**Nuclear Data Section**

**International Atomic Energy Agency**

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**Memo CP-D/984**

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**To:** Distribution

**From:** N. Otsuka, O. Schwerer

**Subject: Data set with several variable nuclei**

**1. Total ternary fission charge yield for fragment pair specified**

Recently 252Cf(sf) ternary fission charge yields measured with the US Gammasphere spectrometry have been transmitted in PRELIM.1457 (14331.008 to 010, which will replace 41464.004 to 005). These data sets give charge yields characterized by the charges of all three fragments before β decay without mass specification (though the authors assume the majority of are from 4He for Z=2, 10Be for Z=4, and 14C for Z=6). The data table should be like

COMMON 2 3 14331 8 9

ELEM2 14331 8 10

NO-DIM 14331 8 11

 2. 14331 8 12

ENDCOMMON 3 0 14331 8 13

DATA 3 10 14331 8 14

ELEM1 DATA DATA-ERR 14331 8 15

NO-DIM PC/FIS PC/FIS 14331 8 16

 38. 3.3 1.0 14331 8 17

 40. 14. 3. 14331 8 18

 42. 13. 2.6 14331 8 19

 44. 3.2 0.4 14331 8 20

 46. 0.18 0.025 14331 8 21

…

ENDDATA 12 0 14331 8 27

ENDSUBENT 26 0 14331 899999

(N.B. It is redundant to give the charge or yield of the third fragment since the total charge of the three fragments are always 98.).

Dict. 236 defines IND/TER/CRN,FY for FY(Z1,A1,Z2,A2,Z3,A3) before β decay (c.f. EXFOR 13751.003). EXFOR 14331.008 to 010 gives FY(Z1,Z2,Z3) before β decay, and we propose a new quantity code CHG/TER/CRN,FY. To be consistent with these quantity codes, we also propose replacing TER/CHG,FY with CHG/TER,FY in Dict.236 (11 data setts in 4 entries are affected.)

**Dictionary 236 (Quantities)**

CHG/TER/CRN,FY Total element yield of ternary fission product pair specified

TER/CHG,FY (*Obsolete*)

CHG/TER,FY Total element yield of ternary fission product

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Reaction Type** | **Dimension** | **Subentry** |
| CHG/TER/CRN,FY | FY | NO | 14331.008,009,010 |
| CHG/TER,FY | FY | NO | 30317.003 |

**2. Charge yield coded without CHG in REACTION SF5**

We extracted all fission yield (SF6= \*FY\* ) data sets where REACTION SF4=ELEM but CHG is not in SF5. CHG must replace IND in several subentries:

|  |  |  |
| --- | --- | --- |
| **Subent #** | **REACTION** | **Remark** |
| 13648.008 | 98-CF-252(0,F)ELEM,IND/CRN,FY | IND/CRN -> CHG. Delete ELEM1 or ELEM2 (redundant) |
| 21743.006 | 98-CF-252(0,F)ELEM,IND,FY | IND -> CHG |
| 21743.007 | 90-TH-229(N,F)ELEM,IND,FY,,MXW | IND -> CHG |
| 21919.002 | 90-TH-229(N,F)ELEM,IND,FY/DE,,MXW/REL | IND -> CHG |
| 21919.003 | 90-TH-229(N,F)ELEM,IND,FY,,MXW | IND -> CHG |
| 21919.004 | 92-U-232(N,F)ELEM,IND,FY/DE,,MXW/REL | IND -> CHG |
| 21919.005 | 92-U-232(N,F)ELEM,IND,FY,,MXW | IND -> CHG |
| 30418.003.2 | 98-CF-252(0,F)ELEM,IND/TER,FY | Add SF8=MSC. PC/FIS -> ARB-UNITS for DATA and DATA-ERR (charge yield per ternary fission). |
| O1012.002 | 82-PB-208(92-U-238,F)ELEM,IND,FY | IND -> CHG |
| O1012.004 | 4-BE-9(92-U-238,F)ELEM,IND,FY | IND -> CHG |

N.B. CHG is used only when FY in SF6. When a production *cross section* is characterized with a Z number and the product is before β-decay or stable, CHG is omitted (like IND).

