Spontaneous Fission Assembly (SFASS) Code, Update of Dictionary 18

(B. Pritychenko, 2020-02-07, Memo CP-C/476,
N. Otsuka, 2021-04-27, Memo CP-D/1013)

CP-C/476

The EXFOR format FACILITY field provides important information about the institution where the measurements were made, helps to find the responsible compilation centers and arrange institutes during the compilation process. The LEXFOR manual defines it as:
``FACILITY is used to identify the main apparatus or machine used in the experiment, e.g.,
reactor or cyclotron. The institute at which the facility resides may be entered, if known, following the facility code. This is especially important if there is more than one institute associated with the
experiment."

Unfortunately, this rule does not apply for spontaneous fission measurements because the list of 34 facilities completely ignores spontaneous fission sources that are present in 1614 EXFOR data sets. There are Dictionary 19 incoming source codes for CF252, CM244, CM246 and CM248 spontaneous fission sources. They are obviously not applicable for experiments on the spontaneous fission of Cf-252 itself where no incident particles and, therefore, no INC-SOURCE plays a role. The total number of such data sets are 714, 98, 23 and 43 for CF252, CM244, CM246 and CM248, respectively. Such entries contain authors institution information; however, institutions can be different from the research facilities. This may result in the situations when external user facilities would not be credited in an EXFOR compilations.

To resolve this issue and provide the proper credits to user facilities a new facility code SFASS (Spontaneous Fission Assembly) is proposed. Examples of affected entries and future updates for Cf-252 and Cm-244 are shown in Appendix.

Technical Note:

Spontaneous fission sources (i.e. ^{252}Cf) represent complex assemblies that provide high neutron fluxes with an average energy of 2.13 MeV and absorb gammas and other fission products. ^{252}Cf emits ~3.757 neutrons/fission, and 1 mg of californium produces ~2.3×10^{9} neutrons/s. Therefore, large samples of ^{252}Cf (>l00 mg) are often described as ``poor man nuclear reactors" and even small ~25 μg sources include extensive radiation shielding [1]. These spontaneous fission sources are produced at the Oak Ridge National Laboratory (ORNL) in the United States and the Research Institute of Atomic Reactors, Dimitrovgrad, Russian Federation. In fact, the ORNL High Flux Isotope Reactor (HFIR) and the adjacent Radiochemical Engineering Development Center (REDC) are responsible for ~70% of the world's ^{252}Cf supply.

Appendix: Original entries and future updates.

1) Original Cf-252

```
ENTRY            13067     890518              20050926       0000
SUBENT        13067001     890518              20050926       0000
BIB                  7          8
INSTITUTE  (1CANCRC,1USALRL)
REFERENCE  (J,CJP,41,2080,63)
AUTHOR     (J.S.FRASER,J.C.D.MILTON,H.R.BOWMAN,S.G.THOMPSON)
TITLE      PRECISE KINETIC ENERGY MEASUREMENTS AND FINE
           STRUCTURE IN THE SPONTANEOUS FISSION OF CF252
ERR-ANALYS NO INFORMATION
STATUS     (RIDER) REFERENCE 63FRA1
HISTORY    (890512C) VM
ENDBIB               8
```

2) Updated Cf-252

```
ENTRY     C      13067   20200207
SUBENT    C   13067001   20200207
BIB                  7          8
TITLE      Precise kinetic energy measurements and fine
           structure in the spontaneous fission of Cf252
AUTHOR     (J.S.Fraser,J.C.D.Milton,H.R.Bowman,S.G.Thompson)
REFERENCE  (J,CJP,41,2080,1963)
           #doi:10.1139/p63-205
INSTITUTE  (1CANCRC,1USALRL)
FACILITY   (SFASS,1CANCRC)
```

3) Original Cm-244

```
ENTRY            13583     930330              20050926       0000
SUBENT        13583001     930330              20050926       0000
BIB                 11         15
INSTITUTE  (1USALRL)
REFERENCE  (J,PR,99,183,5507)
AUTHOR     (G.H.HIGGINS,W.W.T.CRANE,S.R.GUNN)
TITLE      Average Number of Neutrons per Spontaneous Fission of
            Cm244
SAMPLE     Sample contains unspecified amount of 242Cm.
DETECTOR   (SCIN) Large tank containg a saturated solution of
                  manganese sulphate.
DECAY-DATA Alpha decay energies and half-lives taken from
            Hollander, et al., Rev.Mod.Phys. 25, 469 (1953).
CORRECTION Corrected for neutrons from spontaneous fission of
            242Cm in sample using nu(bar)=3.0+-0.3.
ERR-ANALYS (DATA-ERR) No information on source of error given.
STATUS     Data taken from article
HISTORY    (930330C)
```

