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REVISED EVALUATIONS OF FISSION-PRODUCT CROSS SECTIONS[1]

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INTRODUCTION

This paper reports on revised cross-section evaluations for ^{134}Ba, ^{149}Sm, ^{154}Eu, ^{155}Eu, ^{160}Dy, ^{161}Dy, ^{162}Dy, ^{163}Dy, and ^{164}Dy. The evaluations for ^{134}Ba, ^{154}Eu, and ^{155}Eu were previously revised[1] for ENDF/B-VI. The other 6 evaluations, carried over from ENDF/B-V, were completed in the 1974-1980 time period. The evaluations for the dysprosium isotopes go back to ENDF/B-IV. Newer experimental data, not considered for the current ENDF/B-VI evaluations, was used in all of the revised evaluations. In the present work the primary emphasis was placed on the resolved and unresolved resonance regions, but newer measured data were also used for energies above the unresolved resonance region. Elastic, capture, and total cross sections are revised. Some important parameters from the revised evaluations are given in Table 1; corresponding values from the ENDF/B-VI evaluations are also given.

SUMMARY OF CHANGES

The current ENDF/B-VI ^{134}Ba evaluation[1] used the resolved resonance parameters from Mughabghab.[2] This revised evaluation is based on measured data[3] taken at ORELA. Analysis of the measured data was performed with SAMMY[4] to get Reich-Moore resonance parameters.[3] The thermal capture cross-section was revised[5] and the unresolved resonance range was added. This revised evaluation should be a big improvement over the present ENDF/B-VI evaluation.

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Samarium-149 accounts for a large fraction of the fission-product absorption rate because of its very large thermal absorption cross-section. In this revision the number of resolved resonances is increased from 30 to 158, the upper limit of the resolved resonance range is increased from 100 to 500 eV, and the unresolved resonance range is revised. The resolved resonance parameters are taken from the Mughabghab compilation.[2]

The ENDF/B-VI evaluations for ^{154}Eu and ^{155}Eu were revised[1] in 1989. Cross-sections for these isotopes are of considerable importance because ^{155}Eu is radioactive with a half-life of 4.75 years and decays to ^{155}Gd, which is stable. ^{155}Gd has a thermal absorption cross-section of 60,900 barns. A few years after discharge ^{155}Gd is one of the most important nuclides in spent reactor fuel because of its very high absorption rate. The ^{155}Gd concentration in spent fuel depends heavily on the ^{155}Eu concentration at reactor shutdown. For this reason it is important to determine the ^{155}Eu concentration and absorption rate as accurately as possible. Burnup calculations show that the calculated ^{154}Eu and ^{155}Eu concentrations are not in good agreement with measured values. The ^{154}Eu and ^{155}Eu cross-sections are most likely the reason for the disagreement between the calculated and measured concentrations. The parameters of the negative (bound) and first positive resonance have been revised for both ^{154}Eu and ^{155}Eu. The thermal capture cross-section of ^{154}Eu is increased from 1357 to 1846 barns and the capture resonance integral for ^{155}Eu is reduced from 23,445 to 15,300 barns. These changes are in agreement with measured data from Sekine.[6] The revised capture cross-sections are compared with the ENDF/B-VI values in Figs. 1 and 2. The revised evaluations will be used in burnup calculations to check the impact of the changes.

Cross-sections for dysprosium are of interest because of the relatively large thermal capture cross-section. The main isotope contributing to the large Dy capture cross-section is ^{164}Dy with a thermal capture cross-section of about 2650 barns. The current ENDF/B-VI evaluations for the dysprosium isotopes were done in 1974. For this work the resolved resonance parameters are taken from the Mughabghab[2] compilation; the upper limit of the resolved resonance range and the number of resolved resonances have been increased. For ^{164}Dy the unresolved resonance range was revised; for ^{160}Dy, ^{161}Dy, and ^{162}Dy an unresolved resonance range has been added. Unresolved parameters are not given for ^{163}Dy. For the energy range 3 to 700 keV, the capture cross-sections in the revised evaluations are based on measured data.[7,8] The ^{162}Dy evaluated capture is compared with the measured data of Kononov[8] in Fig. 3. The agreement between the evaluated and measured capture for the other Dy isotopes is similar.

CONCLUSIONS

The study presented in this paper strongly indicated that new fission-product evaluations utilizing both differential and integral data are needed. In the case of ^{134}Ba this procedure was followed.[3] For the other 8 nuclides considered, resolved resonance parameters from Mughabghab[2] were used. For energies above the resolved resonance region the revised capture cross-sections are based on measured data.[7-8] If and when new high quality differential data becomes available it should obviously be utilized to perform new evaluations.

