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
Note:

The IAEA-NDS-reports should not be considered as formal publications. When a nuclear data library is sent out by the IAEA Nuclear Data Section, it will be accompanied by an IAEA-NDS-report which should give the data user all necessary documentation on contents, format and origin of the data library.

IAEA-NDS-reports are updated whenever there is additional information of relevance to the users of the data library.

For citations care should be taken that credit is given to the author of the data library and/or to the data center which issued the data library. The editor of the IAEA-NDS-report is usually not the author of the data library.

Neither the originator of the data libraries nor the IAEA assume any liability for their correctness or for any damages resulting from their use.

96/11

Citation guideline:

See pages 1.15 and 1.16.
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)

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


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
NDS EXFOR MANUAL

CONTENTS

PROTOCOL: Cooperation of Neutron Data Centers

Part One: EXFOR Systems Manual - For Programmers and Compilers

1. Introduction
2. Record Identification and Alter Flags
3. System Identifier Keywords
4. BIB Section
5. COMMON-Section and DATA-Section
6. Links between BIB, COMMON and DATA Sections
7. Dictionaries
8. BIB-Keywords and Coding Rules
9. Communications, Updating and Alterations

Part Two: LEXFOR - For Compilers

Introduction

Lexicon: Subject-headings in alphabetical order

NDS X4 85/3
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.

NDS X4 79/10
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 Karlsruhe (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).

NDS X4 79/10
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.

NDS X4 79/10
Chapter 1

INTRODUCTION TO EXFOR

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1.1</td>
</tr>
<tr>
<td>General structure</td>
<td>1.2</td>
</tr>
<tr>
<td>Summary of transmission tape format</td>
<td>1.3</td>
</tr>
<tr>
<td>Definition of a subentry</td>
<td>1.4</td>
</tr>
<tr>
<td>Permitted character set</td>
<td>1.5</td>
</tr>
<tr>
<td>Short guide to EXFOR</td>
<td>1.7</td>
</tr>
</tbody>
</table>
1.1

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.

NDS X4 83/9
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:

![Diagram of tape structure]

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:

![Diagram of set and sub-set structure]

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.
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 \( (92-U-235(N,P),,SIG) = \sigma_{n,f} \) for \( ^{235}U \)

REACTION \( (28-NI-60(P,N)29-CU-60,,DA = \frac{d\sigma}{d\theta} (\theta) \) 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 refer 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

FIRST SUBENTRY 30282.001

INFORMATION COMMON TO THE ENTIRE ENTRY

**TABLE**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Activity Cross-Sections of Pt-195 With Fast Neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KEYWORDS**

- **STANDARD**
- **PMTS.A**
- **COOES**
- **ISD-Ouant**
- **HALP-LIPE**
- **I-T.**
- **N-CNT**
- **CONNO**
- **ISO-Ouant**
- **P**
- **M**
- **N**
- **H**

**CODES**

- **CM**
- **CO**
- **PE**
- **PT**
- **EM**

**SECOND SUBENTRY 30282.002**

**CONSTANT PARAMETERS**

- **Q**
- **S**
- **L**
- **A**

**DATA TABLE**

<table>
<thead>
<tr>
<th>Data Defined Above ISO-Ouant</th>
<th>SUBENTRY 30282.002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td></td>
</tr>
</tbody>
</table>

**THIRD SUBENTRY 30282.003**

**CONSTANT PARAMETERS**

- **O**
- **I**

**DATA TABLE**

<table>
<thead>
<tr>
<th>Data Defined Above ISO-Ouant</th>
<th>SUBENTRY 30282.003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td></td>
</tr>
</tbody>
</table>

---

NUCLEAR DATA SECTION, INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, ACCESSION NUMBER: EXFOR_30282
**EDITED** LISTING

**STANDARD** LISTING

BIBLIOGRAPHY, EXPERIMENTAL DESCRIPTION, EXPLANATIONS

ISO-QUANT

- RESONANCE ENERGY
- NEUTRON- WIDTH
- SPIN

ANALYSIS

- MATRIX MULTI-LEVEL ANALYSIS

CONSTANT PARAMETERS

MOMENTUM L = 1

DATA TABLE DATA DEFINED ABOVE UNDER ISO-QUANT

<table>
<thead>
<tr>
<th>KEY</th>
<th>KEY</th>
<th>KEY</th>
<th>NO-20</th>
<th>NO-00</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26.65</td>
<td>0.325</td>
<td>0.020</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>48.75</td>
<td>1.67</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>67.65</td>
<td>4.5</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

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

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.
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.

Example 2

EDITED LISTING

STANDARD LISTING
1.13

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.


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:
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 ENDEX ENTRY 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:


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 up-to-date 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.

NDS X4 96/11
1. **EXFOR Summary descriptions:**


2. **EXFOR online services**


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:**


4. **The EXFOR data centers network**


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


Chapter 2

RECORD IDENTIFICATION

Record Identification - General 2.1
Originating center identification 2.2
Accession number 2.3
Sub-accession number 2.4
Sequential record numbering 2.5
Alter flag 2.6
Record identification summary 2.8
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:

<table>
<thead>
<tr>
<th>Column(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>originating centre identification )</td>
</tr>
<tr>
<td>68-71</td>
<td>centre assigned accession number )</td>
</tr>
<tr>
<td>72-74</td>
<td>centre assigned sub-accession number = subentry number</td>
</tr>
<tr>
<td>75-79</td>
<td>sequential record numbering within a sub-accession number (subentry)</td>
</tr>
<tr>
<td>80</td>
<td>alter flag</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Preliminary: may be assigned by data producers when transmitting information to the centre in the exchange format, or by centres for their internal use.</td>
</tr>
<tr>
<td>1</td>
<td>NNDC (Brookhaven)</td>
</tr>
<tr>
<td>2</td>
<td>NEA-DB (Saclay)</td>
</tr>
<tr>
<td>3</td>
<td>NDS (Vienna)</td>
</tr>
<tr>
<td>4</td>
<td>CJD (Obninsk)</td>
</tr>
<tr>
<td>5</td>
<td>data from area 1 converted by NNDC from the SCISRS-1 NND</td>
</tr>
<tr>
<td>6</td>
<td>data from area 2 Library to Exfor format; not part of the normal NND Exfor transmission; series 5, 6 and 7 were meanwhile deleted and converted into series 1, 2 and 3, series 8 still exists</td>
</tr>
<tr>
<td>7</td>
<td>data from area 3</td>
</tr>
<tr>
<td>8</td>
<td>data from area 4</td>
</tr>
<tr>
<td>9</td>
<td>special use for transmission of Dictionaries, see page 7.1</td>
</tr>
</tbody>
</table>

#### 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 normal NND Exfor transmission; series 5, 6 and 7 were meanwhile deleted and converted into series 1, 2 and 3, series 8 still exists
- 7 data from area 3
- 8 data from area 4

#### 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
2.3

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 subaccession 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.
- **X** 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.
2.7

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 count changed) 999999C
...
ENDENTRY record 99999

NDS X4 85/8
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).

<table>
<thead>
<tr>
<th>Universal accession number (Entry number)</th>
<th>Originating center identification</th>
<th>Center-assigned access-number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Center-assigned sub-accession number</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sequential numbering within subentry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alter flag</td>
</tr>
</tbody>
</table>

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 throughout 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

<table>
<thead>
<tr>
<th>System Identifiers - General</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANS, ENDTTRANS</td>
<td>3.1</td>
</tr>
<tr>
<td>(NDS internal: UPDAT, ENDUPDAT)</td>
<td>3.3</td>
</tr>
<tr>
<td>ENTRY, ENDENTRY</td>
<td>3.4</td>
</tr>
<tr>
<td>SUBENT, ENDSUBENT, NOSUBENT</td>
<td>3.5</td>
</tr>
<tr>
<td>BIB, ENDBIB, NOBIB</td>
<td>3.6</td>
</tr>
<tr>
<td>COMMON, ENDCOMMON, NOCOMMON</td>
<td>3.7</td>
</tr>
<tr>
<td>DATA, ENDDATA, NODATA</td>
<td>3.8</td>
</tr>
<tr>
<td>Summary of system identifier records</td>
<td>3.9</td>
</tr>
<tr>
<td>Legal system identifier sequence</td>
<td>3.10</td>
</tr>
</tbody>
</table>

NDS X4 79/6  
September 1978
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.
3.2

[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:

- **N1** - 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

- **N2** - A six-digit number containing the data (year, month, and day) on which the transmission tape was generated. The format should be YYMMDD.

- **N4 - N5** - Exfor tapes transmitted by NDS contain in this field the information 'EXFOR - IAEA NUCL.DATAG'

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) ENDTTRAN

This record must be the last one on the transmission tape.

**N1** is interpreted as:

- **N1** - 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 ENDTTRAN 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 ENDTTRAN record.

(3) DICTION

for EXFOR Dictionary Transmissions see page 7.1
NDS internal page:

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 retransmitted EXFOR subentries, UPDAT tapes include the entire revised entry.

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)

N₁ - the UPDAT tape number, starting with 3001, then sequentially numbered right adjusted

N₂ - the date (yymmdd) the tape was retrieved, right adjusted

N₃ - 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 N₃ and N₂.

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'

N₁ - 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.

NDS X4 84/2
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).

\( N_4 \) - 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).

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 N\( \&\)SUBENT records are included in a work, then they should be counted as sub-works when computing \( N_1 \).

(8) (cancelled)
3.6

(9) SUBENT N₁ N₂
-------------------
This record must be the first one of each subentry. N₁ and N₂ are interpreted as:

N₁ - An eight digit universal sub-accession number (originating centre identification, centre assigned accession and sub-accession number).

N₂ - Date of last alter (or date of entry if never altered) (year, month, date).

N₃ - 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.

N₄ - N₅ - 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 N₁ N₂
----------------------
This record must be the last one of each subentry. N₁ and N₂ are interpreted as:

N₁ - The number of records within the subentry. (Excluding the SUBENT and ENDSUBENT records. - HDL)

N₂ - 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 N₁ N₂
---------------------
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.

N₁ and N₂ are interpreted as:

N₁ - An eight-digit universal sub-accession number (originating centre identification, centre assigned accession and sub-accession number).

N₂ - 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.

NDS X4 83/6
(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:

\[\begin{align*}
N_1 & \quad \text{Number of keywords in the BIB section (not counting pointers in column 11, see page 6.1)} \\
N_2 & \quad \text{Number of records in the BIB section (not counting the BIB and ENDBIB records)}
\end{align*}\]

(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:

\[\begin{align*}
N_1 & \quad \text{Number of records in BIB section (same as } N_2 \text{ in the BIB record)} \\
N_2 & \quad \text{Presently unused (may be blank or zero)}
\end{align*}\]

(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.
3.8

(15) COMMON

This record must be the first one of each Common Section if one is present. N₁ and N₂ are interpreted as:

N₁ - Number of values given in the COMMON Section.

N₂ - 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. N₁ and N₂ are interpreted as:

N₁ - Number of records in the Common Section (same as N₂ in the COMMON record).

N₂ - Not used (may be zero or blank).

(17) NOCOMMON

Positive indication that there is no Common Section associated with the sub-entry. N₁ and N₂ 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.

NDS X4 83/9
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; ENDEXTR - 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

   CXXX - tape identification
   YYMMDD - date tape was generated
   \( N \) - number of works on the tape

NDS X4 83/9
3.11

(2) Entries will be:

(a) Headed by ENTRY CXXXX YYMMDD
(b) Ended by ENDTRANS N1

CXXXX - universal accession number
YYMMDD - date work was last altered
N1 - 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 N1 YYMMDD ) or NOSUBENT N1 YYMMDD
(b) Ended by ENDSUBENT N2 )

N1 - sub-accession number
YYMMDD - date sub-work was last altered
N2 - number of records in the sub-work (excluding the SUBENT and ENDSUBENT records)

(4) Each subentry but the first must 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 N2 ) or NOBIB
(b) Ended by ENDBIB N1 )

K - number of keywords in the BIB-section
N1=N2 - number of records in the BIB-section
(excluding the BIB and ENDBIB records)

COMMON section:
(a) Headed by COMMON M N2 ) or COMMON
(b) Ended by ENDCOMMON N1 )

M - number of pieces of common data
N1=N2 - 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 N1 )

C - number of columns (fields) in the table
L - number of lines (rows) in the table
N1 - number of records in the data table section (including column headings and units, but excluding the DATA and ENDDATA records)

The DATA (or NODATA) section may never appear in the first (all common) subentry (subentry 001).
3.12

The transmission tape then has the following form:

```
TRANS
   |
   |
ENTRY
   |
   |
ENDTRANS
   |
   |
ENDENTRY
```

```
SUBENT
   |
   |
BIB
   |
   |
ENDBIB
   |
   |
COMMON
   |
   |
ENDCOMMON
   |
   |
DATA
   |
   |
ENDDATA
   |
   |
ENDSUBENT
```

or

```
NOBIB
```

or

```
IMCCGMN
```

or

```
CONDATA |
```

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).

<table>
<thead>
<tr>
<th>SYSTEM IDENTIFIER</th>
<th>LEGAL FOLLOWING RECORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANS</td>
<td>ENTRY</td>
</tr>
<tr>
<td>ENDTTRANS</td>
<td>(no information follows ENDTTRANS)</td>
</tr>
<tr>
<td>ENTRY</td>
<td>SUBENT, NOSUBENT</td>
</tr>
<tr>
<td>ENDTENTRY</td>
<td>ENTRY, ENDTTRANS</td>
</tr>
<tr>
<td>SUBENT</td>
<td>BIB, NOBIB</td>
</tr>
<tr>
<td>ENDSUBENT</td>
<td>SUBENT, ENDTENTRY, NOSUBENT</td>
</tr>
<tr>
<td>NOSUBENT</td>
<td>SUBENT, ENDTENTRY, NOSUBENT</td>
</tr>
<tr>
<td>BIB</td>
<td>(a record starting with an information identifying keyword)</td>
</tr>
<tr>
<td>ENDBIB</td>
<td>COMMON, NOCOMMON</td>
</tr>
<tr>
<td>NOBIB</td>
<td>COMMON, NOCOMMON</td>
</tr>
<tr>
<td>COMMON</td>
<td>(a column heading record)</td>
</tr>
<tr>
<td>ENDCOMMON</td>
<td>in subentry 001: ENDSUBENT</td>
</tr>
<tr>
<td></td>
<td>in other subentry: DATA, NODATA</td>
</tr>
<tr>
<td>NOCOMMON</td>
<td>in subentry 001: ENDSUBENT</td>
</tr>
<tr>
<td></td>
<td>in other subentry: DATA, NODATA</td>
</tr>
<tr>
<td>DATA</td>
<td>(a column heading record)</td>
</tr>
<tr>
<td>ENDDATA</td>
<td>ENDSUBENT</td>
</tr>
<tr>
<td>NODATA</td>
<td>ENDSUBENT</td>
</tr>
</tbody>
</table>

