Memo CP-D/199

7 November 1989

To: Distribution

From: M. Lammer

Subject: Fission Yield Nuclear Data

Conclusions and Recommendations concerning EXFOR from the Consultants' Meeting on the Compilation and Evaluation of Fission Yield Nuclear Data.

The Consultants' Meeting (CM) on the Compilation and Evaluation of Fission Yield Nuclear Data issued conclusions and recommendations concering EXFOR and the Computation Format, which were reviewed at the 1989 NRDC Meeting and resulted in some actions.

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The CM's conclusions and recommendations are summarized below. A preliminary list of information to be included in fission yield EXFOR entries is given in Appendix 1, where the recommendations of the CM (see 3. below) are supplemented by items from my own experience. The final list will be issued after receipt of evaluators' contributions by the end of 1989.

Appendix 2 shows, as example, a listing of the entry EXFOR30768. This entry contains pertinent information requested in Appendix 1, or comments about missing information and a critique on the analysis as presented by the authors. The latter have been asked for a clarification and to provide us with the missing information.

1. General recommendations:

EXFOR is now accepted as the format for the compilation and exchange of experimental fission yield data, and will be used by all evaluators.

It is recommended that EXFOR be advertised at meetings, in publications, etc., dealing (among other topics) with fission yield data.

EXFOR entries are recommended to be recognized as publications, which can be quoted as references by the evaluators, provided that all detailed information pertinent to evaluators is included (see below).

2. Completeness of the EXFOR data base and conversion of the Rider file:

The compilation of fission yield data into EXFOR started only in the late seventies. However, the completeness of the EXFOR data base with respect to fission yield data is essential for evaluators. Therefore a special effort has been started to convert Rider's file of experimental data, which is regarded as being complete with respect to pre-1980 data, into a quasi-EXFOR format. This effort, as described in Memo 4C-3/328, has come close to completion, and the following actions are still pending:

- V. McLane will transmit the last batch of (roughly) post 1975 data in quasi-EXFOR format to the other centers for completion.
- The 4 Neutron Centers will complete these entries.
- Wang Dao will complete the entries assigned to him and send the pre-1960 entries to NNDC and the other entries to NDS for transmission to the other centers.

After completion of this special effort a completeness cross-check should be made between CINDA, EXFOR and the evaluators' files and all data still found missing in EXFOR should be compiled.

New publications containing fission yield data should be compiled without delay.

3. Information to be included in EXFOR entries:

It was noted that 2 participants, who are measurers of fission yields, have not received author-proof copies for EXFOR entries of their measurements from NEA-DB. It is strongly recommended, that author-proof copies should be sent for all compiled fission yield data.

All information about an experiment important to evaluators for a judgement of the experiment, correction of data and assignment of uncertainties should be included in EXFOR entries. Evaluators will send a complete "wish list" of such information to M. Lammer who will distribute it to other centers as 4C-Memo. During the meeting, the following pieces of information to be provided by measurers and included EXFOR entries were agreed:

- detailed error information (including the types of errors);
- information on data analysis, such as:
  * which corrections were applied during data analysis;
  * whether data used by authors for data analysis are given or not;
  * numerical data used for data analysis, in particular decay data and their uncertainties;
  * precursors considered;
  * product isomers considered;
- in addition for independent yield measurements:
  * delay times (for on-line measurements);
  * specify whether the data are before or after delayed neutron emission;
  * delayed neutron data used (if relevant);
  * spins of product isomers considered.

If this and other information needed by evaluators is not included in publications, it should be requested from authors by the compilers.

In addition, the meeting also issued a recommendation to measurers to send details on their measurements to EXFOR compilers and publish them at least in laboratory reports, if journal editors do not accept too lengthy descriptions.

Evaluators should send their comments about measurements and the corrections applied to results to EXFOR compilers, who should include them in the respective EXFOR entries with appropriate comments and flagging.

4. Customer services:

Meeting participants using the Saclay on-line retrieval system for EXFOR entries found the present indexing system for fission yields not detailed enough. The index should be designed to enable the retrieval on:

- target nucleus (REACTION SF1)
- fission product (A for SF4=MASS, Z/A for SF4=ELEM/MASS)
- type of yield (particularly: SF5=IND,CUM,CHN and SF6=FY)
- incident neutron energy.

Also, NEA-DB is asked to improve the "help section" for customers.

5. Computation format:

A computation format for data compiled in EXFOR would be useful to evaluators for inputting these data into their computer programs for evaluation.

For the sake of a cooperation between evaluators and for a better comparison of data bases, it is desirable that the Neutron Data Centers agree on a common computation format.