Table 1. Fission-Product Evaluations

			ENDF/B-VI		REVISED	
Nuclide	MAT	TAPE	EHIR	RF,NR,UN	EHIR	RF,NR,UN
Ba-134	5637	103	2.072e+3	ML,9	1.0e+4	RM,87,UN
Sm-149	6240	106	1.000e+2	ML,30,UN	5.0e+2	ML,158,UN
Eu-154	6334	103	6.300e+1	ML,59,UN	6.3e+1	ML,60,UN
Eu-155	6337	120	3.500e+1	ML,7	3.5e+1	ML,8
Dy-160	6637	106	2.444e+1	SL,3	1.69e+3	ML,66,UN
Dy-161	6640	106	6.764e+1	SL,27	1.0e+3	ML,254,UN
Dy-162	6643	106	4.302e+2	SL,8	1.22e+4	ML,142,UN
Dy-163	6646	106	4.876e+2	SL,60	1.0e+3	ML,115
Dy-164	6649	106	2.720e+2	SL,2,UN	1.6e+4	ML,92,UN

			ENDF/B-VI		REVISED	
Nuclide	MAT	TAPE	CAPTURE	R.I.	CAPTURE	R.I.
Ba-134	5637	103	1.98	24.0	1.40	21.8
Sm-149	6240	106	39698	3264	40573	3493
Eu-154	6334	103	1357	1345	1846	1357
Eu-155	6337	120	3944	23445	3765	15300
Dy-160	6637	106	61.01	1674	57.03	1105
Dy-161	6640	106	585.1	1215	600.3	1085
Dy-162	6643	106	199.1	2778	193.8	2745
Dy-163	6646	106	134.4	1465	124.2	1487
Dy-164	6649	106	2520	329.0	2651	341.4

MAT = ENDF/B-VI material number
TAPE = ENDF/B-VI tape number
EHIR = upper limit of resolved resonance range (eV)
RF = resolved resonance formalism
- RM = Reich-Moore
- ML = Multi-level Breit-Wigner
- SL = Single-level Breit-Wigner

NR = number of resolved resonances
UN = unresolved resonance data given
CAPTURE = thermal capture at 0.0253 eV (barns)
R.I. = capture resonance integral (barns)

