+2P)], the branch code 'UND' (undefined reaction channel) should be given in REACTION SF5; then, the particles coded in SF3 denote only the sum of emitted nucleons, implying that the product nucleus coded in SF4 has been formed via different reaction channels. The reaction is coded either as given by the author or by giving only the emitted nucleons, e.g. (Z-S-A(P,2N+2P)Z'-S'-A',UND,SIG).

Where it is not clear whether the reaction channel is undefined or defined, the reaction is coded as specified by the author with the code '(DEF)' in SF5, e.g.

> (Z-S-A(P,A)Z'-S'-A',(DEF),SIG) or
> (Z-S-A(P,2N+2P)Z'-S'-A',(DEF),SIG)

In cases where the reaction channel is unambiguously defined either by measuring the outgoing particles or due to theoretical considerations, the reaction is written as specified by the author and no special code is given in SF5; the codes 'UND' and '(DEF)' are not used.

Free text comments should explain any reasons not explicitly given in the publication, by which the reaction is proved to be defined.

Absence of the codes 'UND' or '(DEF)' gives a positive definition of the reaction coded, stating it to be defined with respect to the reaction channel and the outgoing particles coded in SF3.

The "undefined" processes X and F are not combined with the branch-code 'UND'. In cases where an explicit specification of the number of outgoing nucleons is meaningless (e.g. too many outgoing nucleons, spallation, etc.), the coding

> (Z-S-A(P,X)Z'-S'-A',,SIG) should be used rather than
> (Z-S-A(P,XN+XP)Z'-S'-A',UND,SIG)
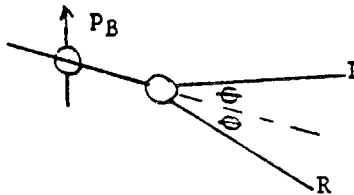
Polarization

The following definitions and coding rules are given for spin-1/2 particles. Cartesian notation is used. Definitions will be added for spin-1 particles as the need arises.

Definitions

Under the influence of a spin-orbit force, an unpolarized beam of particles becomes at least partially polarized (i.e., the particles acquire a preferred spin).
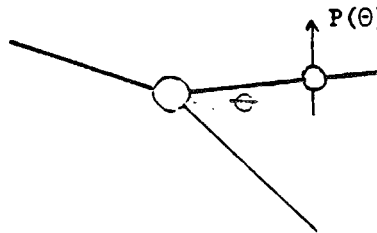
The inverse of this situation is the asymmetric scattering of a polarized beam of particles. The degree of polarization of such a beam may be determined by measuring the left-right asymmetry upon scattering from a target nucleus which plays the role of an Analyzer.

$$e = L-R/L+R = P_B A_Y$$

where   e = asymmetry
P_B = polarization of incident particle beam
A_Y = analyzing power
L,R = intensity of particles scattered right and left in the same plane under the same angle

The principle of Polarization-Asymmetry Equality states that, for time-reversal invariant reactions, the polarization induced in a previously completely unpolarized beam by elastic scattering from spin-zero nuclei is identically equal to the asymmetry ensuing from the scattering of a perfectly polarized beam under the same conditions.

November 1982

NDS X4

Basel (sign) Convention for spin-1/2 Particles

In nuclear interactions the positive polarization of particles with spin
1/2 is taken in the direction of the vector product k(i) x k(o), where k(i)
and k(o) are circular wave vectors of the incoming and outgoing particles
respectively.

See Reference 1 for more detail.

Madison Convention

The state of spin orientation of an assembly of particles, referred to as
polarization, should be denoted by the symbols t(kq) (spherical) or
p(i),p(ij) (Cartesian).

These quantities should be referred to a right-handed coordinate system in
which the positive z-axis is along the direction of momentum of the
particles, and the positive y-axis is along k(i) x k(o) for the nuclear
reaction which the polarized particles initiate, or from which they emerge.

Terms used to describe the effect of initial polarization of a scatterer on
the differential cross section for a nuclear reaction (referred to as
analyzing power) should include the modifiers analyzing or efficiency.
These quantities should be referred to a right-handed coordinate system in
which the positive z-axis is along the beam direction of the incident
particles and the y-axis is along k(i) x k(o) for the reaction in question.

In the expression for a nuclear reaction A(b,c)D, an arrow placed over the
symbol denotes a particle which is initially in a polarized state or whose
state of polarization is measured.

Example: A(b,c̄)D; polarization is measured for a particle c
                    emerging from a reaction between unpolarized
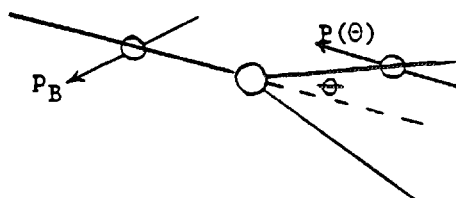   particles A and b.

See Reference 2 for more details.

<u>Depolarization</u> Parameter (D): change in polarization due to scattering.
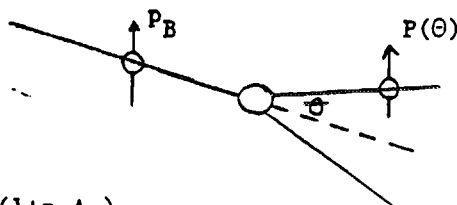
$$P(\Theta)=(A_Y+Dp_B)/(1+p_BA_Y)$$

<u>Rotation Parameter</u>: measure of rotation of spin of scattered beam

$$R=\frac{P(\Theta)}{P_B}$$

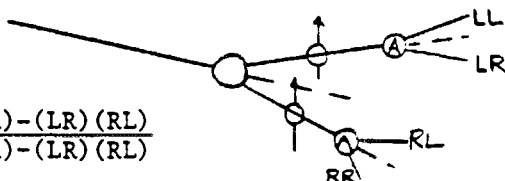<u>Differential polarization</u>:

$$I_p=I_oP(\Theta)$$

where I_o = differential cross section for an unpolarized beam

<u>Spin-Correlation Parameters</u>

C_{NN}: unpolarized beam; unpolarized target; outgoing particle spins normal to scattering plane; outgoing particles scattered right and left analyzed.

$$C_{NN}=\frac{1}{A_Y^2}\frac{(LL)(RL)+(LR)(RR)-(LL)(RR)-(LR)(RL)}{(LL)(RL)+(LR)(RR)+(LL)(RR)-(LR)(RL)}$$

A_{YY} : polarized beam; polarized target; outgoing particle spins normal to scattering plane; asymmetry is measured.

$$e=|P_b||P_t|A_{YY}$$

If time reversal holds: $C_{NN}=A_{YY}$

C_{kp}: unpolarized beam; polarized target; outgoing particle spins in scattering plane.

$$C_{kp}=\frac{1}{A_Y^2}\frac{(LU)(RU)+(LD)(RD)-(LU)(RD)-(LD)(RU)}{(LU)(RU)+(LD)(RD)+(LU)(RD)-(LD)(RU)}$$
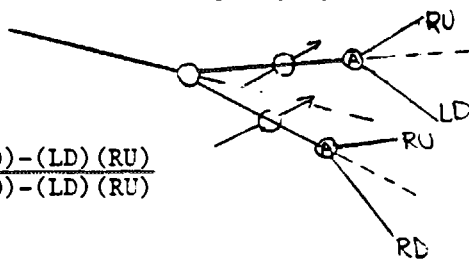
References

1. "Proceedings of the International Symposium on Polarization Phenomena of Nucleons", P.Huber and K.P.Meyer, eds. Helvetica Phys.Acta, Suppl. VI (1961)

2. "Polarization Phenomena in Nuclear Reactions", page xxv, H.H.Barschall and W.Haeberli, eds. The University of Wisconsin Press, Madison (1971)

3. "Polarization Phenomena in Nuclear Physics - 1980", G.G.Ohlsen, R.E.Brown, N.Jarmie, W.W.McNaughton, G.M.Hale, eds., American Institute of Physics (1981).

4. W.Larkin, Phys. Rev. $\underline{98}$, 139 (1955)

5. L.J.B.Goldfarb, Nuclear Phys. $\underline{7}$, 622 (1958)

6. A.Simon, Phys. Rev. $\underline{92}$, 1050 (1953)

7. "Physics of Nuclei and Particles", Vol. II, Ch. 13, P.Marmier and E.Sheldon, Academic Press, 1970.

8. "Polarization of Fast Neutrons", L.Wolfenstein, Annual Review of Nuclear Science $\underline{6}$, 43 (1956)

9. "Nucleon-Nucleon Experiments", J.C.Hopkins, LA-DC-10061 (1968).