V. McLane will send a proposed computation format to evaluators before the end of October 1989. The evaluators will return their comments to V. McLane by December 1989. V. McLane will send the proposed format to M. Lammer for inclusion in the summary report of the meeting. M. Lammer will also distribute it to other centers as 4C-Memo for discussion.

During the meeting, the following improvements to the present computation format used By NNDC and NEA-DB were proposed:

- method codes should be included;
- product spin values should be included;
- the format should allow for 3 different ways of sorting and listing the data according to 3 different types of yield data, namely:
  absolute yields - relative yields - R-values.

Enclosures

APPENDIX 1: Preliminary list of information to be included in EXFOR entries.

A. Information needed by evaluators

Evaluators need (qualitative and quantitative) information on experiments for different purposes. The detailed information to be compiled in EXFOR for these different purposes (marked a, b, ...) is identefied by, e.g., "==>(a,b)" at the left hand margin in part C. below.

a. Basic information

The basic information for inputting the data into an evaluation are: target, reaction, incident neutrons, errors and results.

b. Judgement of the experiment

For a judgement of the experiment generally only qualitative information is needed, except for correction factors and nuclear data used for the analysis.

c. Correction of author's data

Correction factors, nuclear data used for the analysis, information on incident neutrons and decay times are needed for corrections (if possible) to be applied by evaluators.

d. Assignment of errors

Evaluators have to judge the errors assigned by experimenters and, if deemed necessary, to assign their own errors.

e. Calculation of correlations and covariances

Any correlations given by the authors, as well as information on facility, detectors, methods, correction data used, that may be common to different experiments from the same institute.

B. Information to be compiled (in general)

Irradiation conditions and decay times

Method description (use codes; if not available, propose a new code)

Detector used, calibration, corrections

Sample composition, dimensions and treatment after irradiation

Analysis of raw data (including nuclear data used)

Error analysis, correlations

If important information is not given in the publication(s), this should also be stated and requested from the author(s).

C. Specific pieces of information

1. What data were measured

for fragment mass and charge measurements:
==>(b,c) data before or after prompt neutron emission (REACTION)

for independent yield measurements:
==>(b,c) data before or after delayed neutron emission

2. Facility

==>(b,e) use codes, including the lab-code for the location

3. Irradiation and measurement

long term irradiations (reactors, fission spectrum, accelerators)

times:
==>(c) irradiation time
==>(c) decay time before start of measurement
==>(c) duration of measurement

==>(c) value of neutron flux

neutron spectrum:

thermal reactor:
==>(a,c) Maxwellian temperature or mean energy
==>(b,c) fraction of epithermal neutrons (Westcott r-factor)

fast reactor:
==>(a,b,c) mean energy or other spectral index

fission spectrum:
==>(a,b,c) source of fission neutrons

monoenergetic neutrons:
==>(a,b) neutron source description
==>(b,d) spectral shape

on-line measurements

==>(b,c) delay times
==>(c) duration of measurement

4. Sample

==>(a,b) sample composition

==>(b,c) if relevant (self-shielding): dimensions of irradiated sample
==>(b,c) and of flux monitor

==>(b,c) (relevant) dimensions of measured sample (self-absorption)

5. Method

radiochemistry: sample dissolution and fission product extraction
==>(b,e) procedure applied (qualitative)
==>(b) chemical yield
==>(b) any losses reported by authors

mass-spectrometry
==>(b,e) (type of) spectrometer
==>(b) (chemical compounds measured)
==>(b) were fission products separated chemically before measurement
==>(b) (spike data, if applicable)

determination of the number of fissions

neutron flux measurements:
==>(b-d) monitor and fission cross section values used
==>(b-d) correct use of spectrum-averaged cross section (formula)

summation method:
==>(c) values of interpolated and extrapolated yields
==> should be coded as "relative" data

6. Detector(s)

==>(b,d,e) (type of) detector(s) used
==>(b,d,e) efficiency calibration, including (source of) nuclear data used
==>(b,d) corrections taken into account

7. Analysis of raw data

==>(b-d) corrections applied, correction factors (if relevant)

==>(b-d) precursors considered

==>(b-d) product isomers considered, and
==>(a) spins of isomers (iclude in data table) for independent yields

nuclear data used (if applicable) and their uncertainties:
==>(b-d) neutron capture cross sections
==>(b-d) decay data for corrections (half-life, branching fraction)
==>(b,d) decay data for spectrum analysis (beta-, gamma-ray data)
==>(b-d) delayed neutron data

gamma-ray spectrometry:
==>(b,d) information on spectrum analysis, interfering peaks (if given by authors)

beta-ray spectrometry:
==>(b,d) information on spectrum decomposition

mass-spectrometry (if reported in the paper):
==>(b,d) mass discrimination effects
==>(b,d) incomplete collection (of gaseous fission products)