NDS X4 83/9
<table>
<thead>
<tr>
<th>SYSTEM IDENTIFIER</th>
<th>LEGAL PRECEDING RECORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANS</td>
<td>(no information precedes TRANS)</td>
</tr>
<tr>
<td>ENDTRANS</td>
<td>ENDENTRY</td>
</tr>
<tr>
<td>ENTRY</td>
<td>ENDENTRY, TRANS</td>
</tr>
<tr>
<td>ENDENTRY</td>
<td>ENDSUBENT, NOSUBENT</td>
</tr>
<tr>
<td>SUBENT</td>
<td>ENTRY, ENDSUBENT, NOSUBENT</td>
</tr>
<tr>
<td>ENDSUBENT</td>
<td>in subentry 001: ENDCOMMON, NOCOMMON</td>
</tr>
<tr>
<td></td>
<td>in other subentry: ENDDATA, NODATA</td>
</tr>
<tr>
<td>NOSUBENT</td>
<td>ENTRY, ENDSUBENT, NOSUBENT</td>
</tr>
<tr>
<td>BIB</td>
<td>SUBENT</td>
</tr>
<tr>
<td>ENDBIB</td>
<td>(a text record)</td>
</tr>
<tr>
<td>NOBIB</td>
<td>SUBENT</td>
</tr>
<tr>
<td>COMMON</td>
<td>ENDBIB, NOBIB</td>
</tr>
<tr>
<td>ENDCOMMON</td>
<td>(a numerical record)</td>
</tr>
<tr>
<td>NOCOMMON</td>
<td>ENDBIB, NOBIB</td>
</tr>
<tr>
<td>DATA</td>
<td>ENDCOMMON, NOCOMMON</td>
</tr>
<tr>
<td>ENDDATA</td>
<td>(a numerical record)</td>
</tr>
<tr>
<td>NODATA</td>
<td>ENDCOMMON, NOCOMMON</td>
</tr>
</tbody>
</table>

NDS X4 83/9
## Chapter 4
### BIB SECTION

<table>
<thead>
<tr>
<th>BIB Section - General</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyword (Information Identifier)</td>
<td>4.2</td>
</tr>
<tr>
<td>Machine retrievable information (codes)</td>
<td>4.2</td>
</tr>
<tr>
<td>Free text</td>
<td>4.2</td>
</tr>
<tr>
<td>Codes and free text</td>
<td>4.3</td>
</tr>
<tr>
<td>Example</td>
<td>4.4</td>
</tr>
</tbody>
</table>
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 keyword 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.
4.3

(4) Codes and free text

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

   either by a point immediately following the closing parenthesis

   or 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 not
   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
NOCOMMON ENDSUBENT SUBENT 00001002
BIB 2 13
REACTION 1(92-U-235,(N,EL),,WID) THIS IS AN EXAMPLE OF MULTIPLE REACTIONS WITH POINTERS
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 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
NOCOMMON
ENDSUBENT
ENDENTRY
```

For pointers see page 6.1

NDS X4 84/11
### Chapter 5

**COMMON-Section and DATA-Section**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure of COMMON and DATA Sections</td>
<td>5.1</td>
</tr>
<tr>
<td>Numerical data formats</td>
<td>5.3</td>
</tr>
<tr>
<td>Repetition of column-headings</td>
<td>5.4</td>
</tr>
<tr>
<td>Column sequence in a DATA table</td>
<td>5.6</td>
</tr>
<tr>
<td>Line sequence in a DATA table</td>
<td>5.7</td>
</tr>
<tr>
<td>1. One-dimensional tables</td>
<td></td>
</tr>
<tr>
<td>2. Multi-dimensional tables</td>
<td></td>
</tr>
<tr>
<td>Blank fields in a DATA table</td>
<td>5.8</td>
</tr>
</tbody>
</table>

NDS X4 83/9
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 example of a COMMON section is shown below with its associated COMMON and ENDCOMMON records.

<table>
<thead>
<tr>
<th>COMMON</th>
<th>1</th>
<th>12</th>
<th>23</th>
<th>34</th>
<th>45</th>
<th>56</th>
<th>66</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEV</td>
<td>2.73</td>
<td>0.16</td>
<td>1.38</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENCOMNON</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An example of a COMMON section with more than 6 columns

<table>
<thead>
<tr>
<th>COMMON</th>
<th>1</th>
<th>12</th>
<th>23</th>
<th>34</th>
<th>45</th>
<th>56</th>
<th>66</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN</td>
<td>7</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EN-ERR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEV</td>
<td>4.1</td>
<td>0.05</td>
<td>0.1</td>
<td>3.124</td>
<td>3.175</td>
<td>90.</td>
<td></td>
</tr>
<tr>
<td>ADEG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENDCOMNON</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>DATA</th>
<th>1</th>
<th>12</th>
<th>23</th>
<th>34</th>
<th>45</th>
<th>56</th>
<th>66</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANG</td>
<td>4</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANG-ERR</td>
<td>ANG-ERR</td>
<td>DATA</td>
<td>DATA-ERR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADEG</td>
<td>10.4</td>
<td>0.8</td>
<td>243.</td>
<td>8.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.9</td>
<td>1.2</td>
<td>127.</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39.1</td>
<td>0.9</td>
<td>83.2</td>
<td>3.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>59.1</td>
<td>0.7</td>
<td>14.8</td>
<td>2.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>83.0</td>
<td>1.0</td>
<td>19.2</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>112.</td>
<td>1.3</td>
<td>21.2</td>
<td>4.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>173.</td>
<td>1.1</td>
<td>16.8</td>
<td>3.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENDDATA</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.3

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 between 1.0E-38 and 9.9999E+38.

All the following examples are valid entries:

<table>
<thead>
<tr>
<th>Fixed-point numbers</th>
<th>Floating-point numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>with decimal point</td>
<td>with exponent</td>
</tr>
</tbody>
</table>

```
<table>
<thead>
<tr>
<th>0.14</th>
<th>+0.0.014.E+0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.14</td>
<td>0.014.E+2</td>
</tr>
<tr>
<td>+0.14</td>
<td>0.014.E+2</td>
</tr>
<tr>
<td>-0.14</td>
<td>-0.14.E+0</td>
</tr>
<tr>
<td>-1.4</td>
<td>-1.4.E-1</td>
</tr>
<tr>
<td>1.4</td>
<td>-0.1</td>
</tr>
<tr>
<td>1.4</td>
<td>1.4.E+0</td>
</tr>
</tbody>
</table>
```

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:

<table>
<thead>
<tr>
<th>E-LVL</th>
<th>E-LVL</th>
<th>E-LVL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEV</td>
<td>MEV</td>
<td>MEV</td>
</tr>
<tr>
<td>0.077</td>
<td>0.107</td>
<td>0.177</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>ANG</th>
<th>ANG</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADEG</td>
<td>AMIN</td>
</tr>
<tr>
<td>90.</td>
<td>47.</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>HL</th>
<th>HL</th>
<th>HL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC</td>
<td>D</td>
<td>YR</td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td>28.3</td>
</tr>
</tbody>
</table>

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) **Two or more flags** defined under the BIB keyword FLAG which apply to the same line of the data table, may be entered as follows:

<table>
<thead>
<tr>
<th>FLAG</th>
<th>FLAG</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO-DIM</td>
<td>NO-DIM</td>
</tr>
<tr>
<td>1.</td>
<td>3.</td>
</tr>
<tr>
<td>2.</td>
<td>3.</td>
</tr>
<tr>
<td>1.</td>
<td>2.</td>
</tr>
</tbody>
</table>

**Note:** The data-heading keyword FLAG cannot occur in a COMMON section.

5) **Errors or resolutions given in different units** over an energy range may be entered as follows:

<table>
<thead>
<tr>
<th>EN-RSL</th>
<th>EN-RSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEV</td>
<td>PER-CENT</td>
</tr>
<tr>
<td>20.</td>
<td>10.</td>
</tr>
<tr>
<td>20.</td>
<td>10.</td>
</tr>
<tr>
<td>20.</td>
<td>10.</td>
</tr>
</tbody>
</table>

6) **Two or more unresolved masses** (for mass yields) may be entered as follows:

<table>
<thead>
<tr>
<th>MASS</th>
<th>MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO-DIM</td>
<td>NO-DIM</td>
</tr>
<tr>
<td>135.</td>
<td>136.</td>
</tr>
</tbody>
</table>
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.

```plaintext
COMMON
.
.
.
ENDCOMMON

DATA
  independent variable(s) dependent variable(s)
  + associated quantities + associated quantities
  + additional information

ENDDATA
```

NDS X4 February 1979
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.      -
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  -      -          -          -
4.5  1.400  1.412  -      -          -          -
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**

<table>
<thead>
<tr>
<th>Pointers</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Multiple Reaction Formalism</td>
<td>6.2</td>
</tr>
<tr>
<td>2. Vector COMMON</td>
<td>6.3</td>
</tr>
<tr>
<td>3. BIB/DATA links</td>
<td>6.4</td>
</tr>
<tr>
<td>4. BIB/BIB links</td>
<td>6.5</td>
</tr>
<tr>
<td>5. Alternative results</td>
<td>6.6</td>
</tr>
</tbody>
</table>

## Links between data-heading keywords and BIB keywords | 6.7

1. **DATA** (resp. **RATIO**, **SUM**) | 6.7

2. Data-headings for independent variables | 6.8

   - **EN**
   - **EN-DUMMY**
   - **EN-RES**
   - **E**
   - **ANG, COS**
   - **NUMBER**
   - **MOMENTUM L**
   - **ELEMENT, MASS, ISOMER**
   - **N-OUT, P-OUT**
   - **HL**

3. Other data-heading keywords | 6.10

   - **-ERR, ERR-**
   - **MONIT**
   - **-NRM**
   - **HL1, HL2 etc.**
   - **ASSUM**
   - **FLAG**
   - **DECAY-FLAG**
   - **MISC**

---

NDS X4 83/9
6.1

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 encountered 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 coefficient 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. **Multiple REACTION Formalism**

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 **only** in the specific cases listed on page 8.REACTION.12 and in LEXFOR under **Multiple REACTION Formalism**.
2) **Vector COMMON**

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

**First alternative**

```
DATA
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
```

**Second alternative ("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
```

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:**
  - COMMON
    - ANG
    - ADEG
    - 30.
  - 1ANG
    - ADEG
    - 30.
  - 2ANG
    - ADEG
    - 40.
  - ZANG
    - ADEG
    - 0.

- **Forbidden:**
  - E
    - 1E
  - 2E-MIN
  - 3E-MAX
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
ADEC 10.
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.

NDS X4 84/11
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-CŌL 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) **Alternative results**

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(REA). 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 incident 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.
6.10

(independent variables, continued)

**N-OUT, P-OUT**  *Variable number of emitted nucleons (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).

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

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 CPWD this formalism has not yet been used.
# Chapter 7

**DICTIONARIES**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Transmission Tapes for Dictionaries</td>
<td>7.1</td>
</tr>
<tr>
<td>2. Format of Dictionaries</td>
<td>7.2</td>
</tr>
<tr>
<td>3. Alterations of Dictionaries</td>
<td>7.5</td>
</tr>
<tr>
<td>4. Procedure for Updating and Transmitting Dictionaries</td>
<td>7.8</td>
</tr>
<tr>
<td>5. Table of Dictionaries</td>
<td>7.10</td>
</tr>
<tr>
<td>6. Additional information on specific dictionaries</td>
<td>7.11</td>
</tr>
<tr>
<td>2. Information-Identifier Keywords</td>
<td>7.11</td>
</tr>
<tr>
<td>3. Institute</td>
<td>7.12</td>
</tr>
<tr>
<td>4. Type of Reference</td>
<td>7.13</td>
</tr>
<tr>
<td>5. Journals</td>
<td>7.13</td>
</tr>
<tr>
<td>6. Reports</td>
<td>7.14</td>
</tr>
<tr>
<td>7. Conferences and Books</td>
<td>7.15</td>
</tr>
<tr>
<td>9. Chemical Compounds</td>
<td>7.16</td>
</tr>
<tr>
<td>10., 11., 12., 14. (ISO-QUANT, no longer used)</td>
<td>7.16</td>
</tr>
<tr>
<td>24. Data-Heading Keywords</td>
<td>7.17</td>
</tr>
<tr>
<td>25. Data-Unit Keywords</td>
<td>7.18</td>
</tr>
<tr>
<td>27. Nuclides</td>
<td>7.18</td>
</tr>
<tr>
<td>34. Modifiers (REACTION)</td>
<td>7.20</td>
</tr>
<tr>
<td>36. Quantities (REACTION)</td>
<td>7.20</td>
</tr>
<tr>
<td>41. Conversion Table of Quantities used earlier under ISO-QUANT</td>
<td>7.21</td>
</tr>
</tbody>
</table>
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 ENDTTRAN 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 ENDTTRAN 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: '30000NN000001' 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 (Compare 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 purposes 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:

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

<table>
<thead>
<tr>
<th>DICTION</th>
<th>5</th>
<th>930505 JOURNALS</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td></td>
<td>(ASTRON. AND ASTROPHYS.) ASTRONOMY AND ASTROPHYSICS</td>
<td>2GER</td>
</tr>
<tr>
<td>AAB</td>
<td></td>
<td>(AN. ACADEMIAE BRASILEIRA) ACADEMIA</td>
<td>3BZL</td>
</tr>
<tr>
<td>AAF</td>
<td></td>
<td>ANNALES ACADEMIAE</td>
<td>2SF</td>
</tr>
<tr>
<td>AANL</td>
<td></td>
<td>(ATTI ACCAD. NAZ. LINCEI, REND., CL. SCI. FIS., MAT. NAT.)</td>
<td>2ITY</td>
</tr>
<tr>
<td>AAST</td>
<td></td>
<td>ATTI DELLA ACADEMIA NAZIONALE DEI LINCEI</td>
<td>2ITY</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DICTION</th>
<th>24</th>
<th>930505 DATA-HEADING KEYWORDS</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN</td>
<td></td>
<td>ENERGY OF INCIDENT PARTICLE</td>
<td>A</td>
</tr>
<tr>
<td>EN-NM</td>
<td></td>
<td>EN FOR NUMERATOR OF REACTION RATIO</td>
<td>A</td>
</tr>
<tr>
<td>EN-DN</td>
<td></td>
<td>EN FOR DENOMINATOR OF REACTION RATIO</td>
<td>A</td>
</tr>
<tr>
<td>EN-APRX</td>
<td></td>
<td>APPROXIMATE VALUE OF 'EN'</td>
<td>A</td>
</tr>
<tr>
<td>EN-CM</td>
<td></td>
<td>INCIDENT PARTICLE ENERGY IN C.M. SYSTEM</td>
<td>A</td>
</tr>
<tr>
<td>EN-MIN</td>
<td></td>
<td>LOW LIMIT OF 'EN' RANGE</td>
<td>A</td>
</tr>
<tr>
<td>EN-MIN-NM</td>
<td></td>
<td>LOW LIMIT OF 'EN' RANGE F.NUMERATOR OF REACTION RATIO</td>
<td>A</td>
</tr>
<tr>
<td>EN-MIN-DN</td>
<td></td>
<td>LOW LIMIT OF 'EN' RANGE F.DENOMIN. OF REACTION RATIO</td>
<td>A</td>
</tr>
</tbody>
</table>
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) Insert

(a) Insertion of a single record

Col. 1-66 Text of record to be inserted
67-79 ID of record after 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