Coding

The sign should follow the "Basel" or "Madison" Convention.

The following quantities are coded in EXFOR:

- The spin-polarization probability, integrated over all pertinent angles is coded with 'POL' in REACTION SF6.

- The differential spin-polarization probability with respect to angle of emmission is coded with 'POL/DA' in REACTION SF6.

- The asymmetry is coded with 'POL/DA' in REACTION SF6 and 'ASY' in SF8.

- The analyzing power is coded with 'POL/DA' in REACTION SF6 and 'ANA' in SF8.

- The spin-correlation parameter (A_{YY}), is coded with 'POL/DA' in REACTION SF6 and 'AYY' in SF8.

The data units should be coded as 'NO-DIM'.

Data are assumed to be in Cartesian Coordinates. (Coding rules for data in spherical coordinates should be propsed as the need arises.)

Polarized incident-projectile source

Entries should be made under the Information-Identifier Keyword INC-SOURCE for the following cases:

- A polarized neutron source is entered using the code 'POLNS'.

- A polarized target is entered using the code 'POLTR'.

- An atomic beam source is entered using the code 'ATOMIC'.

- A Lamb-shift source is entered using the code 'LAMB'.

The incident-projectile source should be coded in sufficient detail to describe the reaction. The polarization of the beam and target should be given in the data table, if known, using the data headings POL-BM and POL-TR, respectively.

Example:

        INC-SOURCE   (POLTR,LAMB) Polarized target and Lamb-shift ion source

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Definition: The production cross section for a particle Y is defined as the sume of all energetically possible reactions resulting in the production of at least one particle Y in the exit-channels, each reaction weighted by the multiplicity of particle Y. The interactions involved and their multiplicity need not be known.

The term emission cross section is defined as a special case and excludes elastic scattering. In the case where the incident projectile is not equal to Y, the production and emission cross sections are equal.

Note: These quantities are sum cross sections, which should be used only when two or more reactions producing particle Y are energetically possible.

Sum rules (for neutron data):

neutron production = neutron emission + elastic
neutron emission   = $(n,n')+2(n,2n)+3(n,3n)+n,np)+\bar{\nu}(n,f)+...$

For B-11 with 14 MeV neutrons:

alfa-emission = $(n,\alpha)+(n,n\alpha)+2(n,n+2\alpha)$

REACTION coding:

For production cross-sections the code X is entered in SF3 (Process) and the particle (or nuclide) for which the production is measured is entered in SF4.

For emission cross sections, the code EM is entered into SF5 (Branch). This is coded only when the incident projectile is not equal to the particle Y.

For inelastic gamma emission, see Inelastic Scattering.

Examples:

(.....(P,X)0-G-0,,SIG)	proton-induced gamma-production cross-section
(.....(N,X)0-NN-1,EM,SIG)	neutron-induced neutron emission cross-section, excluding elastic scattering
(.....(N,X)0-NN-1,,SIG)	neutron-induced neutron production cross-section, including elastic scattering
(.....(P,X)6-C-12,,SIG)	proton induced C-12 production cross-section.

1. **Products of 2 or more reactions** can be expressed as a reaction combination using the separator '*'.

   Examples:

   > REACTION ((42-MO-98(N,TOT),,WID)*(42-MO-98(N,EL),,WID))

   > ISO-QUANT ((42-MO-98,TOT/WID)*(42-MO-98,EL/WID))

2. **Products implicit in the quantity codes**

   For certain products which can be measured directly, or are frequently used, special quantity codes have been introduced.

   The following factors are coded using special codes:

   $$\sigma o = \text{SO in modifier field for REACTION, in SF2 for -QUANT keyword}$$

   $$g, ag, 2g, 2ag = \text{G,AG,2G,2AG in modifier field} \quad \text{(for resonance parameters)}$$

   $$a = \text{A in modifier field (times natural isotopic abundance)}$$
   $$\text{or (A) in modifier field (if unclear whether corrected for natural isotopic abundance)}$$

   $$\sqrt{E} = \text{RTE in modifier field}$$

   $$4\pi = \text{4PI in modifier field}$$

   $$(---)^2 = \text{SQ in modifier field for REACTION, in SF2 for -QUANT keyword}$$

   $$\frac{4\pi}{\sigma el} = \text{RS in modifier field}$$

See also **Fitting Coefficients**.

The following refers primarily to resonance parameters of <u>neutron data</u>, where the following quantum numbers are given in EXFOR:

Momentum "ℓ"   -   the orbital angular momentum of neutrons exciting a
                        compound-nucleus resonance

Resonance-Spin "J" -   the total spin-value of the compound-nucleus resonance

Parity "π"   -   the parity of a compound-nucleus resonance

These quantum-numbers could also be used for photonuclear and charged-particle reaction data, but only if they are essential parameters of the data given. Before they are introduced for other than neutron data, an appropriate Lexfor entry must be proposed.

These quantum-numbers can be entered in two different ways:

    a)   frequently such quantum-numbers are <u>parameters</u> of strength-functions,
        reduced neutron-widths, or other quantities. Then they are entered
        as parameters in an additional column of the data table, either in
        the "COMMON" or in the "DATA" section, under the data-heading keywords

            MOMENTUM L
            SPIN J
            PARITY

    b)   if the quantum-number is the result of the resonance parameter
        analysis, one of the following <u>quantity-codes</u> is used:

            REACTION   ----(N,0),,L)
                        ----(N,0),,J)
                        ----(N,0),,PTY)

In this case the data are entered into the data table with the data-heading keyword "DATA", and the data-unit keyword "NO-DIM".

The quantum numbers, themselves, should be entered with a decimal point (in the case of parity as 1. or -1.).

Note: In WRENDA Spin, Parity and energy of levels are grouped together in one
       category LQN (level quantum numbers).

    c)   In addition, there is the <u>statistical weight "g"</u> of a
        compound-nucleus resonance:

$$g = \frac{(2J+1)}{(2I+1)(2s+1)}$$

This is coded either in the COMMON or DATA Section under the data heading STAT-W G, or as

            REACTION   ----(N,0),,SWG.

(If g is a factor of other resonance-parameter data, the quantity-modifier 'G' is used, see Dict. 34.)

Ratios   Ratios

1. **Ratios of 2 or more reactions** can be expressed as a reaction combination
    using the separator '/' (see page 8.REACTION.11)

    Example: ((3-LI-6(N,T)2-HE-4,,SIG)/(92-U-235(N,F),,SIG))

2. **Ratios implicit in the quantity codes**

    For certain frequently used ratios, special quantity codes have been
    introduced.

         ALF (SF6) = capture-to-fission cross-section ratio (see under Alpha)

         ETA (SF6) = average neutron yield/nonelastic event (under Neutron Yield)

         Various modifiers in SF8 for relative angular distributions (see under
         Differential Data and Fitting Coefficients).

3. **Isomeric Ratios** are coded using the separator '/' in the isomer field of
    the reaction product (SF4), and with the modifier 'RAT' in SF6. See under
    Isomeric Sates.

4. **Data-Heading Keyword RATIO**

    The Data-Heading Keyword RATIO may (optionally) be used instead of the
    keyword DATA with, and only with, ratios expressed as explicit ratios or
    isomeric ratios, sections 1 and 3, above.

    It must not be used for implicit ratios, see Section2, above.

5. **Parameter RAT (REACTION SF6)**

    The code 'RAT' in SF6 is given when, and only when

    either: the separator '/' appears in the isomer extension of the reaction
              product (see 3, above),

    or: when SF5 contains the codes 'TER/BIN' or 'BIN/TER'

Raw Data
========

Raw Data
========

"Raw" data are experimental data which are not yet reduced to the final form but still contain, for example, contributions from detector efficiency, instrumental resolution, or sample thickness.

Although such data are of little use to normal data center customers, it has been recognized that "raw" data should be stored by the data centers. Such data would then be available:

- for re-analysis when improvements in analysis techniques are made

- for realistic assessments of data errors becoming increasingly important to evaluators.

(See recommendation by the NEANDC/NEACRP meeting on neutron data for structural materials, Geel, December, 1977.)

The following types of "raw" data have been encountered so far:

1. measured transmissions:

$$\langle e^{-n\sigma_T} \rangle = 1 - n\langle \sigma_T \rangle + \tfrac{1}{2}n^2 \langle \sigma_T^2 \rangle + \ldots$$

2. reaction yields:

$$\langle y_r \rangle = \langle (1 - e^{-n\sigma_T}) \, \bar{\sigma}_r / \bar{\sigma}_T + \sum_{i=1}^{\infty} y_{r,i} \rangle$$

where: $\langle \ldots \rangle$ denotes resolution broadening
       n is the sample thickness in nuclei/barn
       σ_T and σ_r are the Doppler-broadened, abundance-weighted total and partial reaction cross sections, respectively
       $y_{r,i}$ is the reaction yield from neutrons scattered i times before inducing the reaction of type r, e.g., fission, scattering or radiative capture.