**3. ELEM and/or MASS for several variable nuclei**

Headings like ELEM1, ELEM2, MASS1 or MASS2 are used when there are two or more variable nuclei. We propose requirement of such headings depending on the codes in REACTION SF4 and SF5 as follows:

|  |  |  |
| --- | --- | --- |
|  | CRN is not in SF5 | CRN is in SF5 |
| SF4 | ELEM | MASS | ELEM/MASS | ELEM | MASS | ELEM/MASS |
| ELEM | X |  | X |  |  |  |
| MASS |  | X |  |  |  |
| ELEM1 |  |  |  | X |  | X |
| MASS1 |  |  |  |  | X |
| ELEM2 |  |  |  | X |  | X |
| MASS2 |  |  |  |  | X |
| ELEM3 |  |  |  | (X) |  | (X) |
| MASS3 |  |  |  |  | (X) |

X: Presence is obligatory. (X): Presence is optional.

All data sets using the heading ELEMn or MASSn (n=1,2 or 3) are listed in the appendix of this memo. Proper use of such headings is seen only when SF6=FY except for a few cases, and we propose to limit their use only when SF6=FY.

Update of LEXFOR and EXFOR Formats Manual are proposed below:

Proposed update of the LEXFOR “**Fission Yields**”

**Yields of Correlated Fragment Pairs (*Revised*)**

The independent yield of a correlated pair is entered under the field headings such as ELEM1, MASS1, ELEM2 or MASS2.

**REACTION coding**: IND/CRN in SF5.

***Examples:***

(1) Independent yield of a correlated fragment pair

BIB

REACTION (...(N,F)ELEM/MASS,IND/CRN,FY)

...

ENDBIB

COMMON

ELEM1 ELEM2

NO-DIM NO-DIM

 56. 42.

ENDCOMMON

DATA

MASS1 MASS2 DATA

NO-DIM NO-DIM PC/FIS

 138. 104. ...

 138. 105. ...

 ... ... ...

ENDDATA

(2) Independent yield of a correlated fragment pair (ternary fission)

BIB

REACTION (...(N,F)ELEM/MASS,IND/TER/CRN,FY)

...

ENDBIB

COMMON

ELEM1 ELEM2 ELEM3 MASS3

NO-DIM NO-DIM NO-DIM NO-DIM

 56. 42. 2. 4.

ENDCOMMON

DATA

MASS1 MASS2 DATA

NO-DIM NO-DIM PC/FIS

 138. 104. ...

 138. 105. ...

 ... ... ...

ENDDATA

(3) Charge yield of a correlated fragment pair (ternary fission)

BIB

REACTION (...(N,F)ELEM,CHG/TER/CRN,FY)

...

ENDBIB

COMMON

ELEM1

NO-DIM

 2.

ENDCOMMON

DATA

ELEM2 DATA

NO-DIM PC/FIS

 56. ...

 56. ...

 ... ... ...

ENDDATA

***Note:***

The mass and charge numbers are given without redundancy. For example, (1) MASS1 and MASS2 are not used when the mass of one fragment can be determined by the mass of the other fragment for the primary fission yield in a binary fission, (2) ELEM1 and ELEM2 are not used when the charge of one fragment can be determined by the charge of the other fragment for the charge yield in a binary fission.

Proposed addition to LEXFOR “**Reaction Product**”

**Variable Product**

The reaction product maybe a variable of the data table (See EXFOR Formats Manual Chapter 6: Variable nucleus). When the quantity is for a correlated pair of reaction products, they are entered under headings such as ELEM1 and MASS1 with CRN in REACTION SF5. The following table summarises presence of the headings characterizing variable product depending on REACTION SF4 and SF5:

|  |  |  |
| --- | --- | --- |
|  | CRN is not in SF5 | CRN is in SF5 |
| SF4 | ELEM | MASS | ELEM/MASS | ELEM | MASS | ELEM/MASS |
| ELEM | X |  | X |  |  |  |
| MASS |  | X |  |  |  |
| ELEM1 |  |  |  | X |  | X |
| MASS1 |  |  |  |  | X |
| ELEM2 |  |  |  | X |  | X |
| MASS2 |  |  |  |  | X |
| ELEM3 |  |  |  | (X) |  | (X) |
| MASS3 |  |  |  |  | (X) |

X: Presence is obligatory. (X): Presence is optional

Use of CRN in REACTION SF5 is allowed only for fission yields (i.e., FY is in SF6).