4) Updated Cm-244

```
ENTRY     C      13583   20200207
SUBENT    C   13583001   20200207
BIB                 11         15
TITLE      Average number of neutrons per spontaneous fission of
           Cm244
AUTHOR     (G.H.Higgins,W.W.T.Crane,S.R.Gunn)
REFERENCE  (J,PR,99,183,1955)
           #doi:10.1103/PhysRev.99.183
INSTITUTE  (1USALRL)
FACILITY   (SFASS,1USALRL)
```

References

1. B.C. Anderson, K.E. Holbert, H. Bowler, `` Design, Construction, and Modeling of a ^{252}Cf Neutron Irradiator," Science and Technology of Nuclear Installations 2016, 9012747 (2016).

CP-D/1013

Memo CP-C/476 proposes addition of a new facility code SFASS (spontaneous fission assembly) for spontaneous fission samples with EXFOR 13067 and 13583 as examples.

Example:

```
ENTRY      C       13067   20200424
SUBENT     C    13067001   20200424
BIB                   7          8
TITLE       Precise kinetic energy measurements and fine
            structure in the spontaneous fission of Cf252
AUTHOR      (J.S.Fraser, J.C.D.Milton, H.R.Bowman, S.G.Thompson)
REFERENCE   (J,CJP,41,2080,1963)
INSTITUTE   (1CANCRC,1USALRL)
FACILITY    (SFASS,1CANCRC)
SAMPLE      ~3 mm in diameter on VYNS backing
…

SUBENT         13067002   20200207
BIB                   3          7
REACTION    (98-CF-252(0,F)MASS,CHN,FY)
NOCOMMON              0          0
DATA                  2         89
…
```

I agree that the spontaneous fission sample is small (~ 3 mm in diameter on VYNS backing for the 13067 experiment) but its presence is essential in measurements of spontaneous fission quantities such as neutron multiplicity, fission fragment/product yield etc. The sample is always followed by various instruments such as detectors, and it can be a large measurement system. But it is not clear for me if such a measurement system is known as a "spontaneous fission assembly" (Google found this term only in WP2021-09 and Memo CP-C/476.) The keywords SAMPLE and DETECTOR look more appropriate place to accommodate relevant information.

Use of a new facility code for a "spontaneous fission assembly" also may add redundancy to EXFOR entries since REACTION SF2=0 always means a spontaneous fission material is used. It would be also confusing if some datasets with REACTION SF2=0 are coded with FACILITY=SFASS but others not. (According to Memo CP-C/476, there are about 1600 relevant EXFOR entries.)

At the same time, I also see the problem is originated from the FACILITY format rule. Currently the Facility Field of this keyword must be always present, and we can indicate the location of the experimental site in the Institute Field only when an appropriate facility code exists. A possible solution to solve this problem is to allow a code in the Institute Field without a code in the Facility Field. I suggest the following amendment of the formatting rule agreed in the NRDC 2016 meeting (Conclusion 20).

FACILITY. Defines the main apparatus used in the experiment. See also **LEXFOR, Measurement Techniques**.

1. 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.

2. The format of coded information is: (facility, institute).
   Facility Field: a code from Dictionary 18. ~~This field must be present~~. This field may be omitted, in which case the following comma must be included.
   Institute Field: a code from Dictionary 3, which specifies the location of the facility. This field must be present except when the location is not known.

Example:

```
…
REFERENCE   (J,CJP,41,2080,1963)
INSTITUTE   (1CANCRC,1USALRL)
FACILITY    (,1CANCRC)
SAMPLE      ~3 mm in diameter on VYNS backing
NOCOMMON                0           0
DATA                    2          89
MASS        DATA-MAX
NO-DIM      PC/FIS
 80.          0.0145
…
```

Note added this Working Paper (after discussion with some colleagues after memo submission)

1. Do we really need to treat the location of the experiment in a special manner? There can be another institute contributing to the experiment on a similar level (*e.g.*, detector developer).

2. Addition of a new code for spontaneous fission could cause systematic addition of
   `FACILITY    (SFASS)`
   without an institute code under FACILITY. Not only (0,F) datasets but also datasets measured under ^{252}Cf(sf) prompt fission neutron field (INC-SOURCE=CF252, REACTION SF8=FIS) are affected.

3. Once we introduce SFASS, then one may start to "invent" other new facility codes (e.g., BDASS – beta-decay assembly (?) for (0.B-) data sets.)

4. My example shows a FACILITY record without facility information. This might be a shortcoming of my proposal.

5. **I am very fine with the current practice without any new rules**– providing the details of the spontaneous fission source (including its location) in free text under SAMPLE or INC-SOURCE.