Note that for thin samples ($n\bar{\sigma}_T \ll 1$) the following simple relation with the (broadened) cross section exists:

$$-\frac{1}{n} \ln \langle e^{-n\bar{\sigma}_T} \rangle \simeq \langle \bar{\sigma}_T \rangle, \quad \frac{1}{n} \langle y_r \rangle \simeq \langle \bar{\sigma}_r \rangle$$

Data may be given as "counts" or as uncorrected cross-sections in "barns".

Additional data types may be added as they are encountered.

The data may be transmitted in EXFOR using the modifier RAW in REACTION SF8. The RAW modifier should always be explained in free text.

A center is free to transmit or not to transmit such data, but if it decides not to do so, a NODATA entry should be made (see LEXFOR NODATA).

Important: In EXFOR, the REACTION code is meant to define the reaction end products irrespective of the reaction mechanism. Whatever is to be said about the reaction mechanism, should be given in free text, e.g. under the BIB keyword COMMENT. Only in the case that a reaction cross-section is subdivided in two or more partial cross-sections, only then some appropriate modifier is used to distinguish the partial reaction data from the complete reation.

Partial Cross Sections due to different reaction mechanisms

An author may assign fractions of a measured cross section to different reaction mechanisms. The following reaction mechanisms are defined, based on currently accepted nuclear models and may be entered into EXFOR in the manner described below.

Definitions

Compound-Nucleus Interaction: A reaction in which the incident projectile is absorbed by the target nucleus and its initial energy is assumed to be shared by all other nucleons, such that the mode of disintegration of the 'compound nucleus' is independent of the way in which it was produced.

Note: In charged-particle reactions the term 'Fusion' is often used when it is not clear that the compound reaction really proceeds.

Direct Interaction: A reaction in which there is direct interaction between the incident projectile and single nucleons or clusters of nucleons in the target.

Spallation: A reaction where several particles are ejected from the target nucleus by direct interaction leaving behind a nucleus in an excited state which then evaporates nucleons or clusters of nucleons. (Compare under Spallation)

High-energy Fission (Energies about 50MeV): proceeds in essentially the same manner as spallation except that the excited nucleus divides into roughly two fragments. See under Fission for the fission process at lower energies.

Data Specification

1. ### Compound-Nucleus Interaction and Direct Interaction

   If a reaction proceeds by either mode, the total reaction is equal to the sum of the compound-nucleus interaction and direct interaction portions. In this case, the partial cross-sections of a reaction may be coded with the modifiers 'CN' and 'DI', respectively, in SF5 (branch) for the keyword REACTION.

   Examples:

   REACTION   (-----(N,P),CN,SIG)
               (-----(N,P),DI,SIG)

   These partial cross-sections cannot be measured directly but are deduced from theoretical considerations. Therefore, careful explanation in free text is required whenever these modifiers are used.

   Note: If the author measures the total (n,p) cross-section and states that this reaction is totally a direct interaction, then the modifier "DI" must not be given , because "DI" and "CN" designate partial cross-sections.

2. ### Spallation and High-energy Fission

   The breakup of a nucleus at high energies may, in some cases, proceed by either mode. In this case, the partial quantity for fission or spallation may be coded under the keyword REACTION using the modifiers 'SPL' and 'FIS', respectively, in SF5 (branch).

   Examples:

   (6-C-12(P,X),SPL,SIG) Spallation cross secton
   (6-C-12(P,X),FIS,SIG) High-energy fission cross section

   Note: If the author measures the total break-up or production of a given product and states that this reaction is totally due to spallation or fission, then the codes SPL or FIS must not be given, because these designate partial cross sections.

   For the production of specified product nuclei see Product Yields.

Reaction Rate

The term "reaction rate" is widely used in nuclear fusion and astrophysics.

Definition+: The thermonuclear reaction rate is defined as

cross-section times ion velocity averaged over the Maxwellian ion velocity distribution of the temperature kT:

$$< \sigma.v > = \frac{\int_0^\infty (\sigma.v)\exp(-mv^2/2kT)\ v^2\ dv}{\int_0^\infty \exp(-mv^2/2kT)\ v^2\ dv}$$

The ion with the mass m_2 has the velocity v relative to the target ion of mass m_1. The reduced mass m^2 of the ion pair is $m = m_1\ m_2/(m_1+m_2)$.

Coding:

The reaction rate has the quantity code ,SGV,,MXW

Data are usually given in units of cm^3/sec to be coded as CM3/SEC.

Data are given as function of the Maxwellian temperature kT to be coded under the column heading KT with energy units, e.g. KEV.

Literature:

[1] D.D. Clayton, Principles of Stellar Evolution and Nucleosynthesis (McGraw-Hill Book, N.Y., 1968)

[2] W.A. Fowler et al., Thermonuclear Reaction Rates, Ann. Rev. Astron. Ap. 5, 525 (1967)

[3] T.A. Trombello, Conf. on Nuclear Cross Sections and Technology, Washington D.C., 3-7 March 1975, p. 659

[4] J.M. Davidson et al., Low energy cross-sections for B-11 (p,3α), NP/A 315, 253 (1979)

For coding rules see in Chapter 8 pages 8.REFERENCE.

Exfor is not a bibliographic system with one entry per reference. Rather, there should be one Exfor entry per experiment and, quite often, an experiment has been reported in several references such as

-    one or more progress reports or preliminary publications ·
-    a local journal article
-    a paper in an international journal
-    a lab report.

All such references should be quoted in Exfor under the BIB-keyword REFERENCE. All bibliographic references which contain information of importance directly relating to the data compiled in Exfor, should be quoted.

The actual source from which the Exfor data were taken, is given under the BIB-keyword STATUS. This source is either one of the references quoted or a private communication from the author.

NDS note: For neutron data the REFERENCE information should conform to the
          relevant CINDA block.

The purpose of the bibliography under the keyword REFERENCE is

    to help the compilers:

-    to avoid duplicate entry of data in EXFOR
-    to help identifying a data set when data are requested by reference

    to help the users of EXFOR:
-    to get easy access to any additional information he may wish to look
     up in the published references
-    to check whether a given reference has been considered by the
     compiler.

Therefore, the free text should indicate to the user of EXFOR:

-    which is the main reference.
-    the kind of information contained in each given reference, e.g.,
     "instrumentation only", "graphs only", "no data", "theoretical
     analysis", etc.

When translations of references exist, these should be included also, for the convenience of the users of EXFOR.

References which are published only after the first comilation of the EXFOR entry, should be added subsequently. Usually they will provide additional information on the experiment or the numerical data, which should be added in EXFOR. The updated EXFOR entry is then retransmitted according to Manual page 9.2.

REFERENCE (page 2)

Overlapping references: Consider the following case:

Reference 1 contains data for reactions a,b,c and these have been compiled in Exfor entry 1, subentries 002 to 004.

Subsequently, reference 2 is published containing the continuation of the same experiment giving revised data for reactions b and c, plus new data for reaction d and e. There are several solutions.

Solution A:

The data in entry 1, subentries 003 and 004, are revised on the basis of reference 2, and new subentries 005 and 006 are added to include the new data for reactions d and e. In this case, the keyword REFERENCE should no longer be given in subentry 001 but rather in subentries 002 to 006. Under the keyword REFERENCE

- subentry 002 would refer to reference 1 only
- subentries 003 and 004 would refer to reference 2 as the main reference, but would also quote reference 1 with the free text "DATA SUPERSEDED"
- subentries 005 and 006 would quote reference 2 only.
The revised entry 1 is then retransmitted.

Solution B:

The data from reference 2 are entered in a new entry, say in entry 2 in subentries 002 to 005. In this case the subentries 003 and 004 of entry 1 must be labeled as superseded under the BIB keyword STATUS. The revised entry 1 is then retransmitted together with the transmission of the new entry 2.

Solution B may be easier for the compiling physicist. But in this solution, superseded data will accumulate in the Exfor file.

Solution A will be more convenient for the Exfor user, because he will find all information on the given experiment in a single entry.

Relative   Relative

Data that are not given in absolute units but in some arbitrary units are
defined under REACTION by the modifier REL in SF8. In the DATA table such
data are given the unit "ARB-UNITS". (Note, that ratio data that do not
require the modifier REL have usually the unit "NO-DIM"; compare under Ratios).