First 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) Obsolete/Extinct

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

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Max code</th>
<th>Expansion length</th>
<th>Expansion provided</th>
<th>see page</th>
<th>Additional information</th>
<th>Max code</th>
<th>Expansion length</th>
<th>Expansion provided</th>
<th>see page</th>
</tr>
</thead>
<tbody>
<tr>
<td>†1.</td>
<td>System-Identifier Keywords</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†2.</td>
<td>Information-Identifier Keywords</td>
<td>10</td>
<td>yes</td>
<td>yes ext</td>
<td>7.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Institutes</td>
<td>7*</td>
<td>yes</td>
<td>yes ext</td>
<td>7.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†4.</td>
<td>Reference Type</td>
<td>1</td>
<td>yes</td>
<td>7.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Journals</td>
<td>6*</td>
<td>yes</td>
<td>7.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Reports</td>
<td>11</td>
<td>-</td>
<td>7.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Books and Conferences</td>
<td>10</td>
<td>yes(ext)*</td>
<td>7.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Elements</td>
<td>6</td>
<td>yes</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†9.</td>
<td>Chemical Compounds</td>
<td>7 to 10</td>
<td>yes</td>
<td>7.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.-14.</td>
<td>ISO-QUANT subfields</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-10.</td>
<td>Process/Parameter (Quantity SF1)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-11.</td>
<td>Function (Quantity SF2)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12.</td>
<td>Modifier (Quantity SF3)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†13.</td>
<td>Particle (PART-DET and Quantity SF4)</td>
<td>3</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-14.</td>
<td>Quantity (SF1-4)</td>
<td>18</td>
<td>yes ext</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>HISTORY</td>
<td>1</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>STATUS</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>REL-REF SF1</td>
<td>1</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>FACILITY</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>INC-SOURCE</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Additional Results (ADD-RES)</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>METHOD</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>DETECTOR</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>ANALYSIS</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Data-Heading Keywords</td>
<td>10</td>
<td>-</td>
<td>7.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Data-Unit Keywords</td>
<td>10</td>
<td>-</td>
<td>7.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>Nuclides</td>
<td>10</td>
<td>*</td>
<td>7.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.-36.</td>
<td>REACTION subfields</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†28.</td>
<td>Incident Particles (REACTION SF2)</td>
<td>3</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†29.</td>
<td>Product Particles (REACTION SF3)</td>
<td>3</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†30.</td>
<td>Process (REACTION SF3)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†31.</td>
<td>Branch (REACTION SF5)</td>
<td>5+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†32.</td>
<td>Parameter (REACTION SF6)</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†33.</td>
<td>Particles Considered (REACTION SF7)</td>
<td>3</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>†34.</td>
<td>Modifiers (REACTION SF8)</td>
<td>3</td>
<td>*</td>
<td>7.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.</td>
<td>Data-Type (REACTION SF9)</td>
<td>5</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36.</td>
<td>Quantities (REACTION SF5-8)</td>
<td>44*</td>
<td>yes ext</td>
<td>7.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41.</td>
<td>Conversion table of Quantity (Dict. 14)</td>
<td>18</td>
<td>yes ext</td>
<td>7.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>to REACTION formalism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(one-to-one correspondence to Dict. 14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42.</td>
<td>CINDA Quantities</td>
<td>3</td>
<td>yes</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Additional information given on the following pages.
† Additional 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-character 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.

NDS X4 86/4
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).

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-character 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.

NDS X4 86/4
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.

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

* 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. **Columns 12-26** have the following structure:

**Column 12**

'('  

Each column contains either a flag or blank:

**Column 13 - 23**

- '1' indicates validity,  
- 'X' indicates a warning for unusual use.

**Column 14**

used for REACTION SF2

- '2' indicates validity

**Column 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

**Column 16**

used for nuclides in Reaction SF1 when SF2=0

- '4' indicates validity

**Columns 17 - 21**

are presently unused

**Column 22**

used for CINDA

- 'C' indicates validity
- 'T' indicates validity for theoretical work only

**Column 23**

used to indicate a stable isotope

- 'S' indicates stability

**Columns 24 - 25**

isomer field:

- either blank, indicating that the nuclide has no isomeric states,
- a number, right justified, indicating the maximum number of metastable states, (i.e., number of isomeric states not including the ground state),

**Column 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 Nuclide checking.

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,

<table>
<thead>
<tr>
<th>col.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-18</td>
<td>quantity code (or longer, see item 5. below)</td>
</tr>
<tr>
<td>19-21</td>
<td>dimension code</td>
</tr>
<tr>
<td>22</td>
<td>special flag</td>
</tr>
<tr>
<td>23-66</td>
<td>expansion and free text.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction</td>
<td>8.1</td>
</tr>
<tr>
<td>2.</td>
<td>General format for coding</td>
<td>8.1</td>
</tr>
<tr>
<td>3.</td>
<td>Coding of nuclides</td>
<td>8.2</td>
</tr>
<tr>
<td>4.</td>
<td>Keyword categories</td>
<td>8.3</td>
</tr>
<tr>
<td>5.</td>
<td>Keyword sequence</td>
<td>8.3</td>
</tr>
<tr>
<td>6.</td>
<td>Summary of keywords</td>
<td>8.4</td>
</tr>
</tbody>
</table>

Specific coding rules for each keyword ordered alphabetically by keyword  

8.ADD-RES to 8.TITLE
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:

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Code</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATUS</td>
<td>(DEP  )</td>
<td>Yes</td>
</tr>
<tr>
<td>STATUS</td>
<td>(DEP ,COREL)</td>
<td>Yes</td>
</tr>
<tr>
<td>STATUS</td>
<td>(COREL, DEP)</td>
<td>No</td>
</tr>
<tr>
<td>STATUS</td>
<td>(DEP, 10048007)</td>
<td>No</td>
</tr>
</tbody>
</table>

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 occurring in the EXFOR file, is maintained in Dictionary 27; see page 7.15. Compare also in Lexfor under **Nuclide Checking**.
4. **Keyword categories**

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 not 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-mémoire but do not replace the detailed coding rules given on the subsequent pages.

5. **Keyword sequence**

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

<table>
<thead>
<tr>
<th>Keyword</th>
<th>obligatory</th>
<th>obligatory except when not relevant</th>
<th>obligatory for specific data-heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bibliography</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TITLE</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTHOR</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INSTITUTE</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXP-YEAR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REFERENCE</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REL-REF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MONIT-REF</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Specification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REACTION</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MONITOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASSUMED</td>
<td>X</td>
<td>MONIT etc</td>
<td></td>
</tr>
<tr>
<td>Assumed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DECAY-DATA</td>
<td></td>
<td>DECAY-FLAG</td>
<td></td>
</tr>
<tr>
<td>DECAY-MON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HALF-LIFE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PART-DET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAD-DET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EN-SEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMS-SEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOM-SEC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADD-RES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISC-COL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLAG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INC-SOURCE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INC-SPECT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAMPLE</td>
<td></td>
<td></td>
<td>EN-DUMMY</td>
</tr>
<tr>
<td>METHOD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FACILITY</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANALYSIS</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DETECTOR</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CORRECTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERR-ANALYS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COVARIANCE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRITIQUE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Book-keeping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STATUS</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HISTORY</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NDS X4 89/4
### 8.5

<table>
<thead>
<tr>
<th>Keyword</th>
<th>typical coding and/or Dictionary-number</th>
<th>when keyword present, coded information should not be repeated in free text</th>
</tr>
</thead>
</table>

#### Bibliography
- **TITLE**: free text only
- **AUTHOR**: (A.B.AUTHOR)
- **INSTITUTE**: (3)
- **EXP-YEAR**: (year)

#### Reference
- **REFERENCE**: (4,5/6/7,vol.,page,date)
- **REL-REF**: (17,acc#,AUTHOR,Ref.)
- **MONIT-REF**: (acc#,AUTHOR,Ref.)

#### Data Specification

#### Related Data
- **MONITOR**: as REACTION
- **ASSUMED**: (ASSUMI,REACTION)
- **DECAY-DATA**: (Z-S-A-X,HL,13,E,abund.)
- **DECY-MON**: as DECAY-DATA
- **HALF-LIFE**: (HL1,Z-S-A-X)
- **PART-DET**: (13) or (Z-S-A-X)
- **RAD-DET**: (Z-S-A-X,13)

#### Physics
- **INC-SOURCE**: (19)
- **INC-SPECT**: free text only
- **SAMPLE**: free text only
- **METHOD**: (21)
- **FACILITY**: (18) or (18,3)
- **ANALYSIS**: (23)
- **DETECTOR**: (22)
- **CORRECTION**: free text only
- **ERR-ANALYS**: (DATA-ERR1)
- **COVARIANCE**: free text only, or (COVAR)
- **CRITIQUE**: free text only
- **COMMENT**: free text only

#### Book-keeping
- **STATUS**: (16) or (16,Acc#)
- **HISTORY**: (770630X)

NDS X4 85/8
8. ADD-RES

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.
8. AUTHOR

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 (W.W.HAVENS JR)

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

**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.

---

**8.COMMENT**

**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.

---

**8.CORRECTION**

**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.
8. COVARIANCE

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.

8. CRITIQUE

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 '-C' 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.
8. DECAY-DATA

Example:

DECAY-DATA (Z-S-A-X,n.nHR,DG,E_{1}/E_{2},l_{12})

Here $l_{12}$ 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 photon abundance must 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:

h. 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)
8.DECAY-MON

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.

8.DETECTOR

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, each 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 IF 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-M1N, 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.
8. ERR-ANALYS

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 Diet. 24 that contain the character sequences 'ERR' or 'RSL' (e.g. EN-ERR-1, ERR-5, +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 MEV EN-ERR MEV DATA DATA-ERR1 DATA-ERR2
   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.
8. EXP-YEAR

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).

8. FACILITY

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)
8. FLAG

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.       1.
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

\[(\text{heading,nuclide})\]

- **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
```
8. HISTORY

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 (ymmd) or (ymmdX)

   where yymmd 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.)

8. INC-SOURCE

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.

NDS X4 85/4
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.

NDS X4 83/6
8. METHOD

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

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.
8. MOM-SEC

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 Standards. Information may be entered either in free text only or in coded form with or without free text. However, coded information must be included when the data-heading MONIT (or a derivative) is given in the COMMON- or DATA-Section.

3. The format 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 two or more MONITOR codes are given, each must be coded in a separate line. The respective MONIT column may then be linked to the MONITOR codes either using pointers (see page 6.4 BIB/DATA links) or using the data-heading keywords MONIT1, MONIT2 etc. This formalism is used when two or more monitors are given for one reaction.

Examples:

with pointers:

REACTION 1(AAAAAAAA)
2(BBBBBBBB)
MONITOR 1(CCCCCCCC)
2(DDDDDDDD)
ENDBIB
DATA
EN DATA 1DATA 2MONIT 1MONIT 2
...
...
...
...

with MONIT1, MONIT2; new formalism introduced in 1985:

REACTION (AAAAAA)
MONITOR ((MONIT1)CCCCCCC)
((MONIT2)DDDDDDDD)
ENDBIB
DATA
EN DATA MONIT1 MONIT2
...
...
...
...

with MONIT1, MONIT2; old formalism used until 1985:

REACTION (AAAAAAA)
MONITOR (CCCCCCCC) +--
ENDBIB (DDDDDDDD) +--
DATA |
EN DATA MONIT1 MONIT2
...
...
...
...

5. Bibliographic references 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 MONITOR.

NDS X4 88/11
8. MONIT-REF

MONIT-REF

1. This keyword is used to give information 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 (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.B.PANONTIN+, J, JIN, 30, 2017, 68)
8. N-SOURCE

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.
8. PART-DET

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.
8. RAD-DET

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

\[(\text{nuclide}, \text{radiation})\]

No embedded blanks are permitted in the code.

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

Radiation field 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:

\[((n.)\text{nuclide}, \text{radiation})\]

4. Two or more nuclides. 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.

Examples

a) RAD-DET \((96-\text{CM}-240, \text{A})\)
b) RAD-DET \((25-\text{MN}-52-\text{G, DG})\)
c) RAD-DET \((25-\text{MN}-52-\text{M, DG, B+})\)
d) RAD-DET \((48-\text{CD}-115-\text{G, B-})\)
   \((49-\text{IN}-115-\text{M, DG})\)
e) RAD-DET \(1(94-\text{PU}-237-\text{M1, SF})\)
   \(2(94-\text{PU}-237-\text{M2, SF})\)
f) RAD-DET \(((1.)\text{48-CD-115-G, B-})\)
   \(((2.)\text{49-IN-115-M, DG})\)
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

SF1 - 4. Reaction field
   SF1. Target nucleus
   SF2. Incident particle
   SF3. Process
   SF4. Reaction Product
   1. Definition
   2. Coding
   3. Variable product nucleus

SF5 - 8. Quantity field
   SF5. Branch
   SF6. Parameter
   SF7. Particle considered
   SF8. Modifier

SF9. Data-type field

C. REACTION combinations

D. Multiple REACTION formalism

page

8.REACTION.2

8.REACTION.3

8.REACTION.5

8.REACTION.6

8.REACTION.8

8.REACTION.9

8.REACTION.10

8.REACTION.11

8.REACTION.12
8.REACTION.2

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 O-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(0,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

NDS X4 88/11
**8. Reaction**

**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. \((N,G+F),\text{SEQ},\text{SIG}\)

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 \((Z-S-A(P,P)Z-S-A,.,\text{SIG})\), 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.
8.REACTION.6

(SF4. Reaction Product, continued)

2. Coding: This subfield

either is blank: see a) below

or contains a code in the form Z-S-A-X: see b) below

or contains the code ELEM and/or MASS: see page 8.REACTION.8 "Variable Product Nucleus"

a) SF4 is blank 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 light particles 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:

\[(51\text{-SB-123}(N,G)51\text{-SB-124-M2}/G,,SIG/RAT)\]

= ratio of the cross-section populating the second isomeric state over the cross-section populating the ground state

\[(51\text{-SB-123}(N,G)51\text{-SB-124-M1+M2},,SIG/SUM)\]

= sum of the cross-section populating the first and second isomeric state

\[(51\text{-SN-124}(P,N)51\text{-SB-124-G/T,,TTY/RAT})\]

= 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.

(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,CUT!,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
- 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.DECEAY-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 coefficients, 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))

(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 variables.

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 Reference.

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,

page

8.REFERENCE.2 Some rules pertaining to all types of reference
8.REFERENCE.3 Journals
8.REFERENCE.4 Reports
8.REFERENCE.6 Conferences and Books
8.REFERENCE.7 Private Communications and Theses
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 must 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 always 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 REFERENCE.

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:


   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 excludes 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**:


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.

NDS X4 85/3
(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.
8.REFERENCE.6

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:


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.


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

$CONF\ldots$
$NBS\text{-}SPEC\text{-}PUB\ldots$
$STI/PUB\ldots$ (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.

Private Communications (Type-of-reference = W)

Theses (Type-of-reference = T)

General coding forms: (W or T, Author, Date)
(W or T, Author, Page, Date)

Author subfield contains the family name of the (first) author.
Page subfield, if present, must be numeric.

Examples:
a) (W, BENZI, 661104) = private communication from Benzi dated 4 Nov. 1966.

Note by NDS: Private communications should be coded under REFERENCE only 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

\[(\text{code,subacc\#,author,reference})\]

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.
8.RESID-NUC

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.
8. 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 B0123004 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 Cnnmn001 refers to the entire entry Cnnnn.
   Cnnmn000 (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)
8. TITLE

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 character set defined on page 1.5.
Chapter 9

COMMUNICATIONS, UPDATING, ALTERATIONS

| Procedure for tapes received with errors | 9.1  |
| Alterations to EXFOR-entries             | 9.2  |
| Deletion of entries and subentries       | 9.3  |
| Updating of manual pages                 | 9.4  |
| Inter-center memos                       | 9.5  |
| Addresses of centers                     | 9.6  |
| Physical Structure of Exchange Tapes     | 9.8  |
| Magnetic tape formats and Dictionary Transmissions | 9.9  |
| Distribution of EXFOR tapes by NDS       | 9.10 |
| Distribution of 4C- and CP-Memos          | 9.11 |

NDS X4 84/1
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 minimum 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.
9.2

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).
When an entire entry is deleted where subentry 001 contains all necessary BIB information to be preserved, NOSUBENT records (see page 3.6) may be used for subentry 002 and following ones.

Example:

