MEMO CP/C-46

Date: October 23, 1978

From: V. McLane *CM*

Subject: Manual Update for REACTION, Variable Product Nucleus, Variable
            Number of Emitted Nucleons, Code 'UND'.

Reference: Memo CP-D/63, CP-D/64, CP-B/25, CP-C/45

    The enclosed is an attempt to consolate the above pending proposals
concerning the REACTION keyword into the EXFOR Manual.

    The following modifications have been made.

1.) The bulk of the variable product nucleus writeup has been moved
     to Section VI, 'Links between BIB, COMMON and DATA Sections.

2.) A rule for the order of process codes when more than one code is
     used is proposed; i.e., the same order as Dictionary 30.

3.) It was the concensus at the Paris meeting that spallation as
     process was not presently measurable and, therefore, removing
     'SPL' from SF3 was proposed.

4.) We propose the addition of 0-G-0 to Dictionary 27 with either
     a Z in Col. 15 or a new code (e.g.,G) in Col. 15 (other columns
     blank)

5.) Memo CP-D/63 was rearranged to make the definition section in
     SF3 more complete.

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Has been done.

VI

<u>Secondary Energy (Family E)</u> must be coded when:

a) SF3 for QUANTS or SF8 for reaction contains the modifier code PAR
b) SF2 for QUANTS or SP6 for REACTION contains the code DE or SPC
   See also <u>5.EN-SEC</u>, below.

<u>Angle of Outgoing Particle (Family G)</u> must be used when SF2 for QUANTS or SF6 for REACTION contains the code DA.

<u>Fission Product (Family I)</u> must be coded if SF4 for Reaction contains the codes ELEM and/or MASS. The corresponding codes must be entered in the data. See page VI.6 and LEXFOR <u>Reaction Product.</u>

<u>Legendre or cosine coefficients (Family N)</u> must be coded when SF2 for QUANTS or SF8 for REACTION contains the code LEG OR COS.

<u>Half-Life (Family 6)</u> must be coded if SF3 for QUANTS contains the code MS or GND, or if SF4 of the REACTION keyword contain a product with a metastable state entension (see page VIII.3), and the half-life is not coded under DECAY-DATA. See also LEXFOR <u>Half-lives</u> and <u>Examples.17.</u>

<u>Momentum (ℓ)(Family 2)</u> must be coded when SF2 for QUANTS or SF6 for REACTION contains the code RED.

2. <u>STANDARD/MONITOR</u>

STANDARD is used only in combination with the QUANTS and must be present when the Date-Heading Keyword STAND is coded.

If more than one standard is given STAND1, STAND2, etc., STAND1 refers to the first standard coded, STAND2 refers to the second, etc.

MONITOR is used only in combination with the keyword REACTION and must be present when the Data-Heading Keyword MONIT is coded.

If more than one monitor is given MONIT1, MONIT2, etc., MONIT1 refers to the first monitor, MONIT2 to the second, etc.

The Data-Heading Keywords EN-NRM, and ANG-NRM may be used only when the keyword STANDARD or MONITOR is present.

3. <u>ASSUMED</u>

When assumed values are given in the data under the Data-Heading Keyword ASSUM, they must be defined under the keyword ASSUMED. See also LEXFOR <u>Assumed Values.</u>

4. <u>INC-SPECT</u>

When the Data-Heading Keyword EN-DUMMY is used (i.e., when the quantity contains the modifier MXW, FIS or SPA), the spectrum must be defined in free text under the keyword INC-SPECT.

VI.6

Variable Product Nucleus

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 as variables in the data table.

In this case SF4 of the REACTION keyword contains the code:

ELEM - If the Z (Mass number) of the reaction product is given in the DATA table.

MASS - If the A (atomic weight) of the reaction product is given in the DATA table.

ELEM/MASS - If the Z and A of the reaction product are given in to COMMON section or DATA table.

The reaction products are then entered in the data table as variables under the column headings ELEMENT and/or MASS with units NO-DIM.

If the column-headings ELEMENT and MASS are present, a third column with the heading-keyword ISOMER is used when isomeric states are specified:

0. = ground-state(used only if nuclide has also an isomeric state)

1. = first metastable state
   or: the metastable state when only one is considered
2. = second metastable state

etc.