Renormalization   Renormalization

In general, the data are compiled in the normalization given by the author.
The normalization is entered under MONITOR, see in Lexfor under Standards.

Renormalization should not be done by the compiler except on advice by the
author. However, some "renormalizations" are not a trivial multiplication
with a factor, for instance if a detector-efficiency curve or the geometry of
the experiment is involved. For such cases see CORRECTION.

Resolution

The word resolution can describe:

either the energy spread or channel width (or a combination) of the incident particle
or the angular or energy spread of the outgoing particle(s).

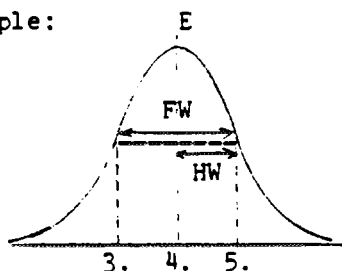### Incident-particle Energy Resolution

The energy resolution describes the distribution curve of the energy spread. It is usually defined as full-width at half-maximun (FWHM), but may be given in other representations. The shape and definition of the resolution function should be given in free text under INC-SPECT, if known.

The resolution is coded using the following data headings:

EN-RSL-FW Incident-particle energy resolution (FWHM)
EN-RSL-HW Incident-particle energy resolution (+1/2 FWHM)
EN-RSL   Incident-particle energy resolution (unspecified)

The energy resolution can be given in energy units, in percent, or in units of a reciprocal velocity (e.g., nsec/m).

Example:

EN-RSL-FW:
     Energy resolution = 2 MeV

EN-RSL-HW:
     E = 4. ± 1. MeV

Outgoing-particle Energy or Angular Resolution

The following data headings are used:

E-RSL   energy resolution of outgoing particles or gammas
ANG-RSL   angular resolution

Note: The terms resolution and error are often misused in the literature. Distinguish, where possible. See Errors.

Resonance Integrals Resonance Integrals

Definition: Effective cross-section (in barns) for the epithermal part of a reactor neutron spectrum.

Function code: RI

The energy limits are specified under the data-heading keywords EN-MIN and EN-MAX.

Infinitely dilute resonance integrals (for the reaction r and for an epithermal spectrum proportional to 1/E) are defined as:

$$I_r = \int_{E_c}^{\infty} \sigma_r (E) \; \frac{d\,E}{E}$$

where E_c = cut-off energy near the lower limit of the epithermal region.

These are usually measured as cadmium ratios where E_c is the cadmium cut-off energy which is dependent on the thickness of the cadmium cover.

In some cases, an upper limit is given for the energy (e.g. 10 MeV) and should be coded. When an upper limit is not given EN-MAX may be omitted.

Resonance integrals over smaller energy ranges, where the sum over the partial energy ranges given from the cut-off energy to the maximum energy is equal to the total resonance integral, should be coded with the quantity modifier "LIM".

Reduced resonance integrals, where the 1/v part of the low-energy cross-section has been substracted, is coded with the quantity modifier "RNV".

Note: Resonance integrals calculated from resonance parameters should be coded in EXFØR only if they are labelled as deduced values as distinct from directly measured experimental values.

For futher detail see:

N.P. Baumann, DP-817 (1963)

J.J. Scoville and J.W. Rogers, IN-1195 (1968)

Resonance integrals (page 2)

Effective Resonance-Energies

The "ideal" resonance-integral is defined for an epithermal flux assumed to be proportional to 1/E. This is an approximation which may be sufficiently accurate in certain cases only. Directly measured resonance-integrals and those computed from cross-section curves assuming a 1/E flux are often discrepant due to the fact that realistic epithermal fluxes deviate from the 1/E shape.

T.B. Ryves [Metrologia 5, 119, (1969)] has developed a better approximation which is sufficiently accurate for most applications. Ryves shows that the epithermal part of a reactor neutron spectrum is proportional to $1/E^{1+\alpha}$ where α is a constant close to zero (either positive or negative), which can be determined for each realistic reactor spectrum. Accordingly, the realistic resonance-integral is defined as:

$$I(\alpha) = \int_{E_c}^{\infty} \frac{\sigma(E) \, dE/eV}{(E/eV)^{1+\alpha}}$$

with E_c = cut-off energy (Cd cut-off near 0.5 eV). For $\alpha=0$ this formula goes over to the "ideal" infinite dilute resonance-integral

$$I_o = \int_{E_c}^{\infty} \frac{\sigma(E) \, dE}{E}$$

The realistic resonance integral ($\alpha \neq 0$) and the ideal resonance integral ($\alpha = 0$) are related by the formula:

$$I(\alpha) = \frac{I_o - 0.429 \, \sigma_o}{(E_r/eV)^{\alpha}} + \frac{0.429 \, \sigma_o}{(2\alpha + 1) \, (E_c/eV)^{\alpha}}$$

where σ_o = 2200 m/s cross-section

E_r = "effective resonance-energy"

Resonance integrals (page 3)

[reference: A. Simonits, F. de Corte, L. Moens, J. Hoste, J. of Radioanal. Chem. 72 (1982) 209, see p. 215].

The "effective resonance-energy" is a microscopic nuclear constant representing a kind of average over the major resonances. It is tabulated in the literature for various nuclides and can be determined by experiment and evaluation. For (n,γ) activation analysis it is needed as a correction factor of similar importance as the resonance integral. Its value need not be known with high accuracy. A 50% uncertainty in the effective resonance-energy may lead to a 1% uncertainty in activation analysis measurements, whereas ignoring the parameter α may lead to a 25% error in activation analysis measurements.

[reference: S. Jovanovic, F. de Corte, L. Moens, A. Simonits, J. Hoste, J. of Radioanal. and Nucl. Chem 82/2 (1984) 379].

Conclusion for EXFOR compilation:

When directly measured resonance-integral data are compiled in EXFOR it is essential

- to give all available information on the epithermal neutron spectrum; if given, to quote the α parameter;

- and to state whether the value given is $I(\alpha)$ for the realistic epithermal neutron spectrum, or whether appropriate corrections have been applied so that the value given is meant to be I_0 for an ideal epithermal 1/E spectrum.

The Scan program produces from an Exfor TRANS tape (or from any other Exfor file) a Scan Listing giving a summary of the contents of the tape.

The columns produced are

- accession number, preceded by "C" if the subentry is a corrected retransmission of a subentry transmitted earlier (only used in center-to-center exchange, not in center-to-customer transmission)

- Reaction

- Reference (only the first reference encountered)

- First author

- Institute code

- "PNTS" = number of data lines (a data line may consist of more than one record)

The statistics at the end of the Scan Listing are self-evident except for the following:

- "DATA POINTS" means again data lines

- The "Number of Records on File" is considerable larger than the sum of BIB records and DATA points, as it includes

                    the System Identifier Records,
                    the COMMON data,
                    the headings and units in COMMON and DATA,
                    the BIB records,
                    the DATA records (may be more than one record per
                                           Data point.)

Definition: Two-body interaction with only one particle, which is the same as the incident particle, in the exit channel.

The following scattering processes are defined:

1.   Total Scattering. The sum of all scattering interactions.

     Sum Rule: Total scattering = elastic plus inelastic
                                  = total minus absorption

     REACTION Coding: SCT in SF3 (Process).

     Example: (----(P,SCT)----,,SIG)
                alternately: (----(P,P)----,,SIG) for use only when the
                             scattering type need not be distinguished.

     Note: In some neutron experiments (e.g., Lane, et al., Phys. Rev. 107,
              1077 (1957)), the data may be called scattering even though they
              extend above a threshold where other reactions producing the
              scattered particle are also possible. It should be specified
              whether such data have to be corrected for the effects of such
              threshold reactions. If not, the quantity should be coded as
              neutron production.

2.   Elastic Scattering. Scattering without excitation of the scattering
     nucleus (Q = 0).

     REACTION Coding: EL in SF3 (Process).

     Example: (----(N,EL)----,,DA)

3.   Inelastic Scattering. Scattering with excitation of the scattering
     nucleus (Q ≠ 0). De-excitation of the residual nucleus, usually, by
     electromagnetic radiation. See LEXFOR Inelastic Scattering.

4.   Potential Scattering. Elastic scattering which proceeds without the
     formation of an intermediate nucleus. (Elastic scattering is a mixture
     of potential and resonance scattering.)

     REACTION Coding: POT in SF5 (Branch).

     Example: (----(N,EL)----,POT,SIG)

5.   Thermal Scattering. Low energy scattering processes for which molecular
     and crystalline forces are involved. See LEXFOR Thermal Neutron
     Scattering.

