MEMORANDUM 4C-2/41

Date: 12th July 1973
From: F.H. Fröhner and H. Potters
Subject: Tables

After consideration of the suggestions made at the last Four-Centre meeting ("Brookhaven proposal" 4C-1/33, "Vienna proposal) and the recent Brookhaven memo 4C-1/38 on two-dimensional tables, we now propose new rules for the coding of tables in EXFOR. Care has been taken to make them compatible with existing rules.

1. Basic table structure

A table can be considered as a representation of a functional relationship of the form $y = y(x)$, where in the most general case both x and y are vectors. The independent-variable vector x describes the experimental conditions under which the result expressed by the dependent-variable vector y was measured.

The most general table in EXFOR consists of

- a row of values (numbers with headings) in COMMON,
- columns with headings like EN, ANGLE, etc. for independent variables, followed by
- columns with the heading DATA or RATIO for the dependent variables (and occasionally columns for additional related information such as STANDARD, MISC), followed by
- columns with the heading FLAG in the DATA section.

The number of COMMON values and of columns in each of the three sections of the DATA table are not restricted except by practical considerations such as legibility of the print-out.

2. Independent variables

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 can apply only to main columns (those with headings like EN, ANGLE, etc.) but not to associated columns (those with headings like EN-ERR, ANGLE-RSL, etc.). Values in a main column must increase monotonically until the value in the preceding main column changes or the end of the table is reached.

Example 1

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

A slight complication arises with groups 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 monotony rule applies to the sequence of numbers consisting of the first (left-most) non-blank value within the group on each line.

Example 2

⋮

DATA

EN	E-LVL	E-LVL	E-LVL	E-LVL-MIN	E-LVL-MAX	DATA
MEV	MEV	MEV	MEV	MEV	MEV	B
3.0	0.405					-
3.0	0.506					-
3.0	0.720	0.725				-
3.0	0.81					-
3.0	0.990	0.998	1.02			-
3.0	1.202	1.215				-
3.0				1.250	1.300	-
3.0	1.400	1.412				-
4.5	0.405					-

⋮

ENDDATA

At the Moscow Four-Centre meeting the concept of hierarchy was developed for independent variables and independent-variable groups, and hierarchy flags were proposed. In order to avoid confusion with the pointers to be introduced in the next section we prefer not to use hierarchy flags in the tables but to flag the table-heading keywords in Dictionary 24. An appropriate memo is in course of preparation.

3. Dependent variables: multiple ISO-QUANT, pointers

The meaning of the dependent-variable columns is defined by the ISO-QUANT vector. The ISO-QUANT vector follows the keyword ISO-QUANT in the BIB-section. It consists of all the tabulated ISO-QUANTs, separated by commas and enclosed in parentheses. Each ISO-QUANT must begin on a new line, preceded by a character in column 11 pointing to the appropriate DATA (or RATIO) column: 1 to 9 for the first nine, A, B, C, etc. for subsequent DATA columns, blank if the ISO-QUANT refers to the whole table. For ease of recognition, the DATA column headings should be sequentially tagged in the same way (one character in the 11th column) whenever 11th column pointers occur somewhere else in the SUBENTRY.

Note: The pointers introduced here (and in a wider context in section 5 below) have always the same simple meaning: they give the serial number of a column in the middle section of the table (middle section: all columns except those for independent variables and flags).

Example 3

```
  :

ISO-QUANT 1((79-AU-197,EN,RES),
          3 (79-AU-197,TOT,WID),
          4 (79-AU-197,EL/WID,,2G),
          5((79-AU-197,NG/WID)*(79-AU-197,EL/WID)/(79-AU-197,TOT/WID)))

  :

DATA      1DATA-ERR  2DATA      3DATA      4DATA      5
EV         EV         MILLI-EV   MILLI-EV   MILLI-EV

  :
```

Besides showing the use of a multiple ISO-QUANT and of pointers, this example illustrates another rule: in resonance parameter tables the heading EN-RES should be replaced by DATA plus the ISO-QUANT (...,EN,RES) in order to avoid formal difficulties when the resonance energy is the only quantity listed on a line.

The whole ISO-QUANT vector must refer to a single nuclide. If data for more than one nuclide are tabulated, Z and/or A could be treated as independent variable(s), as explained in section 7 ("Possible future extensions").

4. Flags

The last columns of a table are reserved for flags. The data heading keyword FLAG can be used more than once. The numerical flags entered in these columns have the same meaning in each column as given after the keyword FLAG in the BIB-section.

Example 4

```
SUBENT
BIB
ISO-QUANT 1((54-XE-128,EN,RES),
          2 (54-XE-128,EL/WID))
FLAG        (1.) DOUBLET
            (2.) XE-126 ALSO POSSIBLE
            (3.) UNCERTAIN
ENDBIB
NOCOMMON
DATA
DATA      1DATA      2FLAG       FLAG
EV         MILLI-EV   NO-DIM      NO-DIM
 -           -          2.
 -           -          1.          2.
 -           -
 -           -          2.
 -           -          3.
ENDDATA
ENDSUBENT
```

5. Pointers for COMMON, COMMENT, etc.

The COMMON section may contain, under the appropriate DATA headings

- numeric values (numbers plus headings) common to the table as a whole;

- numeric values common to individual columns of the table

Pointers of the same type as introduced for the multiple ISO-QUANT serve to distinguish the two groups: a blank in the 11th column of the data heading field characterizes a value common to the whole table, 1, 2, ... 9, A, B, ... characterize values common to the corresponding DATA (or RATIO) column.