```
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 ##
```

Note: In the first two records of above examples NNDC may use 'C' in col. 80 instead of '('*).

Action at NDS: 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.

Retransmission of Subentries which have been combined into one subentry

Note: 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.

NDS X4 August 1979
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. № 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@BNLDA1"

**SG**

Dr. M. Chiba  
Hokkaido University Computing Center  
Kita-11, Nishi-5, Kita-ku  
Sapporo 060, Japan

**RIKEN**

Dr. A. Hashizume  
Nuclear Data Group  
Wako-Shi, Saitama 351-01, Japan

**CDFE**

Dr. V. Varlamov  
Centr Danykh Fotojad. Eksp.  
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

*NDS X4 89/4*
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.GOV"

**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

NDS X4 89/4
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.


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:

<table>
<thead>
<tr>
<th>Center</th>
<th>Tape Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNDC</td>
<td>EBCDIC 9-track 800, 1600, 6250 bpi</td>
</tr>
<tr>
<td>NEA-DB</td>
<td>EBCDIC 9-track 800, 1600 bpi</td>
</tr>
<tr>
<td>NDS</td>
<td>EBCDIC 9-track 800, 1600 bpi</td>
</tr>
<tr>
<td>CJD</td>
<td>EBCDIC 9-track 800 bpi*</td>
</tr>
<tr>
<td>CAJaD</td>
<td>EBCDIC 9-track 800 bpi</td>
</tr>
<tr>
<td>Study Group</td>
<td>EBCDIC 9-track 1600 bpi preferred</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>800 bpi acceptable</td>
</tr>
<tr>
<td>RIKEN</td>
<td>EBCDIC 9-track 800 bpi</td>
</tr>
<tr>
<td>IAE-CP</td>
<td>EBCDIC 9-track 800 bpi</td>
</tr>
</tbody>
</table>

*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:

<table>
<thead>
<tr>
<th>Center</th>
<th>Tape Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNDC</td>
<td>EBCDIC 9-track 800, 1600, 6250 bpi</td>
</tr>
<tr>
<td>NEA-DB</td>
<td>EBCDIC 9-track 800, 1600 bpi</td>
</tr>
<tr>
<td>NDS</td>
<td>EBCDIC 9-track 800, 1600 bpi</td>
</tr>
<tr>
<td>CJD</td>
<td>EBCDIC 9-track 800 bpi*</td>
</tr>
<tr>
<td>CAJaD</td>
<td>EBCDIC 9-track 800 bpi</td>
</tr>
<tr>
<td>Study Group</td>
<td>EBCDIC 9-track 1600 bpi preferred</td>
</tr>
<tr>
<td></td>
<td>800 bpi acceptable</td>
</tr>
<tr>
<td>RIKEN</td>
<td>EBCDIC 9-track 800 bpi</td>
</tr>
<tr>
<td>IAE-CP</td>
<td>EBCDIC 9-track 800 bpi</td>
</tr>
</tbody>
</table>

*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

NDS X4 85/3
9.10

Distribution of EXFOR tapes by NDS

1. TRANS-tapes produced by NDS are sent to:

<table>
<thead>
<tr>
<th>EXFOR-3 and V series</th>
<th>EXFOR -D and G-series</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNDC</td>
<td>NNDC</td>
</tr>
<tr>
<td>NEA-DB</td>
<td>NEA-DB</td>
</tr>
<tr>
<td>CJD</td>
<td>CJD</td>
</tr>
<tr>
<td>CAJaD</td>
<td>CAJaD</td>
</tr>
</tbody>
</table>

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 N2 changed to the date of transmission by NDS. These tapes are sent to:

<table>
<thead>
<tr>
<th>EXFOR series 4, A, M</th>
<th>NNDC</th>
<th>NEA-DB</th>
</tr>
</thead>
</table>

(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 X4 85/6
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
LEXFOR

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.
Absorption

Definition: The sum of all energetically possible interactions excluding elastic and inelastic scattering.

Quantity-Code: ABS - in REACTION SF3

Sum rules (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).

Note: Absorption is a sum 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 Tautologies)

Examples:

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**

**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**

For neutron reaction data only:

**Definition:** Radiative capture-to-fission cross-section ratio

**REACTION coding:**

- at resonance energy: \( (N,ABS),,ALF,,RES \)
- 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.

NDS X4 April 1980
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. "ENDEDENTRY") 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!
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.
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:

\[
\begin{align*}
\text{ANG} &= \text{angle in lab system} \\
\text{ANG-CM} &= \text{angle in center-of-mass system} \\
\text{COS} &= \text{cosine of angle in lab system} \\
\text{COS-CM} &= \text{cosine of angle in center-of-mass system and other codes given in Dictionary 24 with flag G.}
\end{align*}
\]

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:

\[
\text{(....(N,N+P),,COR)}
\]

Exact definition of the data given should always be entered in free text, in particular in more complex cases such as the correlation function \(W(\text{ANG1},\text{ANG2},\text{ANG3})\) 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 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 Є Ё Ж З И Й К Л М Н О П
А Б У Г Д Е Ё Є Ё Ж З І Й К Л М Н О Р
Р С Т У Ф Х Ц Ч Ш Щ Ъ Ь Ь Э Ю Я
Р С Т У Ф Х ТС Ч Ш ШЧ ' Ь ' Є ЫУ Я

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 "l" 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

   \[
   \text{REACTION } (.\ldots(N,EL),,\text{WID/RED},,AV)
   \]

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 \( l \), is coded with the quantity-code "D" in SF6 under REACTION. Example:

   \[
   \text{REACTION } (.\ldots(N,D),,D)
   \]

   If the \( J \) and \( l \) 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 "l". The quantity code is "STF" in SF6 of the keyword REACTION. Example:

   \[
   \text{REACTION } (.\ldots(N,EL),,STF)
   \]

   In general, \( J \) and \( l \) should be specified. However, strength-functions are also given without specifying \( J \) and \( l \) or with specifying \( l \) only. Explanation should be given in free text in order to make sure that the compiler did not forget to enter \( J \) or \( l \).
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

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

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-\(\text{FE}-\text{CMP}\) 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 \((\text{C}_6\text{H}_6)\).

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: \(\text{CaCO}_3\) is coded as 20-\(\text{CA}-\text{CMP}\), and not 6-C-CMP nor 8-0-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
   \((7-N-\text{AMM},\ldots)=(1-H-CXX,\ldots)\)
   b. brass, if it contains 50% Cu and 50% Sn
   \((29-CU-CMP,\ldots)=(50-SN-CMP,\ldots)\)

   (In such cases two CINDA-entries are made, one for each quantity).
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 H₂ must be entered under the isotope l-H-l, 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.
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 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.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.98</td>
<td>1.0</td>
<td>0.90</td>
<td>0.97</td>
<td>1.0</td>
</tr>
<tr>
<td>0.70</td>
<td>0.82</td>
<td>0.93</td>
<td>1.0</td>
<td>0.54</td>
<td>0.68</td>
</tr>
<tr>
<td>0.64</td>
<td>0.75</td>
<td>0.85</td>
<td>0.92</td>
<td>0.95</td>
<td>1.0</td>
</tr>
<tr>
<td>0.64</td>
<td>0.67</td>
<td>0.69</td>
<td>0.69</td>
<td>0.68</td>
<td>0.83</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>,SIG</td>
<td>Independent formation of the product nucleus can be assumed, but no definitive statement is given by the author.</td>
</tr>
<tr>
<td>M+,SIG</td>
<td>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.</td>
</tr>
<tr>
<td>IND,SIG</td>
<td>Independent formation of the product nucleus when it is clearly specified by the author that the formation via radioactive decay is excluded.</td>
</tr>
<tr>
<td>IND/M+,SIG</td>
<td>Formation of the product nucleus including independent formation and formation via isomeric transition.</td>
</tr>
<tr>
<td>(CUM),SIG</td>
<td>The inclusion of the formation via radioactive decay is assumed by the compiler, but no definitive statement is given by the author.</td>
</tr>
<tr>
<td>CUM,SIG</td>
<td>The cross-section includes the formation via radioactive decay and isomeric transition.</td>
</tr>
<tr>
<td>CUM/M-,SIG</td>
<td>The cross-section includes the formation via radioactive decay but excludes the formation via isomeric transition.</td>
</tr>
<tr>
<td>CUM/(M),SIG</td>
<td>The cross-section includes the formation via radioactive decay, the inclusion or exclusion of formation via isomeric transition is uncertain.</td>
</tr>
</tbody>
</table>

November 1982
Cross-section integral between specified energy limits

Definition: \[ \int_{E_1}^{E_2} \sigma_d E \]

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., \( b \times eV \).

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.
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**.
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

DECY-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:

\[
\text{DECAY-DATA } ((1.)54-XE-125-G,16.8HR,... \\
((2.)54-XE-127-M,69.SEC,... \\
((2.)54-XE-127-G,36.4D,... \\
((3.)55-CS-127,6.25HR,... \\
\]

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 (<<10^{-14} sec, see Fission Yield).

**Fission Product:** e.g. Br-87

\[ \text{Br-87} \rightarrow \text{Delayed Neutron Precursor} \]

\[ T_{1/2} = 55.4 \text{ sec} \]

\[ \beta^- \]

\[ 8.0 \text{ MeV} = q^0 \]

\[ \gamma \]

\[ 5.5 \text{ keV} = B^\pi \]

\[ \beta^- \]

\[ \text{Daughter Product} \]

\[ [Z+1, N-1] \]

\[ [Z+2, N-2] \]

\[ [Z+1, H-2] \]

**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:

\[ P_n = \frac{\text{absolute delayed neutron yield}}{\text{precursor fission yield}} \]  

(cumulative or independent)

**Sum rule:**

\[ P_n + \%\text{betas}(\text{dn-emitter}) = 100 \]

\( (\text{dn-emitter} = \text{Kr-87}^* \text{ in the figure}) \)

**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:**

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:** \((\ldots(N,F),DL,NU)\)
  - 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:
  \[
  (\ldots(N,F),DL,NU)/((\ldots(N,F),,NU))
  \]

**Partial delayed fission neutron yields**

There are two main types of measurements:

**Delayed neutron groups**

**REACTION Coding:** \((\ldots(N,F),DL/PAR,NU)\)

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 groups 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:** \((\ldots(N,F)ELEM/MASS,DL/IND,NU)\)

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:** \((\ldots(N,F)ELEM/MASS,DL/CUM,NU)\)

It is 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:** \((\ldots(N,F),DL/PAR,DE,N)\)

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 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 "Variable Product Nucleus" is extended to the target nucleus field SF1 in the following formalism:

\[
\text{REACTION (ELEM/MASS(O,B-),,PN)}
\]

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

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: Interdependent Data and Data Type
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:

\[
\text{REACTION } (\ldots(N,N+P),,DA,P)
\]

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:

\[
\frac{\frac{d\sigma}{d\theta}}{\frac{d\sigma}{d\theta}_0} = 1, \text{ when } \theta = \theta_0
\]

- Quantity Modifier:
  - when \( \theta = 90 \): RSD
  - when \( \theta \neq 90 \): REL
- Data-unit Keyword: NO-DIM

c) Ratios to the integrated cross section:

\[
\frac{1}{\sigma} \frac{d\sigma}{d\theta}(\theta)
\]

Code as a ratio with Data-units 'NO-DIM'

Example: REACTION ((\ldots(N,EL),,DA)/(\ldots(N,EL),,SIG))

d) Values normalized such that their value over the integral equals \(4\pi\):

\[
\frac{4\pi}{\sigma} \frac{d\sigma}{d\theta}(\theta)
\]

- Quantity modifier: RS
- Data-unit Keyword: NO-DIM

NDS X4 84/1
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.
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 \((n,\gamma) + (n,p) + \ldots\). 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.
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)

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Li-6(N,X)He Prod</td>
<td>28-Ni-58(N,P)27-Co-58</td>
</tr>
<tr>
<td>5-B-10(N,X)He Prod</td>
<td>28-Ni-58(N,2N)28-Ni-57 → 27-Co-57</td>
</tr>
<tr>
<td>7-N-14(N,P)6-C-14</td>
<td>28-Ni-60(N,P)27-Co-60</td>
</tr>
<tr>
<td>9-F-19(N,2N)9-F-18</td>
<td>29-Cu-63(N,A)27-Co-60</td>
</tr>
<tr>
<td>11-Na-23(N,G)11-Na-24</td>
<td>29-Cu-63(N,2N)29-Cu-62</td>
</tr>
<tr>
<td>11-Na-23(N,2N)11-Na-22</td>
<td>29-Cu-63(N,G)29-Cu-64</td>
</tr>
<tr>
<td>12-Mg-24(N,P)11-Na-24</td>
<td>29-Cu-65(N,2N)29-Cu-64</td>
</tr>
<tr>
<td>13-Al-27(N,A)11-Na-24</td>
<td>30-Zn-64(N,P)29-Cu-64</td>
</tr>
<tr>
<td>13-Al-27(N,P)12-Mg-27</td>
<td>30-Zn-64(N,2N)30-Zn-63</td>
</tr>
<tr>
<td>15-P-31(N,P)14-Si-31</td>
<td>40-Zr-90(N,P)39-Y-90</td>
</tr>
<tr>
<td>16-S-32(N,P)15-P-32</td>
<td>40-Zr-90(N,2N)40-Zr-89</td>
</tr>
<tr>
<td>21-Sc-45(N,G)21-Sc-46</td>
<td>41-Nb-93(N,InL)41-Nb-93-M</td>
</tr>
<tr>
<td>21-Sc-45(N,2N)21-Sc-44</td>
<td>41-Nb-93(N,2N)41-Nb-92-M</td>
</tr>
<tr>
<td>22-Ti-46(N,P)21-Sc-46</td>
<td>45-Rh-103(N,InL)45-Rh-103-M</td>
</tr>
<tr>
<td>22-Ti-47(N,N+P)21-Sc-46</td>
<td>47-Ag-109(N,G)47-Ag-110-M</td>
</tr>
<tr>
<td>22-Ti-47(N,N)21-Sc-46</td>