See also LEXFOR Scattering amplitude, Differential Data

Definition:

$$\frac{d\sigma}{d\Omega} = |f(\theta)|^2$$

where the scattering amplitude f is a function of the wavelength of the incident particles and of the relative orientation of the incident-particle spin and target spin.

For neutrons, for which only s-wave scattering is possible (and for which the scattering is, therefore, isotropic) and for zero energy:

$$f = -a$$

where a is the Fermi scattering length.

REACTION coding: AMP is SF6 (Parameter)

Example: (----(N,THS)----,COH,AMP)

See also Scattering, Thermal Neutron Scattering

Secondary Effective Mass

Information about the effective squared mass of detected particles or particle systems may be entered as follows:

1. Numerical values are entered in the COMMON or DATA section using data headings from Dictionary 24 with the family code 'S', e.g., EMS.

2. The information-identifier keyword EMS-SEC may be used:

   - to specify to which reaction product the effective squared mass refers
   - to give free text information about secondary mass.

   The keyword is always coded when more than one effective secondary squared mass is given in the COMMON or DATA section using the headings EMS1, EMS2, etc.

3. Mass Correlation of Secondary Particles

   REACTION Coding: 'EMC' in SF6 (parameter)

   Example: (.....(G,N+P).....,,EMC) neutron-proton mass correlation

Note: This was introduced for photonuclear data. For neutron data and CPND this formalism has not yet been used.

Information on the energy state of the nucleus after reaction, or on energy
values of detected particles, or on any other energies except the incident-
projectile energy, is entered as follows:

1. Numerical values are entered in the COMMON or DATA section under
    appropriate Data-Heading Keywords (i.e., keywords from Dictionary 24 with
    an E in column 66), e.g. E or E-LVL.

    In the case of two or more unresolved energy levels the data heading may
    be repeated (see page 5.4.)

    If it is not evident to which reaction product the secondary energy
    refers, this must be specified under the keyword EN-SEC, see below.

    The secondary-energy uncertainty or resolution may be entered using a data
    heading from Dictionary 24 with the family code F, e.g., E-RSL, E-LVL-ERR.
    Further information can be given under the keyword ERR-ANALYS.

2. The BIB keyword EN-SEC may be used:

        -   to specify to which reaction product the secondary energy given in
            the COMMON or DATA section refers. (See page 8.EN-SEC).

        -   to give free text information about the secondary energy.

    This keyword must always be coded when the data headings E1, E2, etc., are
    used in the COMMON or DATA section.

    A secondary-energy data heading which is not defined under the keyword
    EN-SEC, always refers to the same particle to which the code DE (or SPC,
    etc) within the REACTION code refers.

3. Energy Correlation of Secondary Particles

    REACTION Coding: 'ECO' in SF6 (parameter)

    Example: (.....(G,N+P).....,,ECO) neutron-proton energy correlation

Secondary Linear Momentum   Secondary Linear Momentum

Information about the linear momentum of a secondary particle may be entered
as follows:

1. Numerical values are entered in the COMMON or DATA section using data
    headings from Dictionary 24 with the family code 'L', e.g., MOM-SEC.

2. The information-identifier keyword MOM-SEC may be used:

    - to specify to which of several particles the secondary linear momentum
       given in the COMMON or DATA section refers.
    - to give free text information about secondary linear momentum.

    The keyword is always coded when more than one secondary linear momentum
    is given in the COMMON or DATA section using the headings MOM-SEC1,
    MOM-SEC2, etc.

3. Linear Momentum Correlation of Secondary Particles

    REACTION Coding: 'MCO' in SF6 (parameter)

    Example: (.....(G,N+P).....,,MCO)   neutron-proton linear momentum
                                         correlation

Note: This was introduced for photonuclear data. For neutron data and CPND
this formalism has not yet been used.

Sequence of outgoing particles

1. Several outgoing particles

The nuclear reaction to be coded under the keyword REACTION usually specifies the endproducts without specifying the sequence of the outgoing particles. For the convenience of data retrievals, several outgoing particles are coded in the reaction parenthesis always sorted by ascending Z and A number (compare page 8.REACTION.3).

Sometimes, however, data are given for partial reactions where the sequence of outgoing particles is defined for example:

$$\text{total (n,np)} = \text{partial (n,np)} + \text{partial (n,pn)}$$
$$\quad\quad (1) \quad\quad\quad\quad (2) \quad\quad\quad\quad\quad (3)$$

The corresponding REACTION codes are:

REACTION

(1)   ----(N,N+P)--,,SIG
(2)   ----(N,N+P),SEQ,SIG
(3)   ----(N,P+N),SEQ,SIG

Note that the code SEQ should be given within the REACTION code only when it is a partial reaction. If the author states that the reaction proceeds totally in the sequence, e.g., (n,pn) without any contribution in the sequence (n,np), then the reaction shall be coded as (1) above; a comment stating that the reaction proceeds entirely in the sequence (n,pn) may be added in free text (if this occurs at all). Alternatively, both codes may be given in the form of a tautology:

REACTION   ((Z-S-A(N,N+P),,SIG)=(Z-S-A(N,P+N),SEQ,SIG))

2. Combination of process and particle codes

For the following partial reactions the specified sequence of process and particle codes is indicated by the code SEQ:

Excitation of excited level(s) which decay by fission:

(n,n'f) cross section: (N,N+F),SEQ,SIG
(n, f) cross section : (N,G+F),SEQ,SIG

Emission of a primary γ followed by unidentified decays:

(n,γx) cross section : (N,G+X),SEQ,SIG

This formalism can occur only for the process codes F and X.

See also pages 8.REACTION.3+4 for the coding rules in SF3 and SF4. Compare also under Partial Reactions.

Single-level Resonance-Parameters   (p. 1)   Single-Level Resonance-Parameters

Relates to neutron-induced reactions, but may be used for other reactions in analogy.

See also Average Resonance Parameters, Quantum Numbers, Multilevel Resonance Parameters.

Resonance cross sections as a function of energy may be described using a Breit-Wigner single-level formalism.

For s-wave scattering the formula is:

$$\sigma_{sc}(E) = 4\pi \, \lambda_o^2 \, g \, \left| \frac{\Gamma_n}{(E-E_o) + i \, \Gamma/2} + \frac{R'}{\lambda_o} \right|^2 + 4\pi \, R'^2 (1-g)$$

where: $4\pi \, R'^2 = \sigma_{pot}$

For reactions (capture, fission, etc.):

$$\sigma_r(E) = \pi \, \lambda_o^2 \, g \, \left(\frac{E_o}{E}\right)^{1/2} \frac{\Gamma_n \, \Gamma_r}{(E-E_o)^2 + (\Gamma/2)^2}$$

For further detail see:

    A.M. Lane and R.A. Thomas, Rev. Mod. Phys. 30, 257 (1958)
    Experimental Neutron Resonance Spectroscopy, J.A. Harvey, ed., Academic
    Press, 1970.

Definitions and codes for data to be compiled in EXFOR.
(See Dictionary 36 (REACTION) for a complete list of codes.)

1. Resonance Energy (Eo) is coded in EXFOR in one of two ways.

    a)   When the resonance energy is determined by the author, it is assigned
            a REACTION code and entered into the data table under the heading
            DATA.

            REACTION coding: (----(N,0),,EN)

    b)   When the resonance energy is not determined by the author, but is
            taken from other sources, it should be entered into the data table as
            an independent variable under the Data-Heading Keyword EN-RES. In
            this case, it should only be entered for those resonances for which
            the author has presented other resonance parameters.

Negative energy resonances, in many cases, will influence very low energy
cross sections. These bound levels should be coded with the negative
energy, as given.

2. **Resonance widths** are coded with the parameter code WID in SF6 in combination with the code for the reaction described.

    Examples:
    REACTION

    ----(N,TOT),,WID)   = total resonance width Γ for incident neutrons
    ----(N,EL),,WID)   = neutron width Γ_n
    ----(N,G),,WID)   = neutron capture width, Γ_γ, including all primary gamma decays not followed by a neutron or charged-particle emission.

    The units are that of energy, e.g., EV or MILLI-EV.

    Partial capture widths (coded as ...(N,G),PAR,WID) relate to specific gamma-energies (coded under heading E) or to specific level-energies of the resulting nucleus (coded under heading E-LVL-FIN).

3. **Reduced neutron widths** are defined as follows:

$$\Gamma_n^\ell = \frac{\Gamma_n}{\nu_\ell \sqrt{E_o / eV}}$$

where E_o is the resonance energy in eV.
     ν_ℓ is the penetration factor of the nucleus.

