Simplification of Coding Rule for Independent Data (SF5=IND, M-)

(N. Otsuka, 2019-04-12, Memo CP-D/977 Rev.)

LEXFOR "Independent and Cumulative Data" asks compiler to distinguish between

a) no precursor decay exists ("shielded"),

b) precursor decay contribution exists but corrected (subtracted),

and use IND or M- for the latter case only. In our daily compilation, however, it is not always practical (as discussed in Memo CP-C/467). The branch code IND has also been used by some compilers to indicate the first case systematically (which is wrong.). Consequently, this rule has been a source of inconsistency in our REACTION coding.

The abovementioned rule has been ignored for fission product yields: The independent fission product yield has been always coded with IND even for shielded nuclides. Hence REACTION coding has been consistent or independent fission yields due to the ignorance(!).

The purpose of this memo is **to improve the consistency of REACTION coding by simplifying the rule**. (Memo CP-C/467 makes a similar proposal for M-, and this memo extends it to IND).

We often encounter difficulty when we compile a quantity declared by the author as "independent" for a *nearly* shielded product:

Example:
If ^{72}As (26 h) cross section is reported as an "independent cross section" without any description on the ^{72}Se (8.4 d) decay contribution, it is not clear if the author declares it as "independent" by (a) assuming that the IT contribution is negligible, or (b) subtracting the ^{72}Se decay contribution.

There are many data sets of ^{72}As production cross sections coded with SF5=IND but probably ^{72}Se decay contribution was not always subtracted. (N.B. Some compilers automatically added SF5=IND whenever we have such long-lived precursor!)

If the compilation is for a few reaction products in a recent publication, we can ask the author whether subtraction was done or not. But it is not always realistic. For example, I think many compilers do not check the decay scheme one-by-one when the author tabulates "independent cross sections" for several tens of product nuclides. (I routinely detect use of IND even for clearly shielded nuclides! But I cannot blame the compiler because I know it is unrealistic to check it for each product nuclide!)

We also should remember that the "independent" declaration is done by those who deal with *off-line* measurements (*e.g.*, activation, chemical separation). On-line measurements (*e.g.*, prompt particle detection, on-line mass separation) report independent quantities in general. Their results are published without mentioning "independent" explicitly, and then such data are often compiled without IND since the compiler does not check if the same quantity can be cumulative in off-line measurements.

These arguments show it is not practical to distinguish two cases systematically.

I also do not see a point to keep this rule from the view of EXFOR users. EXFOR quantities are always independent unless there is an indication of precursor decay contribution (*e.g.*, CUM), and therefore appearance of IND would be rather confusing for users. Memo CP-C/259 mentions that EXFOR quantities were assumed to be independent if no other indication is given until KaChaPaG proposed various new quantities for their compilation by Memo CP-B/3. (N.B. This assumption is still valid.) Memo CP-C/259 proposes that

"Eliminate the use of the code IND in REACTION sub-field 5, except for use with fission yields where independent yield has traditionally been used in the literature."

I propose to accept it since it simplifies our coding rule and improve the consistency.

If this proposal is accepted, then

1. SF5=IND in retransmitted entries will be always deleted whenever SF6≠FY.

2. We will not need to add a new quantity code with IND whenever the same quantity code without IND is available in the dictionary. (It will simplify Dictionary 236.)

3. When the author says nothing about the precursor decay contribution and the compiler is aware of its existence, the situation will be still expressed by (CUM) or (M).

4. When the author mentions that the independent quantity is obtained by subtraction of the feeding via decay, it should be mentioned under CORRECTION (as routinely done at NDS).

5. For the same product, we will see SF5=IND for the independent fission product yield but will not see it for the corresponding independent cross section. But a similar consistency anyway exists for other fission quantities (e.g., SF5=PR for the prompt fission gamma yields and SF5=TER for the fission light charged-particle yield. These branch codes are not used for the corresponding cross sections.)