Decay-data for each entry under 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 column headings ELEMENT/MASS/(ISOMER) can be linked to entries under DECAY-DATA (and RAD-DET if present) by means of a "DECAY-FLAG" (see pages VI.5, VIII.D.1, and Lexfor Flags). - If the half-life is the only decay-data to be given, this can be entered in the DATA table under the heading HL.

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

XN - variable number of neutrons (see page VI.7)

YP - variable number of protons (see page VI.7)

See also LEXFOR Reaction Products

Variable Number of Emitted Nucleons

In the case where mass and element distributions of product nuclei have been measured and the Z and/or A of the reaction product acts as an independent variable, the sum of outgoing neutrons and protons may be entered as variables into the data table. In this case SF3 of the REACTION keyword contains at least one of the following codes:

XN - variable number of neutrons given in the data table.

YP - variable number of protons given in the data table.

The numerical values of the multiplicity factors X and Y are entered in the data table under the data headings N-OUT and P-OUT, respectively.

See also LEXFOR Particles.

In the case of isomeric ratios and sums the isomer code may consist of a combination of codes separated by a slash or a plus sign. The use of these separators will be algebraic, e.g., M1 + M2/G.

Note: The code "SUM" in SF6 is always given when the arithmetrical "+" appears in the isomer extension of the product nucleus in SF4. Similarly, "RAT" in SF6 is always given when the arithmetrical "/" appears in the isomer extension in SF4. A combination of a sum and a ratio would thus be coded:

(51-SB-123(N,G)51-SB-124M1+M2/T,,SIG/SUM/RAT)

See LEXFOR Isomeric Ratios and Sums

Examples: (92-U-235(N,F)54-XE-124,CUM,FY)
(39-Y-89(P,2N+P)39-Y-87-M/G,,SIG)
(28-NI-0(N,X)0-G-0,,SIG)

or c.) when SF3 includes the code F,X,XN or YP, and emission cross sections, product yields, etc, as in definition d) above, are given, the reaction product may be entered into the data table using the heading codes, ELEMENT, MASS and ISOMER (see page VI.6.) In this case SF4 contains the code:

ELEM   -   If the column-heading ELEMENT is used in the DATA table

MASS   -   If the column-heading MASS is used in the DATA table

ELEM/MASS - If the column-headings ELEMENT and MASS are used in either the COMMON section or the DATA table.

Example: (92-U-235(N,F)ELEM/MASS, CUM,FY)

VIII.R.2

REACTION

1. This keyword is used to specify data which is presented in the DATA Section in columns headed by DATA, RADIO and SUM (and similar headings such as DATA-MIN, DATA-MAX etc.)

2. One of the following keywords must be present, they are mutually exclusive: REACTION, ISO-QUANT, CMPD-QUANT, NUC-QUANT. This keyword must have coded information.

3. A reaction-unit consists of three major fields,

   (reaction, quantity, data-type)

   Embedded blanks within a Reaction unit are not permitted.

   The detailed coding for each field is given following

   a) Reaction field. The reaction field consists of 4 subfields, separated by commas or parentheses (not interchangeable).

   (SF1(SF2,SF3) SF4, quantity, data-type)

SF1. Target nucleus.

The general format of the code is:

either   Z-S-A-X, X may not have the value G, see page VIII.3 and VII.15 (Dictionary 27: Nuclides)

or   Z-S-CMP, see page VIII.3.

SF2. Incident particle.

This subfield contains:

either   a particle code from dictionary 28

or   for particles heavier than alpha, a code in the form Z-S-A (isomer field omitted), see page VIII.3 and VII.15 (Dictionary 27: Nuclides).

or   a compound code of the form Z-S-CMP, see page VIII.3.

SF3.   Process.

This subfield contains one of the following:

a) a process code from dictionary 30, e.g. TOT.

   In cases where mass or element distributions of product nuclei have been measured and the Z and/or A value acts as an independent variable, a variable sum of outgoing neutrons and protons may be indicated in SF3 using the process codes:

XN - If the column heading N-OUT is used in the DATA table.

YN - If the column heading P-OUT is used in the DATA table.