<td>49-In-115(N,InL)49-In-115-M</td>
</tr>
<tr>
<td>22-Ti-47(N,P)21-Sc-47</td>
<td>49-In-115(N,G)49-In-116-M</td>
</tr>
<tr>
<td>22-Ti-48(N,N+P)21-Sc-47</td>
<td>73-Ta-181(N,G)73-Ta-182</td>
</tr>
<tr>
<td>26-Fe-54(N,P)25-Mn-54</td>
<td>79-Au-197(N,2N)79-Au-196</td>
</tr>
<tr>
<td>26-Fe-54(N,A)24-Cr-51</td>
<td>79-Au-197(N,3N)79-Au-195</td>
</tr>
<tr>
<td>26-Fe-56(N,P)25-Mn-56</td>
<td>79-Au-197(N,4N)79-Au-194</td>
</tr>
<tr>
<td>26-Fe-58(N,G)26-Fe-59</td>
<td>80-Hg-199(N,InL)80-Hg-199-M</td>
</tr>
<tr>
<td>27-Co-59(N,P)26-Fe-59</td>
<td>90-Th-232(N,2N)90-Th-231</td>
</tr>
<tr>
<td>27-Co-59(N,A)25-Mn-56</td>
<td>90-Th-232(N,G)90-Th-233 → 91-Pa-233</td>
</tr>
</tbody>
</table>

**Fission Reactions**

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-Th-232(N,F)</td>
<td></td>
</tr>
<tr>
<td>92-U-235(N,F)</td>
<td></td>
</tr>
<tr>
<td>92-U-238(N,F)</td>
<td></td>
</tr>
<tr>
<td>93-Np-237(N,F)</td>
<td></td>
</tr>
<tr>
<td>94-Pu-239(N,F)</td>
<td></td>
</tr>
<tr>
<td>95-Am-241(N,F)</td>
<td></td>
</tr>
</tbody>
</table>
Naturally occurring elements are, in general, entered with \( A = 0 \). However, for monoisotopic elements, the atomic weight of the naturally occurring isotope is used.

A list of mono-isotopic elements follows:

<table>
<thead>
<tr>
<th>Z-S-A</th>
<th>Z-S-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-BE-9</td>
<td>45-RH-103</td>
</tr>
<tr>
<td>9-F-19</td>
<td>53-I-127</td>
</tr>
<tr>
<td>11-NA-23</td>
<td>55-CS-133</td>
</tr>
<tr>
<td>13-AL-27</td>
<td>59-PR-141</td>
</tr>
<tr>
<td>15-P-31</td>
<td>65-TB-159</td>
</tr>
<tr>
<td>21-SC-45</td>
<td>67-HO-165</td>
</tr>
<tr>
<td>25-MN-55</td>
<td>69-TM-169</td>
</tr>
<tr>
<td>27-CO-59</td>
<td>79-AU-197</td>
</tr>
<tr>
<td>33-AS-75</td>
<td>83-BI-209</td>
</tr>
<tr>
<td>39-Y-89</td>
<td>90-TH-232</td>
</tr>
<tr>
<td>41-NB-93</td>
<td></td>
</tr>
</tbody>
</table>

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:

\[ 43-Tc \]
\[ 61-Pm \]
\[ 84 \leq Z < 89 \]
\[ 91-Po \]
\[ 93 \leq Z \]

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.
LEXFOR

Emission Cross-Sections

See under Production Cross-Sections
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 for entering uncertainty information in EXFOR

B. More sophisticated procedure for precision data (such as standards, cross-sections used in dosimetry, or any other data for which a careful and detailed error analysis is given)

C. Example for unsymmetric errors and error limits

D. Errors of independent variables, standards, half-lives, etc.

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".

NDS X4 85/3
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.

NDS X4 85/3
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 publication, 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.
LEXFOR

Errors (page 4)

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:

<table>
<thead>
<tr>
<th>ERR-1</th>
<th>ERR-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ε1</td>
<td>ε2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EN</th>
<th>EN-ERR</th>
<th>EN-RSL</th>
<th>DATA</th>
<th>ERR-S</th>
<th>ERR-3</th>
<th>ERR-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>ΔE1</td>
<td>E_R(E1)</td>
<td>B(E1)</td>
<td>Δ_{stat}(E1)</td>
<td>ε3(E1)</td>
<td>ε4(E1)</td>
</tr>
<tr>
<td>E2</td>
<td>ΔE2</td>
<td>E_R(E2)</td>
<td>B(E2)</td>
<td>Δ_{stat}(E2)</td>
<td>ε3(E2)</td>
<td>ε4(E2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E_i</td>
<td>εE_i</td>
<td>E_R(E_i)</td>
<td>B(E_i)</td>
<td>Δ_{stat}(E_i)</td>
<td>ε3(E_i)</td>
<td>ε4(E_i)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E_n</td>
<td>ΔE_n</td>
<td>E_R(E_n)</td>
<td>B(E_n)</td>
<td>Δ_{stat}(E_n)</td>
<td>ε3(E_n)</td>
<td>ε4(E_n)</td>
</tr>
</tbody>
</table>

where EN = Lab energy of incident particle
EN-ERR = energy uncertainty
EN-RSL = resolution (a Gaussian 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 (ε1)
ERR-2 = constant 2nd major component of systematic error (ε2)
ERR-3 = 3rd major component of systematic error (ε3)
ERR-4 = 4th major component of systematic error (ε4) etc.

The following are assumed:

\[ \langle δ_{stat}(E_i) \delta_{stat}(E_j) \rangle = 0 \text{ if } i \neq j \]
\[ \langle δ_{stat}(E_i) \epsilon (E_j) \rangle = 0 \]
\[ \langle ε(E_i) \epsilon (E_j) \rangle = 0 \text{ if } i \neq m \]
\[ \langle ε(E_i) \epsilon (E_j) \rangle = ε(E_i) \epsilon(E_j) \rho_{ij} \]

where \( \rho_{ij} \) is a constant between -1.0 and +1.0
See General Comment 8, when \( \rho_{ij} \) is energy dependent.
LEXFOR

Errors (page 5)

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

NDS X4 85/3
C. Example: Unsymmetric errors and error limits

A data table may contain different notations as follows:

20. \( \pm 5 \).
21. \( +3.\!/\!-1 \).
\( \approx 22 \).
\( < 23 \).

This must be split into several columns.

<table>
<thead>
<tr>
<th>DATA</th>
<th>DATA-APRX</th>
<th>DATA-MAX</th>
<th>DATA-ERR</th>
<th>+DATA-ERR</th>
<th>-DATA-ERR</th>
</tr>
</thead>
<tbody>
<tr>
<td>MB</td>
<td>MB</td>
<td>MB</td>
<td>MB</td>
<td>MB</td>
<td>MB</td>
</tr>
<tr>
<td>20.</td>
<td></td>
<td></td>
<td>5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td></td>
<td></td>
<td>3.</td>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
See also Fission Yields, Fission-Neutron Spectra, 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:


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: (....(O,F),,NU) spontaneous fission nu(bar)
Ternary Fission

Ternary fission is coded by using the modifier 'TER' in REACTION SF5 (branch).

Examples:

\[ \ldots (N,F),TER,SIG \] Ternary fission cross-section

\[ \ldots (N,F),TER,DA,LCP \] Angular distribution of light charged particles in ternary fission

Frequently, the ternary fission is further specified by the accompanying light particle, e.g., 'alpha-particle accompanied ternary fission'. Such information should be coded by specifying the light particle in REACTION SF4.

Example: \[ \ldots (N,F)2-HE-4,TER,SIG \] 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: \[ \ldots (N,F),BIN/TER,SIG/RAT \]

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:

\[ (92-U-235(N,F)54-XE-124,,FY) = \text{Yield of the fission-product Xe-124} \]
\[ (92-U-235(N,F)54-XE-125-M,,FY) = \text{Yield of Xe-125m} \]
\[ (92-U-235(N,F)ELEM/MASS,,FY) = \text{Yield of the product nuclei specified in the DATA table under the headings ELEMENT and MASS.} \]

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: \[ \ldots (N,F),AKE,HF \] 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:

\[(n,f) = \text{direct fission} + (n,n'f) + (n,2nf) + \ldots + (n, f) + \ldots\]

The partial fission cross sections are coded under the keyword REACTION as follows:

\begin{align*}
(n,n'f) & : (N,N+F), SEQ, SIG \\
(n,2nf) & : (N,2N+F), SEQ, SIG \\
(n,\gamma f) & : (N,G+F), SEQ, SIG
\end{align*}

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:

\begin{align*}
(D,P+F), PR, SIG & : \text{prompt fission} \\
(D,P+F), DL, SIG & : \text{delayed fission via a fission isomer which must be further specified under the BIB keyword DECAY-DATA.}
\end{align*}
Zeitlicher Verlauf der Kernspaltung
reproduced from Thesis M. Lammer
Fission-neutron spectra 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 \( \bar{E} \) and the most probable energy \( E_p \) which are defined as:

\[ \bar{E} = 3T/2 \]
\[ E_p = T/2 = \bar{E}/3 \]

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:

\[ N(E) \sim \exp(-E/T) \sinh\left(\sqrt{E/E_f}\right) \]

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 \( \bar{E} \) is defined here as:

\[ \bar{E} = E_f + 3T/2 \]

The numerical value of \( \bar{E} \) should be approximately the same disregarding the spectrum shape to which the data were fitted.

Fission spectrum average cross-sections are defined as:

\[ \sigma = \frac{\int \sigma(E)N(E)\sqrt{E}dE}{\int N(E)\sqrt{E}dE} \]

October 1980
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


"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 \( \int X(E) \text{d}E = 1 \) (or \( \int X(E) \text{d}E = \text{nu-bar} \)), data have the units of a reciprocal energy.

The data are functions of the outgoing-neutron energy (\( E \)), and incident-projectile energy (\( EN \)).

Examples:

\[ \begin{align*}
\text{---(-,F),PR,DE,N} & \quad \text{Energy spectrum of prompt fission neutrons} \\
\text{---(-,F),DL,DE,N} & \quad \text{Energy spectrum of delayed neutrons} \\
\text{---(-,F),DL/PAR,DE,N} & \quad \text{Energy spectrum for a specific delayed neutron group}
\end{align*} \]

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:

\[ \text{---(-,F),PR,AKE,N} \]

Average kinetic energy of prompt fission neutrons.

Details of the fit and of the spectrum shape assumed should be given under ANALYSIS.
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.
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 divides into two deformed and excited fission fragments. In a small fraction of the scissions 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. 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 \(4 \times 10^{-11}\) sec and gamma-rays \(10^{-12}\) 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 \(10^6\)b. 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


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.
The fractional cumulative fission-product yield is defined relative to the total chain-yield. In all cases the data are entered as REACTION ratios.

\[
\frac{(92-U-235(N,F)ELEM/MASS,IND,FY)}{(92-U-235(N,F)ELEM/MASS,CHN,FY)} \quad \frac{(92-U-235(N,F)ELEM/MASS,IND,FY)}{(92-U-235(N,F)ELEM/MASS,CHN,FY)} \quad \frac{(92-U-235(N,F)ELEM/MASS,CUM,FY)}{(92-U-235(N,F)ELEM/MASS,CHN,FY)}
\]

**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 \( Z_p \). The fractional independent yield of a fission product (after prompt neutron emission) is given by

\[
P(Z) = (\pi c)^{-\frac{1}{2}} \exp \left[ -\frac{(Z-Z_p)^2}{c} \right],
\]

whereas the fractional cumulative yield is given by

\[
\sum_{n=0}^{Z} \left( \frac{1}{\sigma \sqrt{2\pi}} \int_{-\infty}^{Z} \exp \left\{ -\frac{(n-Z_p)^2}{2\sigma^2} \right\} dn \right)
\]

The parameters \( c \) and \( \sigma \) 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.


Note: The Gaussian width parameter has been assumed to be approximately constant for all \( A \) chains, as given by Wahl et al. Therefore \( Z_p \) has sometimes been determined from a single fractional yield measurement. However, there is evidence for a variation of \( c \) and \( \sigma \) with mass \( A \) and they may be determined together with \( Z_p \). 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:

\[(N,F)MASS,,ZP = \text{most probable charge of fragments with given mass } A\]

Similarly, the most probable mass is coded:

\[(N,F)ELEM,,AP = \text{most probable mass of fragments of given element}\]
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 
\textit{fission asymmetry}.

\textbf{Coding:} \((\ldots(N,F),,AP,\text{HF})/(\ldots(N,F),,AP,\text{LF}))\)

Angular distributions and \textit{energy-spectra} of fission fragments are coded as

\((N,F),,DA,FF\) and \((N,F),,DE,FF\)

and similar codes given in Dictionary 36.

LEXFOR

Fission Yields (page 5)

Coding examples

a) Primary fission-fragment yield:

\[
\text{REACTION } (92-U-235(N,F)\text{MASS,PRE,FY})
\]

\[
\begin{align*}
\text{...} \\
\text{COMMON} \\
\text{EN} \\
\text{EV} \\
0.0253 \\
\text{ENDCOMMON} \\
\text{DATA} \\
\text{MASS} & \text{ DATA} \\
\text{NO-DIM} & \text{ PC/FIS} \\
\text{...} & \text{...}
\end{align*}
\]

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:

\[
\text{REACTION } (92-U-235(N,F)\text{ELEM/MASS,IND,FY})
\]

\[
\begin{align*}
\text{COMMON} \\
\text{EN} \\
\text{EV} \\
0.0253 \\
\text{ENDCOMMON} \\
\text{DATA} \\
\text{ELEMENT} & \text{ MASS} & \text{ DATA} \\
\text{NO-DIM} & \text{ NO-DIM} & \text{ PC/FIS} \\
\text{...} & \text{...} & \text{...}
\end{align*}
\]

The cumulative fission product yield is entered as above; only the quantity-modifier IND is replaced by CUM.

c) Fractional yields:

\[
\text{REACTION } ((92-U-235(N,F)\text{ELEM/MASS,IND,FY})/(92-U-235-(N,F)\text{MASS,CHN,FY}))
\]

\[
\begin{align*}
\text{...} \\
\text{COMMON} \\
\text{EN} \\
\text{EV} \\
0.0253 \\
\text{ENDCOMMON} \\
\text{DATA} \\
\text{ELEMENT} & \text{ MASS} & \text{ DATA} \\
\text{NO-DIM} & \text{ NO-DIM} & \text{ NO-DIM} \\
\text{...} & \text{...} & \text{...}
\end{align*}
\]
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
...
...```
(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

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>MASS</th>
<th>ISOMER</th>
<th>HL</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO-DIM</td>
<td>NO-DIM</td>
<td>NO-DIM</td>
<td>D</td>
<td>ARB-UNITS</td>
</tr>
<tr>
<td>50.</td>
<td>118.</td>
<td>0.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>119.</td>
<td>0.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>119.</td>
<td>1.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>120.</td>
<td>0.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>121.</td>
<td>0.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>121.</td>
<td>1.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>122.</td>
<td>1.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>123.</td>