Or more specifically:

for s-wave resonances: ($\nu_o=1$):

$$\Gamma_n^o = \frac{\Gamma_n}{\sqrt{E_o / eV}} \tag{1}$$

for p-wave resonances:

$$\Gamma_n^1 = \frac{\Gamma_n}{\sqrt{E_o / eV}} \left(1+ \frac{1}{k_o^2 R^2}\right) \tag{2}$$

where k_o = wave number
       R = nuclear radius

REACTION coding: ----(N,EL),,WID/RED)

The angular momentum should be specified under the Data-Heading Keyword **MOMENTUM L**. Compare in Lexfor under <u>Quantum Numbers</u>.

The units are that of energy, e.g., eV or milli-eV.

Note: Some authors give the reduced neutron width (for s-wave neutrons) as:

$$\Gamma_n^{(o)} = \frac{\Gamma_n}{\sqrt{E_o}} \qquad (3)$$

which has the dimension of the square-root of an energy. (Compare: Hennies, 66PARIS Vol. 2, page 333). For consistency, only definition (1) with the dimension of an energy should be used in EXFOR, the numerical values of definitions (3), and (1) being anyway identical except for the dimensions.

4. Peak cross section is defined as cross section at peak of the resonance assuming the line shape in a Breit-Wigner formalism, corrected (where important) for instrumental and temperature effects. The peak cross section for s-wave neutrons can be expressed by:

total: $$\sigma_o = 4\pi\lambdabar_o^2 \, g \, \frac{\Gamma_n}{\Gamma}$$

partials: $$\sigma_{or} = \sigma_o \, \frac{\Gamma_r}{\Gamma}$$

These are coded with the code PCS in combination with the code for the reaction described.

Example: Total peak cross section

REACTION   (----(---,TOT),,PCS)

Note: Eta or Alpha at resonance are coded as:

(----(N,ABS),,ETA,,RES)
(----(N,ABS),,ALF,,RES)

5. **Resonance area** is defined:

for scattering:
$$A_{sc} = 2\pi^2 \lambda_o^2 \, g \, \frac{\Gamma_n^2}{\Gamma}$$

for other reactions:
$$A_r = 2\pi^2 \lambda_o^2 \, g \, \frac{\Gamma_n \Gamma_r}{\Gamma}$$

These are coded with the parameter code ARE in combination with the relevant reaction code.

Example: (----(---,EL),,ARE)   Scattering area

The units are cross section times energy, e.g., b*eV.

6. **Special representations** are coded as follows:

(----(---,F),,WID,,SO)	$\sigma_o \, \Gamma_f$
(----(---,TOT),,WID,,SQ/SO)	$\sigma_o \, \Gamma^2$
(----(---,EL),,WID,,G)	$g \, \Gamma_n$
(----(---,EL),,WID,,2G)	$2g \, \Gamma_n$
(----(---,EL,,WID,,AG)	$ag \, \Gamma_n$
(----(---,EL),,WID,,2AG)	$2ag \, \Gamma_n$

where a = isotopic abundance

See also **Average Resonance Parameters**.

7. The **statistical weight factor g** can be coded in two ways

- as additional information to other resonance-parameter data: it is then given under the data-column heading STAT-WG

- or as a REACTION by itself: it is then coded with the code SWG in REACTION SF6 as

    REACTION   (Z-S-A(N,0)Z,-S'-A',,SWG)

Definition: Spallation is a reaction induced by high-energy neutrons or charged particles, where several particles are ejected from the target nucleus by direct interaction, leaving behind a nucleus in an excited state, which then evaporates nucleons or clusters of nucleons. The excited nucleus may also undergo fission.

In the conglomerate process called spallation, a variety of individual spallation reactions occur in parallel, such that the spallation products may be a large number of neutrons, protons, alpha-particles, etc, plus a variety of different heavier products $Z_1-S_1-A_1$ to $Z_n-S_n-A_n$. Considering a specified product, it is usually not possible to decide from which reaction mechanism it results, e.g. spallation or fission.

Codes: An individual reaction out of the conglomerate spallation process is coded by specifiying the particles measured e.g.

    (1)   (Z-S-A(P,4N+3P+A)Z'-S'-A',,SIG)

The production cross-section for a nuclide Z'-S'-A', disregarding by which reaction mechanism (e.g. spallation, fission, etc), is coded in the standard way (compare Lexfor "Production Cross-Sections"):

    (2)   (Z-S-A(P,X)Z'-S'-A',,SIG)

If, by some theoretical consideration, part of the measured cross-section is assigned to spallation, this is coded

    (3)   (Z-S-A(P,X)Z'-S'-A'',SPL,SIG)

For spallation data, the "variable product nucleus" formalism can be used, when the data for a number of product nuclei are to be given in a single subentry (see page 8.REACTION.8). This formalism should preferably be used for product yield distributions but rather not for excitation functions for the production of specified product nuclei.

When the "variable product nucleus" formalism is used, the number of emitted nucleons may be coded as variable as well:

    (4)   (Z-S-A(P,XN+YP)ELEM/MASS,...)

The DATA table would then contain the column headings

        N-OUT   to specify the number of emitted neutron
        P-OUT   to specify the number of emitted protons
        ELEMENT
        MASS   to specify the product nucelus

Compare pages 8.REACTION.8 and 6.9.

(In a special case, see entry A0041.004, only the number of emitted neutrons appears as variable with a constant value of emitted protons, coded as ...(P,XN+4P)ELEM/MASS... This special case was not explicitly foreseen but there seems to be no reason against it.)

Spectrum Average   Spectrum Average

Cross-sections averaged over a broad incident-projectile energy spectrum may be entered into EXFOR using the proper modifier to REACTION SF8. The type of spectrum and its characteristic should be entered in free text under the Information-Identifier Keyword INC-SPECT.

Three neutron spectrum types are defined:

1. **Maxwellian Average**: Modifier MXW.

   Originally, this modifier was used for Maxwellian neutron spectra near 0.0253 eV only. Subsequently, the use of this modifier was extended to any Maxwellian spectrum including plasma spectra or the Maxwellian approximation of a fission neutron spectrum, though no detailed rules have been agreed.

   Note, that in CINDA the term MXW continues to be used for Maxwellians near 0.0253 eV only.

2. **Fission-Neutron Spectrum Average**: Modifier FIS. For details, see in LEXFOR under **Fission-Neutron Spectra Data**.

3. **Spectrum Average**: Modifier SPA. Used for all other spectra, e.g. reactor spectra. Care should be taken to compile only those data which would be of value to the user of EXFOR.

   A cross-section given for a thermal reactor spectrum must be coded with

   * SPA if the spectrum has a non-negligible epithermal part
   * MXW if the result has been corrected for the epithermal part of the spectrum, or if the epithermal part is negligible.

   In the Westcott formalism (see AECL-1101) a cross-section averaged over a thermal reactor spectrum is described as:

$$\langle \sigma \rangle = \sigma_o (g + rs) - (\text{coded with the modifier SPA})$$

where σ_o = cross-section at E_n = 0.0253 eV (2200 m/s)

g, s are factors depending on the shape of the $\sigma(E)$ curve considered

r is a measure of the proportion of epithermal neutrons in the spectrum with $r = 0$ for a Maxwellian spectrum

$g\,\sigma_o$ = Maxwellian average cross-section (coded with the modifier MXW)

Spectrum Average (page 2)

4. ## Coding of the incident-projectile energy

To ensure that spectrum averaged data are included in a data retrieval by
energy, a value is entered under one of the following data-heading
keywords.

    KT   - spectrum temperature
    EN-MEAN - mean energy
    EN-DUMMY - when neither KT nor EN-MEAN appears suitable

Note that for Maxwellian spectra EN-MEAN = 3/2 KT.

If no exact value is known, approximate values can be entered under the
column-heading EN-DUMMY, for example

    0.0253 eV for thermal Maxwellian and thermal reactor spectra
    1.5 MeV for fission-spectra
    4.5 MeV for alpha-Be neutron sources (using the quantity modifier SPA)

EN-DUMMY had been used frequently in old entries, but in new entries its
use should be minimized. It was not explicitly defined whether the
approximate value under EN-DUMMY should correspond to KT or EN-MEAN.

Entries exist in the EXFOR files where a MXW modifier (e.g. when occurring
in a REACTION ratio) must be interpreted as 0.0253 eV Maxwellian although
this energy was ot specified.