8. Error analysis, correlations

==>(b,d) number of samples measured and standard deviation
==>(d) counting satistics (or equivalent)
==>(b,d) other (sources of) errors considered and their types (ERR-ANALYSIS)
==>(d) values of errors considered (DATA table)
==>(e) correlations, correlation coefficients
==> statement on missing information

APPENDIX 2: Example of an EXFOR entry on fission yields

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ENTRY          30768     871214          ML                    3076800000001
SUBENT      30768001     871214                                3076800100001
BIB               17         74                                3076800100002
TITLE       ABSOLUTE YIELDS OF SOME FISSION PRODUCTS IN THE 14 MEV 3076800100003
            NEUTRON INDUCED FISSION OF U-238                    3076800100004
AUTHOR      (S.RAM,N.L.SINGH,S.K.BOSE,J.R.RAO)                  3076800100005
INSTITUTE   (3INDBHU)                                           3076800100006
REFERENCE   (J,NIM/B,24/25,501,8704)                            3076800100007
SAMPLE      ABOUT 1 MG OF SOLID URANYL NITRATE                  3076800100008
MONITOR     ABSOLUTE MEASUREMENT OF THE NUMBER OF FISSIONS:AQUEOUS 3076800100009
            SOLUTION OF URANYL NITRATE IN A THIN GLASS TUBE     3076800100010
            CONTAINING THE FISSION DETECTOR (LEXAN).            3076800100011
FACILITY    (VDG)                                               3076800100012
INC-SOURCE  (D-T) FLUX=2.26*10E+9 N/CM2/S                       3076800100013
METHOD      'TRACK-ETCH-CUM-GAMMA-RAY SPECTROMETRY'             3076800100014
            THE SAMPLE WAS IRRADIATED TOGETHER WITH A MONITOR TUBE 3076800100015
              ON EITHER SIDE IN NEUTRON BEAM DIRECTION.         3076800100016
            FISSION TRACKS WERE COUNTED WITH AN OPTICAL MICROSCOPE.3076800100017
              THE TRACK DENSITY WAS DETERMINED                  3076800100018
            DIRECT GAMMA-RAY SPECTROSCOPY OF UNSEPARATED FISSION 3076800100019
              PRODUCTS BY MEASURING THE SOLID SAMPLE.           3076800100020
DETECTOR    (TRD) LEXAN PLASTIC FISSION TRACK DETECTOR          3076800100021
              THE EFFICIENCY FOR TRACK REGISTRATION IN SOLUTION HAS3076800100022
              BEEN DETERMINED BY COMPARISON WITH ANOTHER LEXAN   3076800100023
              DETECTOR ON WHICH A KNOWN AMOUNT OF SOLUTION WAS  3076800100024
              EVAPORATED.                                       3076800100025
            (HPGE).,PRECALIBRATED,RESOLUTION: 2 KEV AT 1.33 MEV, 3076800100026
              COUPLED TO A MULTICHANNEL ANALYSER.               3076800100027
              THE DETECTOR EFFICIENCY FOR THE MEASURED FISSION  3076800100028
              PRODUCT GAMMA-RAYS IS GIVEN IN TABLE 1 OF NUCL.INSTR.3076800100029
              METH.PHYS.RES. B24/25(1987)501.                   3076800100030
ANALYSIS    THE TOTAL NUMBER OF FISSIONS WAS DERIVED FROM THE   3076800100031
              FISSION TRACK DENSITY TAKING INTO ACCOUNT:        3076800100032
              - WEIGHT OF THE FISSILE MATERIAL                  3076800100033
              - EFFICIENCY FOR TRACK REGISTRATION IN SOLUTION   3076800100034
              - CONCENTRATION OF TARGET MATERIAL IN SOLUTION    3076800100035
              DETAILS ARE GIVEN IN THE MAIN PUBLICATION         3076800100036
            FISSION YIELDS ARE DERIVED FROM MEASURED ACTIVITIES 3076800100037
              AND TOTAL NUMBER OF FISSIONS USING A STANDARD FORMULA3076800100038
              CONTAINING FACTORS FOR DECAY DURING IRRADIATION,   3076800100039
              COOLING AND DATA ACCUMULATION.                    3076800100040
            COMPILERS COMMENT: THE FORMULA DOES NOT ACCOUNT FOR 3076800100041
              ANY PRECURSORS IN DECAY.                          3076800100042
ERR-ANALYS  NO INFORMATION                                      3076800100043
DECAY-DATA  ((1.)42-MO-99,66.02HR,DG,739.4,0.126)               3076800100044
            ((2.)48-CD-115,53.38HR,DG,527.7,0.339)              3076800100045
            ((3.)48-CD-117-M,3.31HR,DG,564.4,0.152)             3076800100046
            ((4.)51-SB-126,12.4D,DG,666.3,0.997)                3076800100047
            ((5.)51-SB-128-G,9.1HR,DG,314.1,0.610)              3076800100048
            ((6.)52-TE-131-M,30.0HR,DG,773.7,0.380)             3076800100049
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                ((7.)56-BA-140,12.789D,DG,537.2,0.236)                    3076800100050