<td>0.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>50.</td>
<td>123.</td>
<td>1.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>51.</td>
<td>123.</td>
<td>0.</td>
<td>D</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

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 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:

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>MASS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO-DIM</td>
<td>NO-DIM</td>
<td>ARB-UNITS</td>
</tr>
<tr>
<td>42.</td>
<td>99.</td>
<td>1.</td>
</tr>
<tr>
<td>58.</td>
<td>144.</td>
<td>0.977</td>
</tr>
<tr>
<td>60.</td>
<td>147.</td>
<td>0.423</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>MASS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO-DIM</td>
<td>NO-DIM</td>
<td>NUC/100F</td>
</tr>
<tr>
<td>58.</td>
<td>144.</td>
<td>5.2</td>
</tr>
<tr>
<td>60.</td>
<td>147.</td>
<td>2.45</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
<table>
<thead>
<tr>
<th>EN-DUMMY</th>
<th>ELEMENT</th>
<th>MASS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EV</td>
<td>NO-DIM</td>
<td>NO-DIM</td>
<td>NUC/100F</td>
</tr>
<tr>
<td>2.0E+6</td>
<td>42.</td>
<td>99.</td>
<td>6.2</td>
</tr>
<tr>
<td>2.0E+6</td>
<td>58.</td>
<td>144.</td>
<td>4.2</td>
</tr>
<tr>
<td>2.0E+6</td>
<td>60.</td>
<td>147.</td>
<td>2.75</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(Fission yield standards continued)

5) The R value is given

\[ R = \frac{\text{(Activity Ce-144 from fast U-238)}}{\text{(Activity Ce-144 from thermal U-235)}} \times \frac{\text{(Activity Mo-99 from thermal U-235)}}{\text{(Activity Mo-99 from fast U-238)}} \]

R is measured in order to determine the Ce-144 yield from fast U-238 assuming the other three yields as known, i.e.

\[ \text{(Yield Ce-144 from fast U-238)} = R \times \frac{\text{(Yield Ce-144 from thermal U-235)}}{\text{(Yield Mo-99 from fast U-238)}} \times \frac{\text{(Yield Mo-99 from thermal U-235)}}{\text{(Yield Mo-99 from fast U-238)}} \]

**REACTION**: (92-U-238(N,F)ELEM/MASS,CUM/FIS/FCT,FY)

**COMMENT**: UNDER DATA THE R-VALUE IS GIVEN WHICH IS DEFINED AS ...

<table>
<thead>
<tr>
<th>DATA</th>
<th>ELEMENT</th>
<th>MASS</th>
<th>DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN-DUMMY</td>
<td>NO-DIM</td>
<td>NO-DIM</td>
<td>NO-DIM</td>
</tr>
<tr>
<td>2.0E+6</td>
<td>58.</td>
<td>144.</td>
<td>1.234</td>
</tr>
</tbody>
</table>

NDS X4 83/9
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:


The following pages contain examples of data to be coded in EXFOR. For a complete list of fitting coefficient codes, see Dictionary 36.
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:

\[ \frac{d\sigma}{d\Omega} (E, \theta) = a_0 + \sum_{k=1}^{n} a_k(E) \cos^k \theta \]

\[ \frac{d\sigma}{d\Omega} (E, \theta) = \frac{\sigma}{4\pi} \left[ 1 + \sum_{k=1}^{n} a_k(E) \cos^k \theta \right] \]

\[ \frac{d\sigma}{d\Omega} (E, \theta) = \frac{d\sigma}{d\Omega} (E, 0^\circ) \sum_{k=0}^{n} a_k(E) \cos^k \theta \]

\[ \frac{d\sigma}{d\Omega} (E, \theta) = \frac{1}{k^2} \sum_{k=0}^{n} a_k(E) \cos^k \theta \]

\[ \frac{d\sigma}{dJ} (E, \theta) = \frac{d\sigma}{d\Omega} (E, 90^\circ) \left[ 1 + \sum_{k=1}^{n} a_k(E) \cos^k \theta \right] \]

* 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 = $A_2$ (dimension, e.g., b/sr) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = a_0(E) + \sum_{\lambda=1}^{n} a_\lambda(E) P_\lambda(\cos\theta)$$

DA,,LEG/RS = $w_\lambda$ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{\sigma}{4\pi} \left[ 1 + \sum_{\lambda=1}^{n} w_\lambda(E) P_\lambda(\cos\theta) \right]$$

DA,,LEG/RSL = $B_\lambda$ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{\sigma}{4\pi} \left[ 1 + \sum_{\lambda=1}^{n} (2\lambda+1) B_\lambda P_\lambda(\cos\theta) \right]$$

DA,,LEG/2L2 = $a_2$ (dimension, e.g., b/sr) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{1}{2} \sum_{\lambda=0}^{n} (2\lambda+1) a_\lambda(E) P_\lambda(\cos\theta)$$

DA,,LEG/L4P = $a_2$ (dimension, e.g., b/sr) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{1}{4\pi} \sum_{\lambda=0}^{n} (2\lambda+1) a_\lambda(E) P_\lambda(\cos\theta)$$

DA,,LEG/1K2 = $a_2$ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{1}{4\pi} \sum_{\lambda=0}^{n} a_\lambda(E) P_\lambda(\cos\theta)$$

k = wave number

DA,,LEG/RSO = $a_\epsilon$ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{d\sigma}{d\Omega}(E, \theta') \sum_{\epsilon=0}^{k} a_\epsilon(E) P_\epsilon(\cos\theta)$$

DA,,LEG/RSD = $a_\epsilon$ (no dimension) where:

$$\frac{d\sigma}{d\Omega}(E, \theta) = \frac{d\sigma}{d\Omega}(E, \theta'') \left[ 1 + \sum_{\epsilon=0}^{k} a_\epsilon(E) P_\epsilon(\cos\theta) \right]$$

NDS X4 83/6
The following codes were proposed but not yet adopted. The code FM stands for 'figure of 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:

\[ FM/DA, AL1 = a_1 \quad (\text{dimension, e.g., } b/sr) \]
\[ \text{where:} \quad P(E, \theta) \times \frac{d\sigma}{d\Omega} = \sum_{l=0}^{n} a_l P_{l}^1(\cos \theta) \]
\[ FM2/DA, AL1 = a_2 \quad (\text{dimension, e.g., } (\text{mb/sr})^2) \]
\[ \text{where:} \quad P(E, \theta) \times \frac{d^2\sigma}{d\Omega^2} (E, \theta) = \sum_{l=0}^{n} a_l(E) P_{l}^1(\cos \theta) \]

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:

\[ FM/DA, SN2 = a_1 \quad (\text{dimension, e.g., } b/sr) \]
\[ \text{where:} \quad P(E, \theta) \times \frac{d\sigma}{d\Omega} (E, \theta) = \sum_{l=0}^{n} a_l \sin^2 \theta \]
\[ FM2/DA, SN2 = a_2 \quad (\text{dimension, e.g., } (\text{mb/sr})^2) \]
\[ \text{where:} \quad P(E, \theta) \times \frac{d^2\sigma}{d\Omega^2} (E, \theta) = \sum_{l=0}^{n} a_l(E) \sin^2 \theta \]
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 separate 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 0 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)O-G-O,,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

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 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

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.

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) Some mispunches in data table corrected
(721130A) Spelling error in BIB 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 usual, 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**

**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.g., 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.

NDS X4 88/11
Examples:

\((-\text{INL})\),\((-\text{SIG})\) total inelastic-scattering cross section

\((-\text{INL})\),\((-\text{SIG,G})\) total inelastic gamma-emission cross section

\((-\text{INL})\),\((-\text{PAR,SIG})\) partial inelastic-scattering cross section for
the excitation of a discrete level or range of
levels

\((-\text{INL})\),\((-\text{PAR,SIG,G})\) partial cross section for the production of a
 discrete inelastic gamma or range of gammas

\((-\text{INL})\),\((-\text{DA})\) angular distribution of inelastically scattered
particles

\((-\text{INL})\),\((-\text{DA,G})\) angular distribution of inelastic gammas

\((-\text{INL})\),\((-\text{DE})\) energy distribution of inelastically scattered
particles

\((-\text{INL})\),\((-\text{DE,G})\) energy spectrum of inelastic gammas

\((-\text{INL})\),\((-\text{DA/DE})\) 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

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 and 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).
Isomeric States

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+.

NDS X4 83/6
The sum coding

\[(\text{target( , )Z-S-A-M+G,...})\]

is used only in cases where the total formation cross section \(\sigma^G\) was obtained from separate measurements. If only the activity of the ground-state was measured which includes the feeding from the metastable state via the isomeric transition, the branch code M+ is used:

\[(\text{target( , )Z-S-A,M+...}).\]

Accordingly, \((\sigma_{M+G})\) is greater or equal to \((\sigma_{M+})\).

**Exception:** In cases where the formation cross-section of a nucleus is determined from a daughter activity ensuring a 100% inclusion of the produced isomer, the sum-code must be used, since the branch-code M+ stating formation via isomeric \(\gamma\)-transition in the residual nucleus does not apply unambiguously to this case.

When the sum cross-section \((\text{target( , )Z-S-A-M+G,...})\) is identical to the total reaction cross-section \((\text{target( , )Z-S-A,...})\), only the latter code without isomer codes should be used. When retrieving data from EXFOR, one should realize that the same data

\[(\text{target( , )Z-S-A,...})\]

to be retrieved may have been coded under the (less preferable!) codes

\[(\text{target( , )Z-S-A-M+G,...}) \text{ or } \text{...M+G...}\]

or \((\text{target( , )Z-S-A-M,...}) + (\text{target( , )Z-S-A-G,...}))\)

Compare also Dictionaries 31, 36 and under Cross-Sections

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. **Fission isomers:** 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 Fission for the coding of reaction data through fission isomers.

NDS X4 83/6
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.

October 1980
<table>
<thead>
<tr>
<th>Reaction</th>
<th>Threshold (MeV)</th>
<th>REACTION</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>H (n, γ) D</td>
<td>0</td>
<td>1H-1(N, G) 1H-2</td>
<td></td>
</tr>
<tr>
<td>D (n, γ) T</td>
<td>0</td>
<td>1H-2(N, G) 1H-3</td>
<td></td>
</tr>
<tr>
<td>D (n, 2n p)</td>
<td>3.34</td>
<td>1H-2(N, 2N) 1H-1</td>
<td></td>
</tr>
<tr>
<td>T (n, 2n d)</td>
<td>8.35</td>
<td>1H-3(N, 2N) 1H-2</td>
<td></td>
</tr>
<tr>
<td>T (n, 3n p)</td>
<td>11.31</td>
<td>1H-3(N, 3N) 1H-1</td>
<td></td>
</tr>
<tr>
<td>He3(n, γ) He4</td>
<td>0</td>
<td>2HE-3(N, G) 2HE-4</td>
<td></td>
</tr>
<tr>
<td>He3(n, p t)</td>
<td>0</td>
<td>2HE-3(N, P) 1H-3</td>
<td></td>
</tr>
<tr>
<td>He3(n, 2d)</td>
<td>4.35</td>
<td>2HE-3(N, D) 1H-2</td>
<td></td>
</tr>
<tr>
<td>He3(n, n p d)</td>
<td>7.32</td>
<td>2HE-3(N, N P) 1H-2</td>
<td></td>
</tr>
<tr>
<td>He3(n, 2n 2p)</td>
<td>&lt;14</td>
<td>2HE-3(N, 2N P) 1H-1</td>
<td></td>
</tr>
<tr>
<td>He4(n, d t)</td>
<td>21.97</td>
<td>2HE-4(N, D) 1H-3</td>
<td></td>
</tr>
<tr>
<td>He4(n, n p t)</td>
<td>24.76</td>
<td>2HE-4(N, N P) 1H-3</td>
<td></td>
</tr>
<tr>
<td>He4(n, 2n)He3</td>
<td>25.72</td>
<td>2HE-4(N, 2N) 2HE-3</td>
<td></td>
</tr>
<tr>
<td>He4(n, n 2d)</td>
<td>29.80</td>
<td>2HE-4(N, N D) 1H-2</td>
<td></td>
</tr>
<tr>
<td>Li6(n, γ) Li7</td>
<td>0</td>
<td>3LI-6(N, G) 3LI-7</td>
<td></td>
</tr>
<tr>
<td>Li6(n, t α)</td>
<td>0</td>
<td>3LI-6(N, T) 2HE-4</td>
<td></td>
</tr>
<tr>
<td>Li6(n, n d α)</td>
<td>1.71</td>
<td>3LI-6(N, N D) 2HE-4</td>
<td></td>
</tr>
<tr>
<td>Li6(n, p)He6</td>
<td>3.19</td>
<td>3LI-6(N, P) 2HE-6</td>
<td></td>
</tr>
<tr>
<td>Li6(n, 2n p α)</td>
<td>5.43</td>
<td>3LI-6(N, 2N P) 2HE-4</td>
<td></td>
</tr>
<tr>
<td>Li6(n, n t)He3</td>
<td>18.42</td>
<td>3LI-6(N, N T) 2HE-3</td>
<td></td>
</tr>
</tbody>
</table>

October 1980
<table>
<thead>
<tr>
<th>Reaction</th>
<th>Threshold (MeV)</th>
<th>REACTION</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li7(n,γ)Li8</td>
<td>0</td>
<td>3-LI-7(N,G)3-LI-8</td>
<td></td>
</tr>
<tr>
<td>Li7(n,n t alpha)</td>
<td>2.81</td>
<td>3-LI-7(N,N+T)2-HE-4</td>
<td>via He5,Li7*,H-4 or three-particles break-up (NP/A,98,305,67)</td>
</tr>
<tr>
<td>Li7(n,2n)Li6</td>
<td>8.29</td>
<td>3-LI-7(N,2N)3-LI-6</td>
<td></td>
</tr>
<tr>
<td>Li7(n,d)He6</td>
<td>8.87</td>
<td>3-LI-7(N,D)2-HE-6</td>
<td></td>
</tr>
<tr>
<td>Li7(n,2n d alpha)</td>
<td>11.06</td>
<td>3-LI-7(N,2N+D)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>Li7(n,n p)He6</td>
<td>11.41</td>
<td>3-LI-7(N,N+P)2-HE-6</td>
<td></td>
</tr>
<tr>
<td>Li7(n,3n p alpha)</td>
<td>14.76</td>
<td>3-LI-7(N,3N+P)2-HE-4</td>
<td>including search for bound trineutron</td>
</tr>
<tr>
<td>Be9(n,γ)Be10</td>
<td>0</td>
<td>4-BE-9(N,G)4-BE-10</td>
<td></td>
</tr>
<tr>
<td>Be9(n,α)He6</td>
<td>0.67</td>
<td>4-BE-9(N,A)2-HE-6</td>
<td></td>
</tr>
<tr>
<td>Be9(n,2n 2alpha)</td>
<td>1.85</td>
<td>4-BE-9(N,2N+A)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>Be9(n,t)Li7</td>
<td>11.59</td>
<td>4-BE-9(N,T)3-LI-7</td>
<td></td>
</tr>
<tr>
<td>Be9(n,p)Li9</td>
<td>14.74</td>
<td>4-BE-9(N,P)3-LI-9</td>
<td></td>
</tr>
<tr>
<td>Be9(n,d)Li8</td>
<td>16.28</td>
<td>4-BE-9(N,D)3-LI-8</td>
<td></td>
</tr>
<tr>
<td>Be9(n,n d)Li7</td>
<td>18.54</td>
<td>4-BE-9(N,N+D)3-LI-7</td>
<td></td>
</tr>
<tr>
<td>Be9(n,n p)Li8</td>
<td>18.76</td>
<td>4-BE-9(N,N+P)3-LI-8</td>
<td></td>
</tr>
<tr>
<td>Be9(n,n t)Li6</td>
<td>19.66</td>
<td>4-BE-9(N,N+T)3-LI-6</td>
<td></td>
</tr>
<tr>
<td>Be9(n,3n)Be7</td>
<td>22.85</td>
<td>4-BE-9(N,3N)4-BE-7</td>
<td></td>
</tr>
<tr>
<td>Be9(n,n He3)He6</td>
<td>23.54</td>
<td>4-BE-9(N,N+HE3)2-HE-6</td>
<td></td>
</tr>
</tbody>
</table>

October 1980

NDS X;
<table>
<thead>
<tr>
<th>Reaction</th>
<th>Threshold (MeV)</th>
<th>Reaction</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>B10(n,\gamma)B11</td>
<td>0</td>
<td>5-B-10(N,G)5-B-11</td>
<td></td>
</tr>
<tr>
<td>B10(n,p)Be10</td>
<td>0</td>
<td>5-B-10(N,P)4-BE-10</td>
<td></td>
</tr>
<tr>
<td>B10(n,t 2alpha)</td>
<td>0</td>
<td>5-B-10(N,T+\alpha)2-HE-4</td>