Standard and/or monitor information should be entered using the
Information-Identifier Keyword MONITOR; (see page 8.MONITOR for coding
rules. Only that standard data to which the data given are proportional,
should be coded. Other information should be entered under the keyword
ASSUMED (see Assumed Values).

Note: Data which are measured as consistency checks should not be coded
under MONITOR. They may be coded as a separate data table.

Standard information should always be given except when it is not
relevant, as for quantities which are usually obtained without a
standard, that is:

-   total cross section

-   nuclear quantities (see Nuclear Quantities)

-   ratios

-   relative data defined by modifiers such as REL, RS, RSL, RSD or
    similar ones

-   scattering radius, strength function, average level spacing

-   resonance parameters; however, for resonance areas, peak cross
    sections and similar quantities, either the standard should be given
    or a cross-reference to the data from which the resonance parameters
    were deduced.

For all other quantities which ban be measured either with a standard or
"absolute", the positive statement in free text that the data were
measured "absolute" is pertinent information and, therefore, should be
included. It should be noted, however, that so-called "absolute" data
often depend on the assumption of certain numerical values (e.g., for
calibrations or corrections); it is desirable to give such values in free
text or under the Keyword ASSUMED. The compiler should restrict the use
of the term "absolute" to those cases in which it is sure that there are
no "hidden" standards.

For complicated descriptions of standards or normalization procedures, a
cross-reference to published literature may be sufficient.

The reference pertinent to the standard(s) used is coded using the
Information-Identifier Keyword MONIT-REF (see page 8.MONIT-REF).

Decay data for the standard(s) used is coded using the
Information-Identifier Keyword DECAY-MON (see page 8.DECAY-MON).

Entry of standard values into DATA or COMMON

1. If standard values are given at several energies, these values are given in the data table as an additional column under the data heading MONIT.

2. If the standard value is given at one energy only (resp. at one angle), there are two possibilities:

   a) the standard is entered as in case 1. above; the field headed by MONIT is blank for all but one line.

   b) the standard is entered in the COMMON section under the data heading MONIT. The incident energy, secondary energy, and/or angle at which the normalization was done are entered under the data headings EN-NRM, E-NRM, ANG-NRM, respectively. These are omitted if the data table includes only one data point for which the independent variables are the same as those for the normalization value.

Note: Every data line must have a dependent variable entry, therefore, standards may not be entered on a separate line in the data table.

3. If the originally measured ratio (data/standard) is also given in addition to the normalized data, the Multiple Reaction Formalism should be used.

4. If the data are normalized at two or more energies in an unspecified way, this should be noted in free text in an appropriate place.

5. If two or more standard reactions are given for the same data set, see EXFOR page 8.MONITOR.

List of commonly accepted standards for neutron data:

1-H-1(N,EL)1-H-1	SIG and DA	1 keV to 20 MeV
2-HE-3(N,P)1-H-3	SIG	above 50 keV
3-LI-6(N,T)2-HE-4	SIG	above 100 keV
5-B-10(N,A)3-LI-7	SIG to gnd and 1st exc.st.	above 100 keV
6-C-12(N,EL)6-C-12	SIG and DA	above 2 MeV
25-MN-55(N,G)25-MN-56	SIG	thermal
27-CO-59(N,G)27-CO-60	SIG	thermal
79-AU-197(N,G)79-AU-198	SIG	thermal, 200 - 3500 keV
92-U-235(N,F)	SIG	100 keV - 20 MeV
98-CF-252(O,F)	NU and DE,N	

Compare also under Dosimetry Reactions some of which are considered also as standards.

Various groups of information are combined under the BIB-Keyword STATUS.
See page 8.STATUS for coding rules and Dictionary 16 for a complete list
of codes and their use. Some general items should be borne in mind:

1. Preliminary - Superseded - Final Data. If the STATUS codes PRELIM
    and SPSDD are absent, the data are understood to be final.   .

    The frequent case in which a preliminary data set is replaced by its
    final version can be solved in two ways:

    a.) the final set replaces the preliminary set under the same
         sub-accession number so that the preliminary set is deleted from
         the file.

    b.) the final set is entered under a new sub-accession number
         (preferrably in the same entry). The earlier set is labeled as
         superseded with a cross-reference to the data set which
         supersedes it. If the earlier set has the status code PRELM, it
         is removed. Therefore, the codes PRELM and SPSDD exclude each
         other.

         Example: STATUS   (SPSDD,10048009)

         The superseding subentry should have a free text cross-reference
         to the superseded subentry.

         This way is preferred to case a.) if the earlier set has already
         been published.

    The code SPSDD can also be used in the case where a data set was
    withdrawn by the author without replacement. Explanation is required
    in free text.

2. Dependent Data - see Dependent Data and Data Type.

3. Author Approval. After the proof copy of a data set has been
    approved by the author, the code APRVD is entered under STATUS. The
    absence of the code APRVD means that no reply on the proof copy has
    yet been received from the author.

4. Source of the data. The actual source from which the numerical values given in the data set were taken must be entered in free text under STATUS. (In some entries this information is found under HISTORY.)

   When the author's original numerical values have been lost or .are not obtainable, the data read from graphs, if available, should be entered into EXFOR for completeness. Data of this type should be labeled with the status code CURVE.

5. Normalization. If the codes OUTDT and RNORM are absent, the data are compiled as resulting from the author's corrections and normalizations.

   Only in exceptional cases should renormalizations or reassessments of the data as given by an evaluator be compiled. However, some "renormalizations" are not trivial multiplication by a factor, for instance, if a detector-efficiency curve or the geometry of the experiment is involved. For such cases, see under Corrections.

   A data set which is renormalized by an evaluator is labeled with the status code RNORM. The older data set which is superseded by the later renormalization or reassessment is labeled with the status code OUTDT. Both must give a cross reference to the other data set as follows:

   STATUS   (OUTDT,10231002)

   STATUS   (RNORM,10231003)

   Renormalization should not be done by the compiler except on the advice of the author.

6. Data translated from the older libraries SCISRS-I or NEUDADA are labeled with the STATUS code SCISRS to indicate that some of the normally required information (under STATUS or another BIB keyword) may be missing.

7. Unobtainable Data – see NODATA.

8. Correlated Data – see Interdependent Data and COVARIANCE.

1. Sums of 2 or more reactions can be expressed as a REACTION
   combination using the separator '+' (see page 8.REACTION.11).

   Examples:

   a.) REACTION   ((28-NI-58(N,N+P)27-CO-57,,SIG)+   .
                   (28-NI-58(N,D)27-CO-57,, SIG))

   b.) REACTION   ((28-NI-58(N,P)27-CO-58,,SIG)+
                   (28-NI-60(N,T)27-CO-58,,SIG))

   To indicate that the sum is weighted by isotopic abundances, the
   latter example should rather be coded as:

       REACTION   ((28-NI-58(N,P)27-CO-58,,SIG,,A)+
                   (28-NI-60(N,T)27-CO-58,,SIG,,A))

2. Sum reactions such as absorption or nuclide production, where the
   individual competing reactions may not be known, cannot be coded
   using the form above.

3. Sums of reactions to isomeric states are coded using the separator
   '+' in the isomer field of the reaction product, see Isomeric States.

4. Data-Heading Keyword SUM

   The Data-Heading Keyword SUM may be used instead of the keyword DATA
   with, and only with, sums expressed as reaction combinations, see
   Section 1, above, or, sums of reactions to isomeric states, see
   Section 3. The heading DATA may be used as well instead of SUM. Any
   implicit sums, such as a total cross section deduced from partial
   cross sections, are, always coded with the data heading DATA.

For the coding of the target nucleus see page 8.REACTION.2.

The target nucleus to be coded is the one to which the data refer; this is not necessarily the same as the actual material which was irradiated in the experiment.

If an isotopic mixture or a chemical compound was used as the experimental target, the data may nevertheless be given for one isotope, and that isotope should be coded.

If a reaction can occur, by energetic reasons, for only one of the isotopes in the irradiated target, preferrably that isotope should be coded as the target nucleus.

In these cases, compilers must take care that, if corrections for isotopic abundance have not been applied, one of the following modifiers is given with the quantity code:

    A   − for a natural isotopic mixture

    (A) − for a natural isotopic mixture, where it is not clear whether the data were corrected for abundance

    FCT − for an enriched target. (In this case free text explanation is necessary).

In these cases the target description must be entered under the keyword SAMPLE.

For elemental targets, see also Elements.

A list of valid codes for target nuclei are given in Dictionary 27 by col. 13 flags (see page 7.15).

For chemical compounds as target, see also Compounds, chemical.