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**Presence of ELEM1, ELEM2, ELEM3, MASS1, MASS2 or MASS3 in EXFOR Master Ver. 2019-09-19**

(Z1 = ELEM1, A1 = MASS1 etc.)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Subent #** | **Z1** | **Z2** | **Z3** | **A1** | **A2** | **A3** | **REACTION** | **Remark** |
| 13066.003 | x | x |  | x | x |  | (((92-U-235(N,F)ELEM/MASS,CUM,FY,,SPA)/(92-U-235(N,F)42-MO-99,CUM,FY,,SPA))//((92-U-235(N,F)ELEM/MASS,CUM,FY,,MXW)/(92-U-235(N,F)42-MO-99,CUM,FY,,MXW)) | Delete. Average of R-values of (Z1,A1) and (Z2,A2). |
| 13066.004 | x | x | x | x | x | x | (((92-U-235(N,F)ELEM/MASS,CUM,FY,,SPA)/(92-U-235(N,F)42-MO-99,CUM,FY,,SPA))//((92-U-235(N,F)ELEM/MASS,CUM,FY,,MXW)/(92-U-235(N,F)42-MO-99,CUM,FY,,MXW)) | Delete. Average of R-values of (Z1,A1), (Z2,A2) and (Z3,A3). |
| 13092.002 | x | x |  | x | x |  | ((92-U-235(N,F)ELEM/MASS,CUM,FY)/(92-U-235(N,F)42-MO-99,CUM,FY))//((92-U-235(N,F)ELEM/MASS,CUM,FY,,MXW)/(92-U-235(N,F)42-MO-99,CUM,FY,,MXW)) | Delete. Average of R-values of (Z1,A1) and (Z2,A2). |
| 13599.002 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13599.003 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) |
| 13648.002 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13648.003 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13648.004 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13648.005 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13648.006 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13648.008 | x | x |  |  |  |  | (98-CF-252(0,F)ELEM,IND/CRN,FY) | Z1 or Z2 is redundant (Z(L)+Z(H)=98). Use CHG instead of IND/CRN? |
| 13648.009 | x | x |  |  |  |  | (98-CF-252(0,F)ELEM,PR,NU) | Z1 or Z2 is redundant (Z(L)+Z(H)=98). |
| 13698.002 | x | x | x | x | x | x | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) | Ok |
| 13698.003.1 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.003.2 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.004.1 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.004.2 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.005.1 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.005.2 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.006.1 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13698.006.2 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13747.002 | x | x |  | x | x |  | (94-PU-242(0,F)ELEM/MASS,IND/CRN,FY,,REL) | Ok |
| 13747.003 | x | x |  | x | x |  | (94-PU-242(0,F)ELEM/MASS,IND/CRN,FY,,REL) |
| 13749.002 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13751.002 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 13751.003 | x | x | x | x | x | x | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 13751.004 | x | x | x | x | x | x | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 13807.002 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/CRN,FY) | Ok |
| 14197.003 |  |  |  | x | x |  | (92-U-235(N,F)MASS,PRE,MLT,G,MXW) | A1 or A2 is redundant (A(L)+A(H)=236). SF6 must be FY.  |
| 14197.004 |  |  |  | x | x |  | (92-U-235(N,F)MASS,PRE,KE,G,MXW) | A1 or A2 is redundant (A(L)+A(H)=236). |