<td>via Be8, Li7(2nd exc. st.), or three-particle break-up</td>
</tr>
<tr>
<td>B10(n,\alpha)Li7</td>
<td>0</td>
<td>5-B-10(N,A)3-LI-7</td>
<td>to ground state and 1st exc. state; (2nd exc. st. decays to t+\alpha)</td>
</tr>
<tr>
<td>B10(n,d)Be9</td>
<td>4.79</td>
<td>5-B-10(N,D)4-BE-9</td>
<td></td>
</tr>
<tr>
<td>B10(n,\alpha)Li6</td>
<td>4.90</td>
<td>5-B-10(N,N+\alpha)3-LI-6</td>
<td></td>
</tr>
<tr>
<td>B10(n,d 2alpha)</td>
<td>6.62</td>
<td>5-B-10(N,N+D+\alpha)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>B10(n,n p)Be9</td>
<td>7.24</td>
<td>5-B-10(N,N+P)4-BE-9</td>
<td></td>
</tr>
<tr>
<td>B10(n,2n p 2alpha)</td>
<td>9.28</td>
<td>5-B-10(N,2N+P+\alpha)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>B10(n,He3)Li8</td>
<td>17.32</td>
<td>5-B-10(N,He3)3-LI-8</td>
<td></td>
</tr>
<tr>
<td>B10(n,n He3)Li7</td>
<td>19.56</td>
<td>5-B-10(N,N+He3)3-LI-7</td>
<td></td>
</tr>
<tr>
<td>B10(n,t)Be7</td>
<td>20.54</td>
<td>5-B-10(N,N+T)4-BE-7</td>
<td></td>
</tr>
<tr>
<td>B10(n,3n)B8</td>
<td>29.72</td>
<td>5-B-10(N,3N)5-B-8</td>
<td></td>
</tr>
<tr>
<td>B11(n,\alpha)Li8</td>
<td>7.23</td>
<td>5-B-11(N,A)3-LI-8</td>
<td></td>
</tr>
<tr>
<td>B11(n,\alpha)Li7</td>
<td>9.44</td>
<td>5-B-11(N,N+\alpha)3-LI-7</td>
<td></td>
</tr>
<tr>
<td>B11(n,d)Be10</td>
<td>9.82</td>
<td>5-B-11(N,D)4-BE-10</td>
<td></td>
</tr>
<tr>
<td>B11(n,t)Be9</td>
<td>10.42</td>
<td>5-B-11(N,T)4-BE-9</td>
<td></td>
</tr>
<tr>
<td>B11(n,p)Be11</td>
<td>11.70</td>
<td>5-B-11(N,P)4-BE-9</td>
<td></td>
</tr>
<tr>
<td>B11(n,n p)Be10</td>
<td>12.25</td>
<td>5-B-11(N,N+P)4-BE-10</td>
<td></td>
</tr>
<tr>
<td>B11(n,n t 2alpha)</td>
<td>12.25</td>
<td>5-B-11(N,N+T+\alpha)2-HE-4</td>
<td></td>
</tr>
</tbody>
</table>

October 1980

NDC XI
<table>
<thead>
<tr>
<th>Reaction</th>
<th>Threshold (MeV)</th>
<th>REACTION</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>B11(n,2n)B10</td>
<td>12.50</td>
<td>5-B-11(N,2N)5-B-10</td>
<td></td>
</tr>
<tr>
<td>B11(n,n d)Be9</td>
<td>17.25</td>
<td>5-B-11(N,N+D)4-BE-9</td>
<td></td>
</tr>
<tr>
<td>B11(n,3n p 2alpha)</td>
<td>21.70</td>
<td>5-B-11(N,3N+P+A)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>B11(n,He3)Li9</td>
<td>25.73</td>
<td>5-B-11(N,HE3)3-LI-9</td>
<td></td>
</tr>
<tr>
<td>B11(n,n He3)Li8</td>
<td>29.68</td>
<td>5-B-11(N,N+HE3)3-LI-8</td>
<td></td>
</tr>
<tr>
<td>C12(n,gamma)C13</td>
<td>0</td>
<td>6-C-12(N,G)6-C-13</td>
<td></td>
</tr>
<tr>
<td>C12(n,alpha)Be9 p</td>
<td>6.17</td>
<td>6-C-12(N,A)4-BE-9</td>
<td>to ground state; Be9* decays to n+2α</td>
</tr>
<tr>
<td>C12(n,n 3alpha)</td>
<td>7.98</td>
<td>6-C-12(N,N+2A)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>C12(n,p)B12</td>
<td>13.63</td>
<td>6-C-12(N,P)5-B-12</td>
<td></td>
</tr>
<tr>
<td>C12(n,d)B11</td>
<td>14.87</td>
<td>6-C-12(N,D)5-B-11</td>
<td></td>
</tr>
<tr>
<td>C12(n,n p)B11</td>
<td>17.29</td>
<td>6-C-12(N,N+P)5-B-11</td>
<td></td>
</tr>
<tr>
<td>C12(n,t)B10</td>
<td>20.50</td>
<td>6-C-12(N,T)5-B-10</td>
<td></td>
</tr>
<tr>
<td>C12(n,2n)C11</td>
<td>20.28</td>
<td>6-C-12(N,2N)6-C-11</td>
<td></td>
</tr>
<tr>
<td>C12(n,He3)Be10</td>
<td>21.09</td>
<td>6-C-12(N,HE3)4-BE-10</td>
<td></td>
</tr>
<tr>
<td>C12(n,n He3)Be9</td>
<td>28.47</td>
<td>6-C-12(N,N+HE3)4-BE-9</td>
<td></td>
</tr>
<tr>
<td>C12(n,n d)B10</td>
<td>27.28</td>
<td>6-C-12(N,N+D)5-B-10</td>
<td></td>
</tr>
<tr>
<td>C12(n,n p t 2alpha)</td>
<td>29.65</td>
<td>6-C-12(N,N+P+T+A)2-HE-4</td>
<td></td>
</tr>
<tr>
<td>C12(n,3n)C10</td>
<td>34.47</td>
<td>6-C-12(N,3N)6-C-10</td>
<td></td>
</tr>
</tbody>
</table>

October 1980

NDS X4
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., reactor 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, see p. 6.9.

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.
Multilevel Resonance Parameters

Compare Single-Level Resonance Parameters. Quantum Numbers.

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: $\sigma_{nT} = 2\pi \left( \sum_\lambda \kappa_\lambda^2 \right) g \text{Re}(1 - U_{nn})$

Other cross sections: $\sigma_{nr} = \pi \kappa_\lambda^2 g \left| \delta_{nr} - U_{nr} \right|^2$

where: $\kappa_n = \text{neutron wave length in the center-of-mass system}$
$g = \text{statistical weight factor}$
$\delta_{nr} = \text{Kronecker delta}$

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:

$$R = \sum_\lambda \gamma_\lambda \times \gamma_\lambda$$

where: $\gamma_\lambda \times \gamma_\lambda$ is the vector product of the vectors $\gamma_\lambda$ and $\lambda$ refers to levels. The diagonal elements of $\gamma_\lambda$ 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 $\lambda$.

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

$$K_{cc'} = \frac{1}{2} \sum_\lambda \left( \frac{\Gamma_{\lambda c}}{E - E_i - \frac{1}{2} \Gamma_{\lambda Y}} \right)$$

The fission cross section can be expressed by:

$$\sigma_{nf} = \sum_{c \neq 2}^{l+1} 4\pi n^2 \left| (\ell - K)_{nc}^{-1} \right|^2$$

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:

- $(N,O)., EN$ $E_\lambda$ Resonance energy; units of energy (e.g., eV)
- $(N,TOT)., WID., RM$ $\Gamma_\lambda$ Total width; units of energy
- $(N,G),, WID., RM$ $\Gamma_{\lambda Y}$ 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: $= |\Gamma_{\lambda f_1}| + |\Gamma_{\lambda f_2}|$
- $(N,EL),, WID., RM$ $\Gamma_{\lambda n}$ Neutron width; units of energy
- $(N,EL),, WID/RED., RM$ $\Gamma_{(\ell)\lambda n}$ 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 \((1-RL^0)\) leads to the definition of the level matrix \(A\), which is given by:

\[
(A^{-1})_{\lambda\lambda'} = (E_\lambda - E) \delta_{\lambda\lambda'} - \frac{i}{2} \sum_c (\Gamma_{\lambda c})^2 (\Gamma_{\lambda' c})^2
\]

where \(c\) is channel number.

A Reduced neutron width for an s wave resonance is defined as:

\[
\Gamma_{\lambda n}^0 = 2\pi \Gamma_{\lambda n} E_j
\]

Vogt Resonance Parameters are entered under the quantity codes:

<table>
<thead>
<tr>
<th>Quantity Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>((N, O), EN)</td>
<td>(E_\lambda) Resonance energy; units of energy (e.g., eV)</td>
</tr>
<tr>
<td>((N, TOT), WID, VGT)</td>
<td>(\Gamma_\lambda) Total width; units of energy</td>
</tr>
<tr>
<td>((N, G), WID, VGT)</td>
<td>(\Gamma_{\lambda Y}) Capture width; units of energy (including all primary gamma decays not followed by neutron or charged-particle emission)</td>
</tr>
<tr>
<td>((N, F), 1, WID, VGT)</td>
<td>(\Gamma_{\lambda f_1}) Fission width for channel 1; units of energy</td>
</tr>
<tr>
<td>((N, F), 2, WID, VGT)</td>
<td>(\Gamma_{\lambda f_2}) Fission width for channel 2; units of energy</td>
</tr>
<tr>
<td>((N, EL), WID, VGT)</td>
<td>(\Gamma_{\lambda n}) Neutron width; units of energy</td>
</tr>
<tr>
<td>((N, EL), WID/RED)</td>
<td>(\Gamma_{\lambda n}^{(e)}) Reduced neutron width; units of energy * sqrt of energy</td>
</tr>
<tr>
<td>((N, O), PHS, VGT)</td>
<td>(\Phi_{\lambda_1 \lambda_j}) Relative phase of channel (\lambda_1) and (\lambda_j); units of angle</td>
</tr>
</tbody>
</table>

April 1980
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 residues G and H.

The resonance part of the reaction cross section (without Doppler Broadening) in the Adler-Adler formalism is given by:

\[ \sigma_\lambda (E) = \frac{1}{\sqrt{E}} \sum_k \frac{G_{r_k}}{v_k + H_{r_k}} \frac{(\mu_k - E)}{(\mu_k - E)^2 + v_k^2} \]

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:

\[(N,O)_{\lambda}, EN, AA \quad \mu_\lambda \quad \text{Resonance energy; units of energy (e.g., eV)}\]
\[(N,TOT)_{\lambda}, WID, AA \quad v_\lambda \quad \text{Corresponding to half the total width; units of energy}\]
\[(N,F)_{\lambda}, AG, AA \quad G_{\lambda f} \quad \text{Fission symmetry coefficient; in B*EV*RT-EV}\]
\[(N,F)_{\lambda}, AH, AA \quad H_{\lambda f} \quad \text{Fission asymmetry coefficient; in B*EV*RT-EV}\]
\[(N,G)_{\lambda}, AG, AA \quad G_{\lambda} \quad \text{Capture symmetry coefficient; in B*EV*RT-EV}\]
\[(N,G)_{\lambda}, AH, AA \quad H_{\lambda} \quad \text{Capture asymmetry coefficient; in B*EV*RT-EV}\]
\[(N,TOT)_{\lambda}, AG, AA \quad G_{\lambda} \quad \text{Total symmetry coefficient; in B*EV*RT-EV}\]
\[(N,TOT)_{\lambda}, AH, AA \quad H_{\lambda} \quad \text{Total asymmetry coefficient; in B*EV*RT-EV}\]

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 SPE.

For further details see:

- M.S. Koore, IN-1222, p. 199 (1969)
- D.E. Adler, F.T. Adler, ANL-6792, p. 695 (1963)
- 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(\(\text{92-U-235(N,TOT),,WID}\))
   \(2(\text{92-U-235(N,EL),,WID})\)
   \(3(\text{92-U-235(N,O),,J})\)

   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(\(\text{92-U-235(N,F),,SIG,,REL})\)
   \(2(\text{92-U-235(N,F),,SIG})\)

   with the pointers being repeated in the data-headings DATA 1 and DATA 2, and perhaps elsewhere.

   or REACTION 1((\(\text{92-U-235(N,F),,SIG})/(\text{79-AU-197(N,G),,SIG}))\)
   \(2(\text{92-U-235(N,F),,SIG})\)

   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(\(\text{39-Y-89(P,2N+P)39-Y-87-M,,SIG})\)
      \(G(\text{39-Y-89(P,2N+P)39-Y-87-G,,SIG})\)
      \(S(\text{39-Y-89(P,2N+P)39-Y-87-,,SIG})\) 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: \((\text{P,2N})\)
   \((\text{P,3N})\)
   \((\text{P,4N})\)

   Example 2: \((\text{N,A})\)
   \((\text{N,NA})\)

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.


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

The following special terms are defined for neutron yields from neutron-induced reactions or from spontaneous fission. For other neutron yields, see Multiplicity.

\( \bar{\nu} \) (nu-bar)

**Definition:** Average number of fission-neutron emitted per fission event

**Coding:**

- \( \bar{\nu}(N,F),NU \) neutron-induced fission nu-bar
- \( \bar{\nu}(O,F),PR,NU \) spontaneous fission prompt nu-bar
- \( \bar{\nu}(N,F),DL,NU \) neutron-induced fission delayed nu-bar
- \( \bar{\nu}(N,F+XN),NU \) probability for the emission of \( x \) neutrons from 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

\( \bar{\nu}(N,F)MASS,PR/PAR,NU \)

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

\( \eta \) (Eta)

**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 the average neutron yield per absorption.

**Coding:**

- for thermally fissile nuclei: \( \bar{\nu}(N,ABS),ETA \)
- in general: \( \bar{\nu}(N,NON),ETA \)
- eta at resonance: \( \bar{\nu}(N,ABS),ETA,RES \)

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:

\[
\eta = \sqrt{\frac{\sigma_f}{\sigma_a}}
\]
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.

October 1980
**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 NIS 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 'G-G-G' 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 not 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 stable 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.
Partial Reactions

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,
- 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 end product. 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)O-NN-1,EM,DA) Differential neutron emission cross-section

NDS X4 88/10
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 variable 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.

\[
(Z-S-A(P,A)Z'-S'-A',(DEF),SIG) \text{ or } (Z-S-A(P,2N+2P)Z'-S'-A',(DEF),SIG)
\]

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

\[
(Z-S-A(P,X)Z'-S'-A',SIG) \text{ should be used rather than } (Z-S-A(P,2N+2P)Z'-S'-A',UND,SIG)
\]
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).

\[ e = \frac{L-R}{L+R} = P_B A_y \]

where
- \( e \) = asymmetry
- \( P_B \) = polarization of incident particle beam
- \( A_y \) = analyzing power
- \( L^R, R \) = 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

KLS X4
**Basel 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 \( k(i) \times k(o) \), 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 \( k(i) \times k(o) \) 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 \( k(i) \times k(o) \) 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: \( A(b,c)D \); polarization is measured for a particle \( c \) emerging from a reaction between unpolarized particles \( A \) and \( b \).

See Reference 2 for more details.

November 1982
Depolarization Parameter (D): change in polarization due to scattering.

\[ P(\theta) = \frac{(A_y + Dp_B)}{(1 + p_B A_y)} \]

Rotation Parameter: measure of rotation of spin of scattered beam

\[ R = \frac{P(\theta)}{P_B} \]

Differential polarization:

\[ I = \frac{I}{P_o} P(\theta) \]

where \( I_o \) = differential cross section for an unpolarized beam

Spin-Correlation Parameters

\[ C_{NN}: \text{unpolarized beam; unpolarized target; outgoing particle spins normal to scattering plane; outgoing particles scattered right and left analyzed.} \]

\[ C_{NN} = \frac{1}{A_y^2} (LL)(RL)+(LR)(RR)-(LL)(RR)-(LR)(RL) \]

\[ A_{TY}: \text{polarized beam; polarized target; outgoing particle spins normal to scattering plane; asymmetry is measured.} \]

\[ e = \left| P_b \right| \left| P_c \right| A_{TY} \]

If time reversal holds: \( C_{NN} = A_{TY} \)

\[ C_{kp}: \text{unpolarized beam; polarized target; outgoing particle spins in scattering plane.} \]

\[ C_{kp} = \frac{1}{A_y^2} (LU)(RU)+(LD)(RD)-(LU)(RD)-(LD)(RU) \]