First table of LEXFOR "Independent and Cumulative Data"

Branch Code	Definition (proposed)	Definition (current)
IND	• Feeding via radioactive decay is absent or excluded. • To be used only with the parameter code FY.	Feeding via radioactive decay exists, but is excluded experimentally. To be used only with process codes X or F. IND may be used only if CUM may also occur with the same reaction (i.e. the same SF1 – SF4). If only independent channels are possible, IND is not coded. Use M- instead of IND when feeding via radioactive decay of another nuclide does not exist.
CUM	• Feeding via radioactive decay of another nuclide (and via isomeric transition when it exists) is included. • To be used only with the process codes X or F.	(Same)
(CUM)	• Uncertain if the formation via radioactive decay (and isomeric transition when it exists) is included. • To be used only with the process codes X or F.	(Same)
M+	• Partial feeding via isomeric transition is included. • To be used only with the isomeric flag –G in SF4[1]. • Use CUM instead of M+ when feeding via decay of another nuclide is also included.	(Same)
M-	• Feeding via isomeric transition exists, but is excluded. • To be used only with the isomeric flag –G in SF4 and CUM in SF5.	Feeding via decay of isomeric transition exists, but is excluded experimentally. To be used only with the isomeric flag –G in SF4. Use IND instead of M- when feeding via decay of another nuclide is also possible and excluded experimentally.
(M)	• Uncertain if the formation via isomeric transition is included. • To be used only with the isomeric flag –G in SF4[1]. • Use (CUM) instead of (M) when also uncertain if feeding via decay of another nuclide is included.	(Same)

[1] Or another isomeric state code when the possible contribution of a higher state is considered, e.g. -M1 when M2 exists.

Second table of LEXFOR "Independent and Cumulative Data"

Proposed

		No isomer exists, or full feeding via IT (No *a* or *a*=1)	IT absent (*a*=0)	IT exists, but excluded (*a* excl.)	Partial feeding via IT (0<*a*<1)	Uncertain if feeding via IT exists (*a*=?)
No feeding via decay of another nuclide (No *b*, *b*=0 or *b* excl.)	SF6≠FY	Z-S-A	Z-S-A-G	Z-S-A-G	Z-S-A-G,M+	Z-S-A-G,(M)
	SF6=FY	Z-S-A,IND	Z-S-A-G,IND	Z-S-A-G,IND	Z-S-A-G,IND/M+	Z-S-A-G,IND/(M)
Feeding via decay of another nuclide exists (0<*b*≤1)		Z-S-A,CUM	Z-S-A-G,CUM-	Z-S-A-G,CUM/M-	Z-S-A-G,CUM	Z-S-A-G,CUM/(M)
Uncertain if feeding via decay of another nuclide exists (*b*=?)		Z-S-A,(CUM)	Z-S-A-G,(CUM)	Z-S-A-G,(CUM)/M-	Z-S-A-G,(CUM)/M+	Z-S-A-G,(CUM)

Current

	No *a* *a*=1	***a*=0**	***a* excl.**	**0<*a*<1**	***a*=?**
No *b* b=0	Z-S-A	Z-S-A-G	Z-S-A-G,M-	Z-S-A-G,M+	Z-S-A-G,(M)
***b* excl.**	Z-S-A,IND	Z-S-A-G,IND	Z-S-A-G,IND	Z-S-A-G,IND/M+	Z-S-A-G,IND/(M)
0<*b*≤1	Z-S-A,CUM	Z-S-A-G,CUM	Z-S-A-G,CUM/M-	Z-S-A-G,CUM	Z-S-A-G,CUM/(M)
***b*=?**	Z-S-A,(CUM)	Z-S-A-G,(CUM)	Z-S-A-G,(CUM)/M-	Z-S-A-G,(CUM)/M+	Z-S-A-G,(CUM)

- No: ^{Am}J or ^{A}L does not exist.
- excl.: Contribution is excluded (*e.g.*, subtraction of its contribution, short cooling time, decay-curve analysis, on-line separation etc.)
- =0: ^{Ag}J is physically shielded from ^{Am}J or ^{A}L (*e.g.*, stable state, no decay branch to ^{Ag}J, $T_{1/2}(^{Ag}J)<<T_{1/2}(^{Am}J)$ or $T_{1/2}$ (^{A}L)).
- =1: Full contribution is expected (*e.g.*, 100% branching ratio to ^{Ag}J, long cooling time, $T_{1/2}(^{Ag}J)>>T_{1/2}(^{Am}J)$ or $T_{1/2}$ (^{A}L) etc.)