NATIONAL NUCLEAR DATA CENTER
Bldg. 197D
Brookhaven National Laboratory
P. O. Box 5000
Upton, NY 11973-5000 U.S.A.

(*Internet*) "NNDC@BNL.GOV   Telephone: (516)344-2902
                                                                                      FAX: (516)344-2806

Memo CP-C/347

DATE: August 6, 2004
TO: Distribution
FROM: V. McLane
SUBJECT: Cross sections measured on thick targets.
                      Updated LEXFOR entry on thick target yields

As Naohiko Otsuka pointed out, the data given as cross sections measured on thick targets, and similarly, product yields, multiplicities, *etc*., are simply cross sections averaged over an incident energy range. Therefore, I propose we make TT a general quantity modifier and eliminate it from codes in Dictionary 36.

Update to Dictionary 34 (Modifiers)
TT   GENQA Average for incident energy degraded through thick target.

An updated LEXFOR entry for Thick and Thin target yields follows. I hope have taken into account all memos. I used the table from CP-E/044 and made some changes to make units types more consistent. Unit types are given for data types not yet encountered to facilitate further additions.

Thick- and Thin-Target Yields

<u>Thick-target yields</u>: yield of an outgoing particle (or radiation) measured on a target whose thickness is such that the incident beam is either:

1) completely stopped within the target,
2) significantly degraded in energy,
3) degraded in energy to below the threshold for producing the measured product.

<u>Thin-target yields</u>: yield of an outgoing particle (or radiation) measured on a target whose thickness is such that the incident beam is less significantly degraded in energy, and which is given as a function of incident beam current. The incident energy range must be given in the data table under the field headings EN-MIN and EN-MAX, or, if the final energy is not specified, the incident energy and target thickness must be given under EN and THICKNESS.

The data are sensitive to target thickness and beam profile. The energy loss is a function of the stopping power (S) of the target material.

The thick target yield is given by

$$Y_{thick} \approx \int_{E_2}^{E_0} \sigma(E') \left[\frac{dE}{dX}(E') \right]^{-1} dE'$$

$$S = dE / dX$$

where E_0 is the incident particle energy,
E_2 is the final energy of the incident particle; either 0 if the beam is stopped in the target, or equal to the energy of the particle exiting the target,
E' is the energy at a given depth in the target,
X is the target thickness in g cm^{-2}.

Types of data compiled:

1) <u>Saturated thick/thin-target yield</u>: target yield measured after a long irradiation time (*i.e.*, longer than 3 half-lives of the product activity) and usually given as decay rate per unit of incident beam current.

   <u>REACTION Coding</u>: TTY in SF6
   <u>Units</u>: a code from Dictionary 25 with dimension TTY (decay rate per unit of beam current), *e.g.*, MCI/MUA.

2) <u>Production[1] thick/thin-target yield</u>: (unsaturated) target yield measured after an irradiation time that is short compared to the product half-life and given as decay rate per unit of incident beam current * time.

   <u>REACTION Coding</u>: TTY,,DT
   <u>Units</u>: a code from Dictionary 25 with dimension TTT (decay rate per unit of beam current * time), *e.g.*, MCI/MUAHR or DPS/MUAHR.

---

[1] Do not confuse with product yields.

3) <u>Physical thick/thin-target yield</u>: target yield measured after an irradiation time that is short compared to the product half-life, is given as decay rate per unit of incident beam current ∗ time, and has been corrected for decays during irradiation.

<u>REACTION Coding</u>: TTY,,PHY
<u>Units</u>: a code from Dictionary 25 with dimension TTT (decay rate per unit of beam current ∗ time), *e.g.*, MCI/MUAHR or DPS/MUAHR.

4) <u>Other representations of thick target yields</u>

   a) <u>Thick Target Cross Sections</u>: cross section measured on a thick target and not corrected for target thickness.

      <u>REACTION Coding</u>: SIG in SF 6; modifier TT in SF8.
      <u>Units</u>: a code from Dictionary 25 with dimension B, *e.g.*, MB

   b) <u>Thick Target Product Yields</u>: thick target yield of a reaction product, where:

      • the value is given in units of number of nuclei per incident projectile.

        <u>REACTION Coding</u>: PY in SF 6; modifier TT in SF8.
        <u>Units</u>: a code from Dictionary 25 with dimension YLD, *e.g.*, PRD/INC

      • the value is given in units of number of nuclei as a function of incident beam current.

        <u>REACTION Coding</u>: TTY/PY in SF 6.
        <u>Units</u>: a code from Dictionary 25 with dimension PYT, *e.g.*, PRD/MUAHR

   c) <u>Thick Target Yield Multiplicities</u>: yield of an outgoing particle (or radiation), where:

      • the value is given as the number of particles per incident projectile.

        <u>REACTION Coding</u>: MLT in SF 6, TT in SF8.
        <u>Units</u>: a code from Dictionary 25 with dimension YLD, *e.g.*, PRT/INC

      • the value is given as the number of particles as a function of incident beam current.

        <u>REACTION Coding</u>: TTY/MLT in SF 6.
        <u>Units</u>: a code from Dictionary 25 with dimension PYT, *e.g.*, PRT/MUAHR

   d) <u>Thick Target Gamma-Ray Yields</u>: gamma spectrum, where the value is given as the number of particles per incident projectile as a function of gamma energy.

      <u>REACTION Coding</u>: SPC in SF 6, TT in SF8.
      <u>Units</u>: a code from Dictionary 25 with dimension YLD, *e.g.*, PRT/INC

Similarly, all quantities may be given as angular distributions, excitation functions, *etc*. See Table following and Dictionary 36 for a complete list of quantities.

Unit definitions

Saturated thick target yields are most often measured as observed decay rate per unit of beam current. Unsaturated thick target yields are most often measured as observed decay rate per unit of beam current per unit time.

Measures of beam current

    Ampere: SI fundamental unit of current.

    Coulomb: SI fundamental unit of charge; 1 C = 1 Ampere of current for 1 second.

Measures of decay rate

    Becquerels   SI fundamental unit of radioactivity; 1 Bq = 1 decay/second.

    Curies[2]:   unit of radioactivity; 1 Ci = 3.7×10^{10} decays/second.

        1 Bq = 2.7×10^{-11} Ci

Table of data types verses unit types

Type of data compiled		Unit type for			
		type	d/dA	d/dE	d2/dA/dE
Saturated thick/thin-target yield		TTY	TDA	TDE	TD2
Production thick/thin-target yield and Physical thick/thin-target yield		TTT	TTDA	TTDE	TTD2
Thick target cross section	Cross section	B	DA	DE	DAE
	Fn. of beam current	BTT	DATT	DETT	DAET
Thick target product yield and multiplicity	Fn. of beam current	PYT	PYTA	PYTE	PYT2
	# of nuclei/inc.	YLD	1/A	1/E	1/AE

[2] The Curie has been replaced in usage by the Becquerel.