                ((8.)58-CE-141,32.55D,DG,145.0,0.484)                     3076800100051
                ((9.)61-PM-151,28.4HR,DG,167.7,0.077)                     3076800100052
                ((10.)63-EU-157,15.15HR,DG,410.6,0.190)                   3076800100053
                DATA TAKEN FROM C.M.LEDERER,V.S.SHIRLEY,TABLE OF          3076800100054
                ISOTOPES,SEVENTH EDITION,1978.                            3076800100055
COMMENT         BY COMPILER: THE FOLLOWING INFORMATION PERTINENT TO        3076800100056
                EVALUATORS IS MISSING OR INSUFFICIENT IN THE PAPER:       3076800100057
                - EXACT VALUE OF THE NEUTRON ENERGY                       3076800100058
                - DURATION OF IRRADIATION,COOLING AND MEASUREMENTS.       3076800100059
                - ANALYSIS OF GAMMA-SPECTRA: INTERFERING PEAKS,           3076800100060
                    UNCERTAINTIES INVOLVED.                               3076800100061
                - GENETIC PARENT-DAUGHTER RELATIONSHIPS; DETAILS ON THE   3076800100062
                    WAY YIELDS WERE OBTAINED.                             3076800100063
                - ERROR ANALYSIS: TYPES AND NUMERICAL VALUES OF           3076800100064
                    DIFFERENT ERROR CONTRIBUTIONS INVOLVED/CONSIDERED.    3076800100065
CRITIQUE        IN THE FOLLOWING CASES IT IS UNCLEAR WHAT TYPE OF YIELD   3076800100066
                  THE VALUES REPRESENT (OR THE VALUES ARE DOUBTFUL):      3076800100067
                1. SB-126: SHIELDED BY 10E+5 YEAR SN-126                  3076800100068
                2. SB-128 HAS A METASTABLE STATE WHICH IS FED BY BETA     3076800100069
                   DECAY OF SN-128 BUT DECAYS ONLY TO 3.6 % TO SB-128G.   3076800100070
                3. TE-131M IS FED ONLY IN 6.8 % OF SB-131 BETA DECAYS.    3076800100071
                   THE YIELD VALUE GIVEN SEEMS TO BE TOO HIGH  FOR THE    3076800100072
                   CUMULATIVE YIELD OF THE METASTABLE STATE.              3076800100073
                THESE POINTS NEED CLARIFICATION.                          3076800100074
STATUS          (TABLE) DATA TAKEN FROM TABLE 1 OF FIRST REFERENCE        3076800100075
HISTORY         (871204C) ML                                              3076800100076
ENDBIB                   74                                               3076800100077
COMMON                    1          3                                    3076800100078
EN                                                                        3076800100079
MEV                                                                       3076800100080
14.                                                                       3076800100081
ENDCOMMON                 3                                               3076800100082
ENDSUBENT                81                                               3076800199999
SUBENT              30768002     871214                                   3076800200001
BIB                       2          2                                    3076800200002
REACTION        (92-U-238(N,F)ELEM/MASS,CUM,FY)                           3076800200003
FLAG            (1.) SEE 'CRITIQUE'                                       3076800200004
ENDBIB                    2                                               3076800200005
NOCOMMON                                                                  3076800200006
DATA                      7         10                                    3076800200007
ELEMENT         MASS       ISOMER     DATA       DATA-ERR    DECAY-FLAG  3076800200008
FLAG                                                                      3076800200009
NO-DIM          NO-DIM     NO-DIM     PC/FIS     PC/FIS      NO-DIM      3076800200010
NO-DIM                                                                    3076800200011
42.              99.                  5.84       0.29         1.         3076800200012
              ..............................
          data table truncated, as it is unimportant
              ..............................
63.             157.                  0.11       0.01        10.         3076800200030
                                                                          3076800200031
ENDDATA                  24                                               3076800200032
ENDSUBENT                31                                               3076800299999
ENDENTRY                  2                                               3076899999999
```