| 14286.004 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,NUM,FY,G) | Two fragments are specified. Add MSC in SF8. |
| 14286.005 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,NUM,FY,G) |
| 14331.002 | x | x | x | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) | Delete CRN in SF5, but add MSC in SF8. A of LCP is not specified. |
| 14331.003 | x | x | x | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 14331.004 | x | x | x | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 14331.005 | x | x | x | x | x |  | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 14331.006 | x | x |  | x |  |  | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 14331.007 | x | x |  | x |  |  | (98-CF-252(0,F)ELEM/MASS,IND/TER/CRN,FY) |
| 22925.003 | x | x |  | x | x |  | ((98-CF-252(0,F)ELEM/MASS,QTR,FY)/(98-CF-252(0,F)2-HE-4,TER,FY)) | Delete these data sets. It involves LCP break-up products, and cannot be defined well within the current EXFOR rule. |
| 22925.005 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,QTR,KE) |
| 22925.007 | x | x |  | x | x |  | ((92-U-233(N,F)ELEM/MASS,QTR,FY,,MXW)/(92-U-233(N,F)2-HE-4,TER,FY,,MXW)) |
| 22925.009 | x | x |  | x | x |  | (92-U-233(N,F)ELEM/MASS,QTR,KE,,MXW) |
| 22925.011 | x | x |  | x | x |  | ((92-U-235(N,F)ELEM/MASS,QTR,FY,,MXW)/(92-U-235(N,F)2-HE-4,TER,FY,,MXW)) |
| 22925.013 | x | x |  | x | x |  | (92-U-235(N,F)ELEM/MASS,QTR,KE,,MXW) |
| 22925.014 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,QTR,FY) |
| 23213.009 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,,KE,LF+HF,MSC) | Add SF5=SEC (c.f. footnote of Table 1). α and A(L) specified. |
| 23213.011 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,TER,KE,G,MSC) | Ok. α and A(L) specified. |
| 23213.013 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,PR/TER,NU,,MSC) | Ok. α and A(L) specified. |
| 23213.015 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,PR/FRG,NU,,MSC) | Ok. α and A(L or H) specified. |
| 23213.017 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,PRE,FY,,MSC) | Ok. α and A(L or H) specified. |
| 23213.028 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,PR/TER,NU,,MSC) | Ok. α and A(L) specified. |
| 41030.018 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,CHN,FY,,MSC) | Ok. t and A(L or H) specified. |
| 41030.019 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,CHN,FY,,MSC) | Ok. α and A(L or H) specified. |
| 41030.020 |  | x |  | x | x |  | (98-CF-252(0,F)MASS,CHN,FY,,MSC) | Ok. 6He and A(L or H) specified. |
| 41084.004 | x | x |  |  |  |  | (94-PU-239(N,F)ELEM/MASS,CUM,FY,,FST) | ELEM1, ELEM2 -> ELEMENT |
| 41084.007 | x | x |  |  |  |  | (92-U-235(N,F)ELEM/MASS,CUM,FY,,FST) |
| 41464.004 | x | x |  |  | x |  | (98-CF-252(0,F)ELEM,TER/CHG,FY) | Delete this data set. US data in 14331.008. |
| 41464.005 | x | x |  |  | x |  | (98-CF-252(0,F)ELEM,TER/CHG,FY) | Delete this data set. US data in 14331.009. |
| 41464.006 | x | x |  |  | x |  | (98-CF-252(0,F)ELEM,TER/CHG,FY) | Delete this data set. US data in 14331.010. |