Tautologies can be expressed as a reaction combination using the separator '='
(see coding rules page 8.REACTION.11). Its use is optional, i.e., at the
descretion of the compiler.

It may be used when a data set can be equally well described by two or more
reactions which are identical in the energy range considered. If it is used,
the sequence of the reactions should be such that the one with the .narrowest
definition (as outlined below) is given first.

Two types of tautologies are considered:

1. Below thresholds.

    Example: Total scattering equals elastic scattering below the inelastic
              threshold.

2. Emission cross sections, for certain secondary energies.

    Example: Gamma emission cross-section equals inelastic gamma
              cross-section for some gamma energies.

For such cases the narrower definition should be coded first.

The broader definitions should, in general, only be used when two or more
competing reactions are present. This rule seems to avoid any real cases of a
tautology. In the case where the author uses the broader definition to define
the reaction, the EXFOR compiler should not hesitate to use the narrower
definition if this is required by above EXFOR rules. The tautology formalism
shoud not be used in the following cases:

1. When a data set extends beyond a known threshold, the broader definition,
    and only the broader difnition, should always be used. See also
    Thresholds.

2. In the case where a compiler has doubts about which quantity is actually
    given in a data set, the compiler must decide in favor of one of the
    possible codes and check back with the author (if possible).

3. In old papers obsolete designations like "inelastic collision
    cross-section" for nonelastic or "absorption" for (n,gamma) may have been
    used. In these cases the presently valid definition must be used. The
    author's designation may be given in free text.

Thermal Neutron Scattering

Theory: The scattering of slow neutrons (energies less than 0.1 eV), with matter depends on the atomic structure of the material (because the wavelength of slow neutrons is of the order of inter-atomic distances) and on the atomic dynamics in the scattering medium (because the energy of slow neutrons is of the same order as the chemical bonding energy and the energy of thermal motion of atoms in crystals and solids). At these energies, two types of scattering must be considered; nuclear scattering and magnetic scattering due to the interaction between the magnetic moment of the neutron and the magnetic moment of the electrons of the target.

Coding: For all scattering processes where molecular and crystalline forces are involved the code THS should be used in REACTION SF3.

The sample temperature should be given under the data heading TEMP.

The crystal structure of the sample should be given under the Information-Identifier Keyword SAMPLE.

The following special processes are defined:

1. Free-Atom Scattering. Scattering by a free nucleus, originally at rest.

    REACTION coding: FA in SF5 (Branch)

2. Bound-Atom Scattering. Scattering by a nucleus bound in a crystal lattice.

    REACTION coding: BA in SF5 (Branch)

3. Coherent Scattering. Collective scattering by a regular arrangement of scattering centers with common physical properties which will ensure a constant phase relationship between waves scattered by different centers. That is, a single wave is produced with a resultant amplitude due to scattering by a set of particles as a whole.

    REACTION coding: COH in SF5 (Branch)

4. Incoherent Scattering. Scattering by a non-regular arrangement of scattering centers which will lead to random phase differences by the scattered waves. That is, the incoherent scattering cross section is the sum of the cross section for the individual centers.

Isotopic Incoherence: due to a random distribution of different isotopes in the scattering target. If there is only one isotope in the target, there will be no isotopic incoherence.

Spin Incoherence: due to orientation of the neutron and nuclear spins. Spin incoherence may be eliminated by using polarized neutrons and polarized targets.

REACTION coding: INC in SF5 (Branch)

See also Scattering, Scattering Amplitude

Literature

I. I. Gurevich and L. V. Tarasov, "Low-Energy Neutron Physics", North Holland Publishing Co., Amsterdam, 1968

W. Marshall and S. W. Lovesey, "Theory of Thermal Neutron Scattering", Oxford University Press, London, 1971

A data set may extend beyond a threshold. For example, a data table resulting from a neutron-detecting experiment may actually give in a single data set:

1. elastic scattering below the inelastic threshold energy, and total scattering above the inelastic threshold energy;

2. total scattering below the (n,2n) threshold energy, and neutron production above the (n,2n) threshold energy.

In these cases the wider definition should be used, that is: In the first case, the table should be entered under "total scattering"; in the second case under "neutron production".

The compiler is not allowed to split the data set in two parts below and above the threshold.

When retrieving, for example, for elastic scattering data, one should realize that it may also be worthwhile to retrieve on total scattering, with En above threshold energy.

If, however, in the case 1., above, the data table has been corrected for inelastic neutrons, or if the portion of inelastic neutrons measured is negligeable, the data set may well be coded under "elastic scattering".

See also Tautologies.

1. Total cross-section:

Definition: the sum of all energetically possible interactions.

REACTION Coding: TOT in SF3

Examples: ---(N,TOT),,SIG = total cross section
            ---(N,TOT),,WID = total resonance width

Sum-rules: Total = elastic plus nonelastic
                    = scattering plus absorption

Note: For thermal neutrons, where a large portion of the total cross-section may be due to crystal effects (thermal scattering), the sample structure should be given under the keyword SAMPLE, if provided by the author.

2. Total as distinct from partial: no code is given under REACTION for "total", except when it refers to the total cross section, see above. Instead, codes are given in the branch field for "partial" reactions.

Examples: (N,F),,NU   = total nu-bar
          (N,F),PR,NU   = prompt nu-bar
          (N,INL),,SIG   = total inelastic scattering cross-section
          (N,INL),PAR,SIG   = partial inelastic scattering
                                  cross-section
          (N,G)Z-S-A-M1,,SIG   = Partial capture cross-section leading
                                  to a mtastable state
          (N,G)Z-S-A,,SIG   = total (n,gamma) cross-section
          Only in the case of an isomeric ratio, "total" may have to be
          coded as follows:
          (N,G)Z-S-A-M1/T,,SIG/RAT   = isomeric ratio of the two
                                       cross-sections given above

Units

A datum or value is always a combination of a number and a unit. For example, 500 mb and .5 b is the same value. mb and b are units of the same dimension or units group. Units of the same dimension can be converted into each other by multiplication with a numerical (dimensionless) factor.

Example: Angstrom and cm are units of the same dimension.

A quantity can have only one dimension;

  that is: a quantity (reaction) code can be combined with only one group of units.

     or: data with different dimensions cannot have the same quantity code.

In Dictionary 36 (REACTION), each quantity code is followed by a code indicating the dimension of the quantity. For example, 'E' means energy units (milli-eV, eV, keV, Mev, etc.), 'NO' means dimensionless (i.e., unit 'one').

The same dimension codes are also given in Dictionary 25 (Units), so that it is possible to check by computer whether a given quantity code is combined with a unit code which has the correct dimension. For example, the REACTION quantity code 'SIG' has the dimension 'B' and can only be given in units B, MB, etc., also having the dimension code 'B'.

In Dictionary 25, a conversion factor is given for each unit code, which allows computerized conversion between different units of the same dimension.

See EXFOR, Chapter 5 for use of unit codes.

Special cases:

1. An angle given in degrees and minutes must be entered in two separate fields with the data heading 'ANG' repeated (see page 5.4).

2. If data are given in arbitrary units (ARB-UNITS), the quantity code is marked as "relative" by entering the modifier 'REL' in REACTION SF8. See Relative.

3. Errors must have the same dimension (not necessarily the same units) as the quantity to which they refer or percent.

4. The unit PER-CENT may only be used for errors and must not be used under the Data-Heading Keywords DATA, RATIO, SUM, etc. If data were given using 'PER-CENT', the meaning of 'PER-CENT' in the error field would be ambiguous. Data given by the author in percent should be converted to NO-DIM by dividing the results by 100. If the DATA (or RATIO, SUM) error is given in percent, this always means a percentage of the relevant DATA (resp. RATIO, SUM).

5. The unit SEE TEXT may be used in a MISC data field when no code from Dictionary 25 applies. It is explained in free text under MISC-COL. It must not be used with any other data heading.

   See Miscellaneous

Note: The compiler should avoid any carelessness in the use of units. This would jeopardize any automatic data processing. It is forbidden to set the light velocity c = 1 or Planck's constant h = 1 as is usually done in high-energy physics.

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The wave-length λ of an incident neutron corresponds to the neutron-energy E:

$$E/meV = \frac{81.8}{(\lambda/\text{Å})^2}$$

λ	ε
1 Å	81.8 meV
1.8 Å	25.3 meV
2 Å	20.5 meV
4 Å	5.1 meV
6 Å	2.3 meV
10 Å	0.8 meV

The wave-length of the incident neutron is entered under the data-heading keyword EN with units ANGSTRØM.

Note: If for whatever reason, the compiler converts the wave-length to neutron energy, this should be noted in the BIB-section.