Analogous 11th column pointers can be used to link visually other BIB keywords such as COMMENT, FLAG, METHOD, etc. with specific DATA columns. Whenever pointers are used, the DATA (or RATIO) columns must be numbered.

One ISO-QUANT, comment, etc. can be linked with more than one column by the use of multiple pointers as shown in Example 5.

Example 5

```
  ⋮
BIB
ISO-QUANT 1((92-U-235,EN,RES),
          2 (92-U-235,J),
          3 (92-U-235,TOT/WID),
          4 (92-U-235,NF/WID))
  ⋮
ANALYSIS  1(SHAPE,MLA) MULE CODE
          2
          3
          4(AREA,SLA) TACASI CODE
  ⋮
ENDBIB
  ⋮
COMMON
MOMENTUM L DATA-ERR  3DATA-ERR  4
NO-DIM     PER-CENT   PER-CENT
0.         5.         8.
ENDCOMMON
  ⋮
DATA
DATA      1DATA      2DATA      3DATA      4
EV         NO-DIM     MILLI-EV   MILLI-EV
  ⋮
ENDDATA
```

6. Two-dimensional tables

The rules set forth in sections 1 - 5 allow a great deal of flexibility. Consider the following table, of a structure which is frequently encountered in the literature :

E_n (keV)	$d\sigma/d\Omega$ (mb/sr) θ = 10°	20°	30°
1.	11.0±1.1	12.0±1.2	13.0±1.3
2.	21.0±2.1	22.0±2.2	23.0±2.3
3.	31.0±3.1	32.0±3.2	33.0±3.3

Straightforward application of the rules would result in the following table :

Example 6

```
  :
NOCOMMON
DATA
```

EN	ANGLE	DATA	DATA-ERR
KEV	ADEG	MB/SR	MB/SR
1.	10.	11.	1.1
1.	20.	12.	1.2
1.	30.	13.	1.3
2.	10.	21.	2.1
2.	20.	22.	2.2
2.	30.	23.	2.3
3.	10.	31.	3.1
3.	20.	32.	3.2
3.	30.	33.	3.3

```
ENDDATA
```

A clever compiler would realize that the rules permit a representation which is much more similar to, and even more compact than, the table published by our hypothetical author (who evidently overlooked the fact that all the errors are 10%). He would code the table as shown in Example 7:

Example 7

```
  :
ISO-QUANT  ( ... )
  :
COMMON
DATA-ERR     ANGLE      1ANGLE      2ANGLE      3
PER-CENT     ADEG        ADEG        ADEG
10.          10.         20.         30.
ENDCOMMON
DATA
EN           DATA       1DATA       2DATA       3
KEV          MB/SR       MB/SR       MB/SR
1.           11.         12.         13.
2.           21.         22.         23.
3.           31.         32.         33.
ENDDATA
```

The absence of a pointer after the keyword ISO-QUANT indicates that the ISO-QUANT refers to all the DATA columns in the table.

Note that the rather similar table given as Example 1 could not have been compiled in this form.

7. Possible future extensions

There are two further extensions which might be considered: more than one nuclide in a table and incident particles other than neutrons.

(a) More than one nuclide in the table

In order to show that the above proposals do not impede further extensions, we should like to show a possible solution without making a definite proposal yet. We define two new data heading keywords 'Z' and 'A', to be distinguished from 'ELEMENT' and 'MASS' which should always apply to nuclides other than target nuclides. Let us assume that (n,p) and (n,alpha) differential cross sections have been measured for a series of nuclides. If we would like to represent these data in one table this should look as follows:

Example 8

```
  :
ISO-QUANT 1((Z-S-A,NP,DA),
          2 (Z-S-A,NA,DA))
  :
COMMON
DATA-ERR  1DATA-ERR  2
PER-CENT   PER-CENT
20.         30.
ENDCOMMON
DATA
Z           A          EN        ANGLE      DATA      1DATA      2
NO-DIM      NO-DIM     MEV       ADEG       MB/SR      MB/SR
  :
ENDDATA
```

Z-S-A in ISO-QUANT means that Z and A are in the data table. Likewise, 54-XE-A indicates that A is in the data table (e.g. for resonance parameters).

(b) Incident particles other than neutrons

A short remark only. For heavy-ion it may turn out that the usual particle designation will not be sufficient any longer and that ISO-fields have to be used for incoming and maybe also for outgoing particles. This may result in breaking up the reaction code in an incident particle field and one or more outgoing particle fields: (Z-S-A,PI,PF1/PF2/...,...), each particle being described in the form Z-S-A whenever no particle designation exists.

F.H. Fröhner

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