| 41536.002 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,QTR,FY,,REL) | ? A and Z of two LCP specified. |
| 41536.003 | x | x |  | x | x |  | (96-CM-248(0,F)ELEM/MASS,QTR,FY,,REL) | ? A and Z of two LCP specified. |
| 41536.004 | x | x |  | x | x |  | (98-CF-252(0,F)ELEM/MASS,QTR,FY) | ? A and Z of two LCP specified. |
| 41536.005 | x | x |  | x | x |  | (96-CM-248(0,F)ELEM/MASS,QTR,FY) | ? A and Z of two LCP specified. |
| 41610.005 | x | x |  | x | x |  | ((98-CF-252(0,F)ELEM/MASS,QTR,FY,,MSC)/(98-CF-252(0,F)2-HE-4,TER,FY)) | Ok. A and Z of two LCP specified. |
| C1581.010 | x | x |  |  |  |  | (1-H-1(6-C-12,X)ELEM,,SIG) | ELEM1, ELEM2 -> ELEMENT |
| C1581.011 | x | x |  |  |  |  | (6-C-0(6-C-12,X)ELEM,,SIG) |
| C1581.012 | x | x |  |  |  |  | (13-AL-27(6-C-12,X)ELEM,,SIG) |
| C1581.013 | x | x |  |  |  |  | (29-CU-0(6-C-12,X)ELEM,,SIG) |
| C1581.014 | x | x |  |  |  |  | (50-SN-0(6-C-12,X)ELEM,,SIG) |
| C1581.015 | x | x |  |  |  |  | (82-PB-0(6-C-12,X)ELEM,,SIG) |
| C1581.016 | x | x |  |  |  |  | (1-H-1(6-C-12,X)ELEM,,SIG) |
| C1581.017 | x | x |  |  |  |  | (6-C-0(6-C-12,X)ELEM,,SIG) |
| C1581.018 | x | x |  |  |  |  | (13-AL-27(6-C-12,X)ELEM,,SIG) |
| C1581.019 | x | x |  |  |  |  | (29-CU-0(6-C-12,X)ELEM,,SIG) |
| C1581.020 | x | x |  |  |  |  | (50-SN-0(6-C-12,X)ELEM,,SIG) |
| C1581.021 | x | x |  |  |  |  | (82-PB-0(6-C-12,X)ELEM,,SIG) |
| C1581.022 | x | x |  |  |  |  | (1-H-1(6-C-12,X)ELEM,,SIG) |
| C1581.023 | x | x |  |  |  |  | (6-C-0(6-C-12,X)ELEM,,SIG) |
| C1581.024 | x | x |  |  |  |  | (13-AL-27(6-C-12,X)ELEM,,SIG) |
| C1581.025 | x | x |  |  |  |  | (29-CU-0(6-C-12,X)ELEM,,SIG) |
| C1581.026 | x | x |  |  |  |  | (50-SN-0(6-C-12,X)ELEM,,SIG) |
| C1581.027 | x | x |  |  |  |  | (82-PB-0(6-C-12,X)ELEM,,SIG) |
| C1581.028 | x | x |  |  |  |  | (1-H-1(6-C-12,X)ELEM,,SIG) |
| C1581.029 | x | x |  |  |  |  | (6-C-0(6-C-12,X)ELEM,,SIG) |
| C1581.030 | x | x |  |  |  |  | (13-AL-27(6-C-12,X)ELEM,,SIG) |
| C1581.031 | x | x |  |  |  |  | (29-CU-0(6-C-12,X)ELEM,,SIG) |
| C1581.032 | x | x |  |  |  |  | (50-SN-0(6-C-12,X)ELEM,,SIG) |
| C1581.033 | x | x |  |  |  |  | (82-PB-0(6-C-12,X)ELEM,,SIG) |
| C1581.034 | x | x |  |  |  |  | (1-H-1(6-C-12,X)ELEM,,SIG) |
| C1581.035 | x | x |  |  |  |  | (6-C-0(6-C-12,X)ELEM,,SIG) |
| C1581.036 | x | x |  |  |  |  | (13-AL-27(6-C-12,X)ELEM,,SIG) |
| C1581.037 | x | x |  |  |  |  | (29-CU-0(6-C-12,X)ELEM,,SIG) |
| C1581.038 | x | x |  |  |  |  | (50-SN-0(6-C-12,X)ELEM,,SIG) |
| C1581.039 | x | x |  |  |  |  | (82-PB-0(6-C-12,X)ELEM,,SIG) |
| C1581.040 | x | x |  |  |  |  | (1-H-1(6-C-12,X)ELEM,,SIG) |
| C1581.041 | x | x |  |  |  |  | (6-C-0(6-C-12,X)ELEM,,SIG) |
| C1581.042 | x | x |  |  |  |  | (13-AL-27(6-C-12,X)ELEM,,SIG) |
| C1581.043 | x | x |  |  |  |  | (29-CU-0(6-C-12,X)ELEM,,SIG) |
| C1581.044 | x | x |  |  |  |  | (50-SN-0(6-C-12,X)ELEM,,SIG) |
| C1581.045 | x | x |  |  |  |  | (82-PB-0(6-C-12,X)ELEM,,SIG) |
| D0545.003 | x | x |  | x | x |  | (6-C-12(6-C-16,X)ELEM/MASS,,SIG) | Add MSC in SF8. SF6 is not FY. |