XN+YP - If the column headings N-OUT and P-OUT are used in the DATA table.
       Example: (P,XN+YP)

See also LEXFOR Particles

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b) a particle code from dictionary 29 which may be preceded by a
   multiplicity factor.

> Examples: A
>   4A

c) for particles heavier than alpha, a code in the form Z-S-A-X, see VIII.3
   (The atomic weight (A) may not have the value zero). No multiplicity
   factor is allowed; instead the nuclide code must be repeated, if necessary.

> Examples: 8-0-16
>   8-0-16+8-0-16

d) combinations of a), b) and c), with the codes connnected 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-X 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 particles are ordered in the sequence as the reaction proceeds.
(See LEXFOR Particles).

> Examples: HE3+8-0-16
>   A+XN+YP

Notes on SF3

Gammas are coded only:

- for a capture process, e.g., (P,G)
- when they are needed to define the partial reaction considered, e.g.,
  (N, G+F), SEQ

In all other cases, gammas are considered as self-evident and are, therefore,
not coded, e.g., (P,N) is coded, not (P,G+N). Compare SF7, Particle considered,
below.

If SF5 contains the branch code 'UND' (undefined), the particle codes given
in SF3 represent only the sum of emitted nucleons, implying that the product
nucleus coded in SF4 has been formed via different reaction channels. The
code '(DEF)' in SF5 denotes that it is not evident from the publication,
whether the reaction channel is undefined or defined.

For details see in LEXFOR 'Particles'.

Note: The code 'UND' is used presently only for charged particle reaction data.

SF4. Reaction Product

Definition: In general, the heaviest of the products defined for the
reaction product (also called residual nucleus) 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) It is undefined if SF3 contains the process code TOT,ABS or NON, or
if the reaction specifies a resonance parameter, as defined in
Dictionary 36 by a point in Col. 22.

c) It may be undefined if:

   - SF3 contains the process code F.

   - SF3 contains a combination of the process code X with a particle
     code, e.g., (P,G+X), SEQ.

   - the reaction is measured on a target of natural composition.

d) If SF3 contains the process code F,X,XN or YP, emission cross-sections,
production cross-sections or product-yields, etc, may be given for
specified nuclides, particles or gammas. The product considered is
then defined as Reaction Product, even if this is not the heaviest of
several reaction products.

Coding: This subfield

   either a.) is blank, cases b) and c) above. In this case the following
           comma must not be omitted.

           Examples: (92-U-235(N,F),,SIG)
                      (26-FE-56(N,EL),,WID)
                      (40-ZR-0(N,C),,SIG)

   or b.) contains a code in the form Z-S-A-X as described on page VIII.3.
           If light particles or gammas are defined as the reaction product,
           these are coded in SF4 using the Z-S-A formalism (i.e., the
           particle codes A,HE3,T,D,P,N,G are not used in SF4).

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b.) <u>Quantity field.</u> The coding consists of 4 subfields each separated by a comma.

(reaction, <u>SF5,SF6,SF7,SF8</u>,data-type)

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,SF8,data-type)

Only certain combinations of codes in the quantity field are meaningful. These are listed in <u>dictionary 36.</u> 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 of certain general quantity modifiers which are not entered into the dictionary (see LEXFOR <u>General Quantity Modifiers).</u>

<u>SF5. Branch.</u>
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.

<u>Note:</u> The code 'RAT' is always given in SF6 when SF5 contains the codes BIN/TER or TER/BIN.

<u>SF6. Parameter.</u>
Code(s) from dictionary 32.
This subfield contains information about the reaction-parameter given, such as integral or differential cross-section.

<u>SF7. Particle considered.</u>
Code(s) from dictionary 33.
This subfield provides particle code(s) indicating to which of several outgoing particles the quantity refers.

The particle-designator can be omitted if there is no ambiguity. For integral data this subfield will usually be empty.

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.

<u>SF8. Modifier.</u>
Code(s) from dictionary 34.
This subfield contains information on the representation of the data, for example relative data, fitting coefficients, etc.

c.) <u>Data-type field.</u>

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 quantity-field, may also be ommitted.
E.g. (reaction,,SF6).

This field indicates whether the data given are experimental, theoretical, evaluated etc. If the field is omitted, the data are experimental.

See also LEXFOR <u>Data Type.</u>