THE TESTING OF PHOTON PRODUCTION DATA
FROM ENDF/B-III MATERIAL 1135 (^{27}Al)*

by

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Photon production data for D. G. Foster and P. G. Young's ENDF/B-III MAT 1135, ^{27}Al , were tested by comparing (n_{th} , γ) yields with published data (see Table 1) and by comparing measured and calculated secondary gamma-ray pulse-height spectra (SGRPHS). This project also provided a test of the LAPHFOR code, a flexibly dimensioned version of LAPHANO.⁶

The measured SGRPHS used as the standards for comparison were obtained from a previously performed series of experiments reported by Muckenthaler and Maerker.⁴ A 5-ft x 5-ft x 1/4-in.-thick Al slab was exposed to filtered and unfiltered neutron beams from the ORNL TSR-II reactor. The resulting SGRPHS were measured with a NaI(Tl) detector system.

Point ENDF/B MAT 1135 neutron cross-section data were reduced with XLACS⁷ to P_3 -expansion cross sections in 100 energy groups. These fine-group cross sections were then spectrally weighted using a Maxwellian-1/E-fission spectrum, spacially weighted over the 1/4-in.-thick Al slab, and reduced to a 27-neutron-group structure ($0 \leq E_n \leq 14.9182$ MeV) with XSDRN.⁸ P_3 -expansion gamma-ray cross sections in 60-energy groups ($0.01 \leq E_\gamma \leq 11.0$ MeV) were calculated with the MUG⁹ program. Using the XSDRN-calculated total flux for the 100 groups at the midpoint of the slab as a weighting function, secondary gamma-ray production cross sections (SGRPXS's) were prepared with LAPHFOR. Since the 1.78-MeV gamma ray produced following

the β -decay of ^{28}Al ($t_{1/2} = 2.27$ min) is not represented in the ENDF/B MAT 1135 data, SGRPKS's for this reaction were prepared using the POPOP⁴ code.^{10,11} The various types of cross sections were then coupled with the ASCC¹² coupling code. Using multigroup representations of the TSR-II beams¹² and the coupled cross sections, the intensity of secondary gamma rays emitted from the Al slab was calculated with ANISN.¹³ After being corrected for the geometric attenuation and for the attenuating effect of a detector neutron shield, the calculated intensity was folded with Maerker and Muckenthaler's response functions for the detection system⁴ to give the calculated SGRPHS for comparison with the measured spectra. These last calculational steps were done with LINFOLD2.¹²

A comparison of the measured and calculated SGRPHS resulting from the Cd-filtered TSR-II beam is shown in the top of Fig. 1. The ratio of the area under the measured curve to the area under the calculated curve for $1.0 \leq E_\gamma \leq 6.4$ MeV is 0.94. Shown in the bottom of Fig. 1 is a comparison of the measured and calculated SGRPHS resulting from the thermal TSR-II beam, i.e., bare beam minus Cd-filtered beam. The ratio of the areas under these curves for $1.0 \leq E_\gamma \leq 7.9$ MeV is 1.07. The number of ground-state transitions at 7.7 MeV appear to be underestimated in the MAT 1135 data by ~30%.

Table 1. Comparison of Al (MAT 1135) Thermal Capture Yields with Previous Results

Data Source	Photons/100 Captures																		%BE ^e
	Gamma-Ray Energy Range (MeV)																		
	0.5- 0.98	0.98- 1.0	1.0- 1.5	1.5- 2.0	2.0- 2.5	2.5- 3.0	3.0- 3.5	3.5- 4.0	4.0- 4.5	4.5- 5.0	5.0- 5.5	5.5- 6.0	6.0- 6.5	6.5- 7.0	7.0- 7.5	7.5- 8.0	8.0- 8.5	>8.5	
MAT 1135	0.3	10.0	2.5	7.9	12.8	18.6	13.9	16.5	19.5	20.3	9.5	1.7	7.9	5.3	3.0	26.5	0.0	0.0	99
Hardell, et.al. ¹	2.4	1.9	7.6	7.0	12.7	20.5	17.3	13.6	16.3	18.8	6.5	2.3	6.4	1.5	0.1	33.0	0.0	0.0	94
Draper, et.al. ²	2.7	0.0	7.7	5.4	13.0	10.0	17.0	7.0	15.0	16.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0	0.0	72
Bartholomew, et.al. ^{2,a}						4.6	13.5	6.9	10.7	7.6	3.3	2.5	3.4	1.5	0.5	20.0	0.0	0.0	52
Groshev, et.al. ^{2,b}					8.1	15.0	10.9	11.8	13.1	15.4	5.5	0.8	5.3	1.7	0.0	24.0	0.0	0.0	71
Greenwood, et.al. ²	0.0	9.2	4.9	4.3	8.0											37.0	0.0	0.0	43
Orphan, et.al. ^{3,c}	0.0	6.3	7.8	15.3	15.9	12.8	13.2	17.9	19.2	6.6	1.5	5.4	4.9	3.2	35.5	0.0	0.0	100	
Maerker & Muckenthaler ⁴	0.0	18.6	10.4	13.1	20.5	15.9	14.3	16.1	17.6	6.8	2.8	6.0	2.2	0.7	32.4	0.0	0.0	95	
Reactor Handbook ^{5,d}	95 (0.5-2 MeV)				69 (2-3 MeV)		62 (3-5 MeV)			19 (5-7 MeV)				19 (7-8.5 MeV)					122

a. No data given for $E_\gamma < 2.84$ MeV.b. No data given for $E_\gamma < 2.12$ MeV.c. Spectrum normalized to binding energy; includes contribution from $E_\gamma < 0.98$ MeV; observed % BE = 83.7.

d. Top gamma group is 7-9 MeV.

e. Al binding energy = 7.724 MeV.

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FIGURE CAPTION

Fig. 1 Comparisons of Calculated and Measured Secondary Gamma-ray
Pulse-height Spectra