Fig. 1 Eu-154 CAPTURE Cross-Section
REVISED 12-12-97

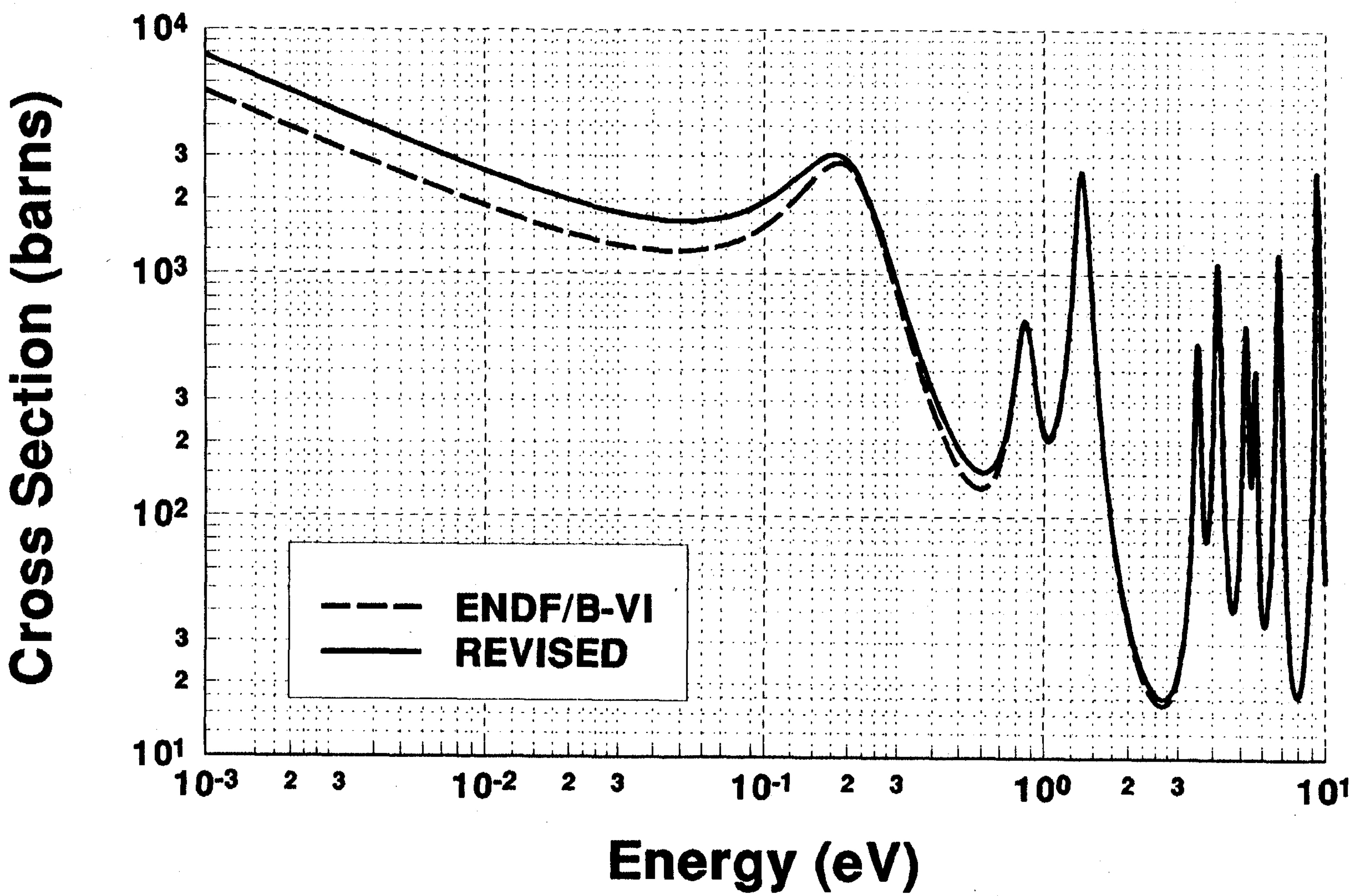


Fig. 2 Eu-155 CAPTURE Cross-Section REVISED 12-12-97

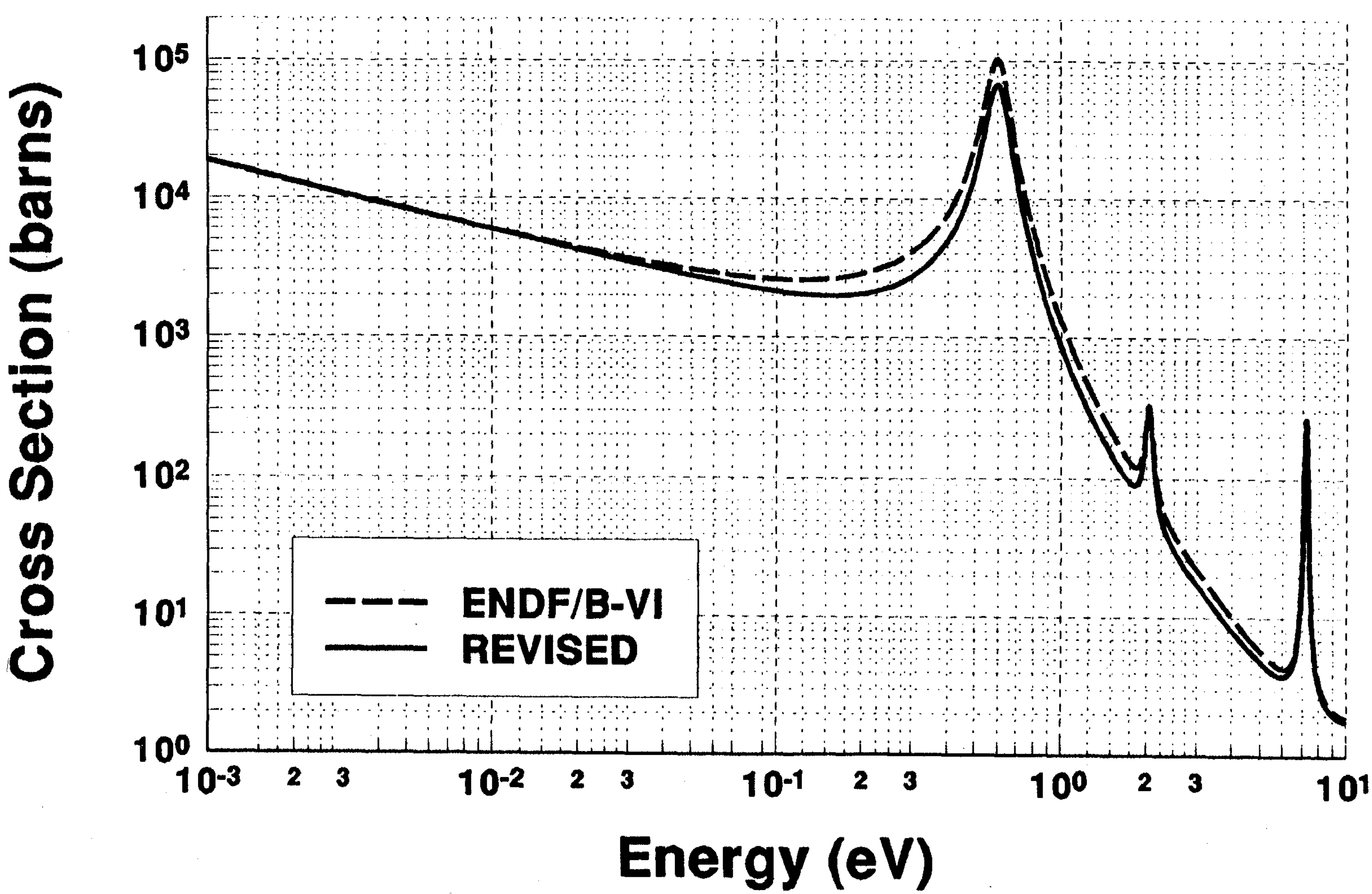