References


5. L. J. B. Goldfarb, Nuclear Phys. 7, 622 (1958)

6. A. Simon, Phys. Rev. 92, 1050 (1953)


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 emission 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 proposed as the need arises.)

Polarized incident-projectile source

Entries should be made under the Information-Identifier Keyword \texttt{?RX-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:

\texttt{INC-SOURCE (POLTR,LAMB) Polarized target and Lamb-shift ion source
Production Cross-Sections

**Definition:** The production cross section for a particle Y is defined as the sum 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 = \((n,n') + 2(n,2n) + 3(n,3n) + \ldots\)

For B-11 with 14 MeV neutrons:

- alfa-emission = \(n,\alpha + (n,\alpha) + 2(n,n+\alpha)\)

**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:**

- \((\ldots(P,X)O-G-O,,SIG)\) proton-induced gamma-production cross-section
- \((\ldots(N,X)O-NN-1,EM,SIG)\) neutron-induced neutron emission cross-section, excluding elastic scattering
- \((\ldots(N,X)O-NN-1,,SIG)\) neutron-induced neutron production cross-section, including elastic scattering
- \((\ldots(P,X)6-C-12,,SIG)\) 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:

\[
\text{REACTION } ((42-MO-98(N,TOT),,WID)•(42-MO-98(N,EL),,WID))
\]

\[
\text{ISO-QUANT } ((42-MO-98,TOT/WID)•(42-MO-98,EL/WID))
\]

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:

- \(oo\) = SO in modifier field for REACTION, in SF2 for QUANT keyword
- \(g,ag,2g,2ag\) = G,AG,2G,2AG in modifier field (for resonance parameters)
- \(a\) = A in modifier field (times natural isotopic abundance)
  or \((A)\) in modifier field (if unclear whether corrected for natural isotopic abundance)
- \(\sqrt{E}\) = RTE in modifier field
- \(4\pi\) = 4PI in modifier field
- \((-\cdots)^2\) = SQ in modifier field for REACTION, in SF2 for QUANT keyword
- \(\frac{4\pi}{cel}\) = RS in modifier field

See also Fitting Coefficients.
Quantum Numbers

The following refers primarily to resonance parameters of neutron data, 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 parameters 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 quantity-codes is used:

REACTION (N,O),L
REACTION (N,O),J
REACTION (N,O),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 statistical weight "g" 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 keyword "STAT-W G", or as

REACTION (N,O),SWG.

(If g is a factor of other resonance-parameter data, the quantity-modifier 'G' is used, see Dict. 34.)
Ratios of 2 or more reactions can be expressed as a reaction combination using the separator '/' (see page 8.REACTION.11)

Example: \(((3\text{-LI-6}(N,T)2\text{-HE-4},,\text{SIG})/(92\text{-U-235}(N,F),,\text{SIG}))\)

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 States.

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 Section 2, 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 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:
   \[ <e^{-n\sigma T}> = 1-n<\sigma_T> + \frac{n^2}{2} <\sigma_T^2> + \ldots. \]

2. reaction yields:
   \[ <y_r> = \frac{<(1-e^{-n\sigma T}) \sigma_T / \sigma^r>}{\sigma^r T} + \sum_{i=1}^{\infty} y_{r,i} \]

where: \(<...>\) denotes resolution broadening
\(n\) is the sample thickness in nuclei/barn
\(\sigma_T\) and \(\sigma^r\) 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 (\(n\sigma_T T < 1\)) the following simple relation with the (broadened) cross section exists:
\[ -\frac{1}{n} \ln <e^{-n\sigma T}> \sim <\sigma_T>, \frac{1}{n} <y_r> \sim <\sigma^r_T> \]

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 reaction.

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 section
   (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**.
The term "reaction rate" is widely used in nuclear fusion and astrophysics. The thermonuclear reaction rate is defined as cross-section times ion velocity averaged over the Maxwellian ion velocity distribution of the temperature $kT$:

$$< \sigma \cdot v > = \frac{\int_{0}^{\infty} (\sigma \cdot v) \exp(-mv^2/2kT) v^2 \, dv}{\int_{0}^{\infty} \exp(-mv^2/2kT) v^2 \, dv}$$

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 $\text{cm}^3/\text{sec}$ 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:


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 compilation 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.
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.
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).

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-maximum (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.
**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:

$$I_r = \int_{E_c}^{\infty} \sigma_r(E) \frac{dE}{E}$$

where $E_c = \text{cut-off energy near the lower limit of the epithermal region}$.

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 subtracted, 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 further detail see:

N.P. Baumann, DP-817 (1963)

J.J. Scoville and J.W. Rogers, IN-1195 (1968)
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 $\alpha$ 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:

$$I(\alpha) = \int_0^\infty \sigma(E) \frac{dE}{eV}$$

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

$$I = \int_0^\infty \sigma(E) \frac{dE}{E}$$

The realistic resonance integral ($\alpha \neq 0$) and the ideal resonance integral ($\alpha = 0$) are related by the formula:

$$I(\alpha) = I - 0.429 \sigma_0 \frac{\alpha}{(E/\text{eV})} + 0.429 \sigma_0 \frac{\alpha}{(2\alpha + 1)(E/\text{eV})}$$

where $\sigma_0 = 2200$ m/s cross-section

$E_r$ = "effective resonance-energy"
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.

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(α) for the realistic epithermal neutron spectrum, or whether appropriate corrections have been applied so that the value given is meant to be I₀ 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.)
Scattering

**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: (-----N,EL-----,DA)

   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 ($Q \neq 0$). 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

NDS X4 October 1980'
Scattering Amplitude

**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

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.
LEXFOR

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:

\[ \text{total (n, np)} = \text{partial (n, np)} + \text{partial (n, pn)} \]

The corresponding REACTION codes are:

\begin{align*}
\text{REACTION} \\
(1) & \quad \text{----(N,N+P)} --, \text{SIG} \\
(2) & \quad \text{----(N,N+P),SEQ,SIG} \\
(3) & \quad \text{----(N,P+N),SEQ,SIG} \\
\end{align*}

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:

\[ \text{REACTION } ((Z-S-A(N,N+P),,SIG)=(Z-S-A(N,P+N),SEQ,SIG)) \]

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:

\begin{align*}
(n,n') f \text{ cross section: } & \quad (N,N+F),SEQ,SIG \\
(n, r) f \text{ cross section: } & \quad (N,G+F),SEQ,SIG \\
\end{align*}

Emission of a primary \(\gamma\) followed by unidentified decays:

\begin{align*}
(n,\gamma X) \text{ cross section: } & \quad (N,G+X),SEQ,SIG \\
\end{align*}

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

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:

\[ \sigma_{sc}(E) = 4\pi k_o^2 g \left( \frac{\Gamma_n}{(E-E_o) + i\Gamma/2} + \frac{R'}{\omega_o} \right)^2 + 4\pi R'^2(1-g) \]

where: \[ 4\pi R'^2 = \sigma_{pot} \]

For reactions (capture, fission, etc.):

\[ \sigma_r(E) = \pi k_o^2 g \left( \frac{E_n}{E} \right)^{1/2} \left( \frac{E-E_o}{(E-E_o)^2 + (\Gamma/2)^2} \right) \frac{\Gamma_n \Gamma_r}{(E-E_o)^2 + (\Gamma/2)^2} \]

For further detail see:

A.M. Lane and R.A. Thomas, Rev. Mod. Phys. 30, 257 (1958)

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**

- 
- 
- 

Examples:

**REACTION**

- 
- 
- 

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:

\[ \Gamma_n = \frac{\Gamma}{\nu_f \sqrt{E_o / eV}} \]

where \( E_o \) is the resonance energy in eV.

\( \nu_f \) is the penetration factor of the nucleus.

Or more specifically:

**for s-wave resonances:** (\( \nu_f = 1 \)):

\[ \Gamma_n^0 = \frac{\Gamma}{\sqrt{E_o / eV}} \]  \hspace{1cm} (1)

**for p-wave resonances:**

\[ \Gamma_n^1 = \frac{\Gamma}{\sqrt{E_o / eV}} \left( 1 + \frac{1}{k_0^2 R^2} \right) \]  \hspace{1cm} (2)

where \( k_0 = \) 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 Quantum Numbers.

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:

\[ \Gamma_n^{(o)} = \frac{\Gamma_n}{\sqrt{E_o}} \]  

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:** \[ \sigma_o = 4\pi k^2 g \frac{\Gamma_n}{\Gamma} \]
- **partials:** \[ \sigma_{or} = \sigma_0 \frac{\Gamma_r}{\Gamma} \]

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: \[ A_{sc} = 2\pi^2 \alpha^2 \gamma_n \frac{\Gamma}{\Gamma} \]

   for other reactions: \[ A_{r} = 2\pi^2 \alpha^2 \gamma_n \frac{\Gamma}{\Gamma} \]

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., \(b\times eV\).

6. **Special representations** are coded as follows:

   \((---(---,F),,,WID,,SO)\) \(\sigma_0 \Gamma_f\)

   \((---(---,TOT),,,WID,,SQ/SO)\) \(\sigma_0 \Gamma^2\)

   \((---(---,EL),,,WID,,G)\) \(\gamma \Gamma_n\)

   \((---(---,EL),,,WID,,2G)\) \(2\gamma \Gamma_n\)

   \((---(---,EL),,,WID,,AG)\) \(a \gamma \Gamma_n\)

   \((---(---,EL),,,WID,,2AG)\) \(2a \gamma \Gamma_n\)

   where \(a = \) isotopic abundance

   See also **Average Resonance Parameters**.

7. The **statistical weight factor** \(\gamma\) 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

   \(\text{REACTION } (Z-S-A(N,O)Z,-S'-A',,,SWG)\)
Spallation

**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 specifying 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 neutrons
- **P-OUT** to specify the number of emitted protons
- **ELEMENT** to specify the product nucleus
- **MASS**

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.)
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:

\[
<\sigma> = \sigma_0 (g + rs) - \quad \text{(coded with the modifier SPA)}
\]

where

- \( \sigma_0 \) = cross-section at \( E_n = 0.0253 \text{ eV (2200 m/s)} \)
- \( g, s \) 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
- \( g \sigma_0 \) = Maxwellian average cross-section (coded with the modifier MXW)
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 not specified.
Standards

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 can 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:

<table>
<thead>
<tr>
<th>Reactions</th>
<th>Standard</th>
<th>Energy Range</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-H-1(N,EL)1-H-1</td>
<td>SIG and DA</td>
<td>1 keV to 20 MeV</td>
<td></td>
</tr>
<tr>
<td>2-HE-3(N,P)1-H-3</td>
<td>SIG</td>
<td>above 50 keV</td>
<td></td>
</tr>
<tr>
<td>3-LI-6(N,T)2-HE-4</td>
<td>SIG</td>
<td>above 100 keV</td>
<td></td>
</tr>
<tr>
<td>5-B-10(N,A)3-LI-7</td>
<td>SIG to gnd and 1st exc.st.</td>
<td>above 100 keV</td>
<td></td>
</tr>
<tr>
<td>6-C-12(N,EL)6-C-12</td>
<td>SIG and DA</td>
<td>above 2 MeV</td>
<td></td>
</tr>
<tr>
<td>25-MN-55(N,G)25-MN-56</td>
<td>SIG</td>
<td>thermal</td>
<td></td>
</tr>
<tr>
<td>27-CO-59(N,G)27-CO-60</td>
<td>SIG</td>
<td>thermal</td>
<td></td>
</tr>
<tr>
<td>79-AU-197(N,G)79-AU-198</td>
<td>SIG</td>
<td>thermal, 200 - 3500 keV</td>
<td></td>
</tr>
<tr>
<td>92-U-235(N,F)</td>
<td>SIG</td>
<td>100 keV - 20 MeV</td>
<td></td>
</tr>
<tr>
<td>98-CF-252(0,F)</td>
<td>NU and DE,N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 (preferably 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 PRELIM, it is removed. Therefore, the codes PRELIM 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, preferably 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 discretion 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 should not be used in the following cases:

1. When a data set extends beyond a known threshold, the broader definition, and only the broader definition, 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


October 1980
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 \(E_n\) 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 negligible, 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 metastable 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 SPS. See Relative.

3. Errors must have the same dimension (not necessarily the same units) as the quantity to which they refer or percent.

April 1980
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.
The wave-length of an incident neutron corresponds to the neutron-energy $E$:

$$E/\text{meV} = \frac{81.8}{(\lambda/A)^2}$$

<table>
<thead>
<tr>
<th>$\lambda$</th>
<th>$E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 $\AA$</td>
<td>81.8 meV</td>
</tr>
<tr>
<td>1.8 $\AA$</td>
<td>25.3 meV</td>
</tr>
<tr>
<td>2 $\AA$</td>
<td>20.5 meV</td>
</tr>
<tr>
<td>4 $\AA$</td>
<td>5.1 meV</td>
</tr>
<tr>
<td>6 $\AA$</td>
<td>2.3 meV</td>
</tr>
<tr>
<td>10 $\AA$</td>
<td>0.8 meV</td>
</tr>
</tbody>
</table>

The wave-length of the incident neutron is entered under the data-heading keyword EN with units ANGSTROM.

Note: If for whatever reason, the compiler converts the wave-length to neutron energy, this should be noted in the BIB-section.