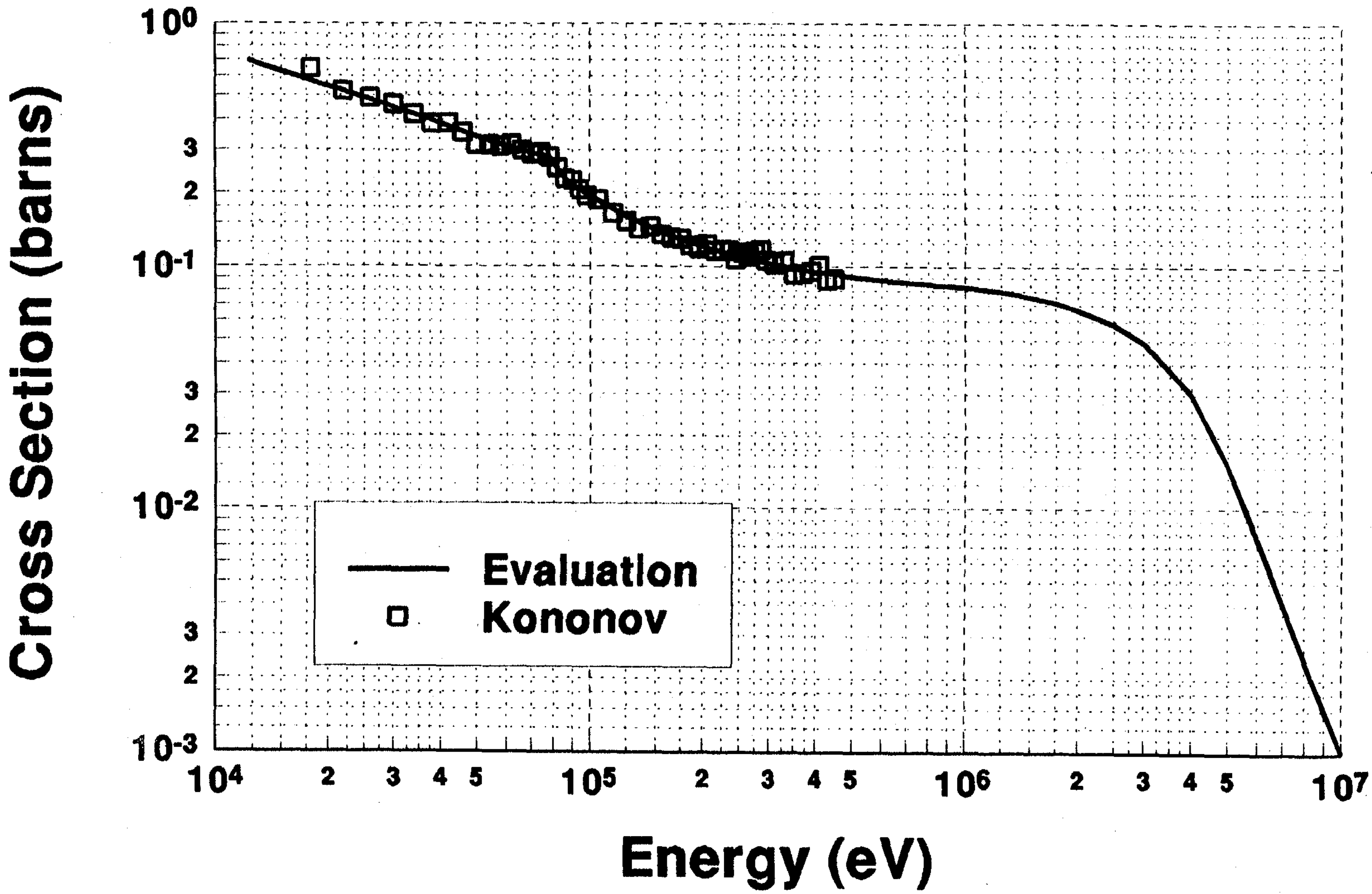


Fig. 3 Dy-162 CAPTURE Cross-Section
REVISED 11-03-97



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