Sub-group 8 : Minor Actinide Data (^{237}Np and ^{241}Am)

Members

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Purpose and working plan

The purposes of this sub-group are to investigate the present status of evaluated data for minor actinides, to make benchmark calculations and to finally make recommendations for future experimental and evaluation work. As an initial phase, we select the data of ^{237}Np and ^{241}Am for our investigation.

(1) Comparison of existing evaluations

The data for both nuclides are available in ENDF/B-VI, JEF-2 and JENDL-3. They will be compared with each other and experimental data by making graphs of cross sections and tables of resonance integral data. The cross sections in the resolved resonance region will be averaged in suitable energy intervals.

Contributor: T.Nakagawa

(2) Identifying reasons for discrepancies among evaluated data

After careful checking the graphs and tables made in the step 1, the members will send any suggestion for possible reasons for the discrepancies to Nakagawa who will collect the results of the investigation into a report.

Contributors: All the members especially E.Fort, E.Menapace, L.W.Weston, P.G.Young, M.G.Sowerby and Y.Kikuchi.

(3) To find possible freely available data for benchmarking the evaluated data

Good benchmark data are necessary to show the effects of the discrepancies in the evaluated data on the integral quantities; results of sample irradiations, reaction rate measurements in critical facilities etc. The members are requested to find such benchmark data and to send freely available ones among them to Nakagawa in order to be used commonly in the step 4.

Contributors: All the members

(4) Comparison of C/E values using the above benchmarks

Benchmark calculations are made by using the evaluated data in ENDF/B-VI, JEF-2 and JENDL-3. Group constants for ^{237}Np and ^{241}Am of these three libraries with common structure should be distributed before and it is desirable to make the benchmark calculations

with the three libraries in each project. The group constants will be made by Dr. Takano. Person who want to do the benchmark calculation should make contact with Mr. Nakagawa. The benchmark data and the group constants will be sent to the person from him. After the calculation with the benchmark data, the results should be sent to Nakagawa.

Contributors:

Y.Naito, H.Takano et al. (for JENDL-3)
M.Salvatores, H.Kuesters et al. (for JEF-2)
S.Raman et al. (for ENDF/B-VI)

(5) Investigation if additional information can be obtained from benchmarks that are not freely available.

Each person or group in charge for the step 4 is requested to try the same calculation for their own benchmarks which are not freely available. The results of C/E values should be gather to Nakagawa.

(6) Making recommendations for future experimental and evaluation work

On the basis of the results of above steps, the recommendations for future work will be made. A draft of them will be made in JENDL group, and then distributed to all the members in order to hear their opinion. The final report will be made by modifying the draft according to the comment from the members.

Present Status of Work

The step (1) of the working steps mentioned above has been completed. Documents for intercomparison of the evaluated data for ^{237}Np and ^{241}Am were prepared and distributed to the members. Relatively large discrepancies were found in the following quantities. Other data are in good areement with each other.

(1) ^{237}Np

Evaluated data

JENDL-3 : Uenohara and Kanda (Ue87)
ENDF/V-VI :Young et al. (Yo90)
JEF-2 : originally evaluated by Derrien et al. (De80), and modified for JEF-2.

Fission cross section

Large discrepancies were found in available experimental data in the subthreshold fission region. As is shown in Fig.1, as an example, the data measured by Brown et al.(Br70), Kolar et al.(Ko71) and Hoffman et al.(Ho76) are quite larger than those by Plattard(Pl73). The ENDF/B-VI and JEF-2 adopted the resonance parameters evaluated by Derrien et al.(De 80) based on the data of Plattard. The resonance parameters of JENDL-3 were based on those of Weston and Todd (We81) and Plattard et al. (Pl76).

Recently, new measurement has been done at Kyoto University by using a lead spectrometer. Their results are in good agreement with the higher data of Refs. Br70, Ko71 and Ho76. More investigation is needed to decide which data are more reasonable.

Inelastic scattering cross section

No experimental data are available. Therefore, large discrepancies are existing among the evaluated data (Fig.2). The evaluated data are the results of theoretical calculations. JENDL-3 used the spherical optical model and the others the coupled-channel optical model. Furthermore, JENDL-3 did not consider the direct inelastic, while ENDF/B-VI and JEF-2 toke account it to the 1-st and 3-rd levels.

(n,2n) cross section

This reaction is important for the estimation of ^{232}U production. However, discrepancies are found among the evaluations (Fig.3).

Average cross sections in reactor flux are compared in the following table.

(unit: mb)

	BWR			FBR		
	total	gound	isomer	total	gound	isomer
JENDL-3	0.989	0.247	0.742	0.457	0.114	0.343
ENDF/B-VI	0.998	0.231	0.767	0.459	0.106	0.353
JEF-2	0.769	-	0.605	0.357	-	0.281

This table shows that the effective data in JENDL-3 and ENDF/B-VI almost agree with each other and JEF-2 is smaller than them.

ENDF/B-VI adopted the theoretical calculation with GNASH above 9 MeV, and experimental data of Kornilov et al.(Ko85) below 9 MeV. The branching ratio to ^{236m}Np was adopted from Gardner's calculation (Ga89).

The total (n,2n) cross section of JEF-2 was evaluated with a code SI2N made by Fort, and the branching ratio was based on the calculation of Gardner et al.(Ga84).

JENDL-3 was based on the experimental data and the calculation with a formalism of Sagev and Caner (Sa78). The branching ration to the isomer was assumed to be 0.75 in the whole energy region.

(n,3n) cross section

No experimental data are existing. However, the large discrepancies found among the evaluations (Fig.4) might not be important.

Average number of neutrons per fission

As is shown in Fig.5, ENDF/B-VI is higher than JENDL-3 and JEF-2. The values at thermal energy are as follows:

	JENDL-3	ENDF/B-VI	JEF-2	Mughabghab(Mu84)
ν	2.5406	2.63581	2.534	
ν_d	0.0122	0.01081	-	
ν_p	2.5284	2.625	-	2.525±0.016

JENDL-3 and JEF-2 seem to be in good agreement with the recommendation of

Mughabghab.

(2) ^{241}Am

Evaluated data

JENDL-3: T.Nakagawa (Na89)
ENDF/B-VI: Zhou Delin, et al. (Zh88)
JEF-2: E. Fort and H.Derrien (Fo82)

Fission cross section

In the resonance region, discrepancies are existing among the evaluated data as is shown in Fig.6. Above the resonance region, discrepancies are small.

Inelastic scattering cross section

No experimental data are available. Therefore, large discrepancies are existing among the evaluated data (Fig.7). The JENDL-3 did not consider the direct inelastic process.

(n,2n) and (n,3n) cross sections

Figures 8 and 9 show the (n,2n) and (n,3n) cross sections which have no available experimental data at all and large discrepancies among the evaluated data.

Average number of neutrons per fission

JEF-2 gives fairly large values in the whole energy region (Fig.10). The thermal values are listed bellow.

	JENDL-3	ENDF/B-VI	JEF-2	Mughabghab(Mu84)
ν	3.2235	3.2235	3.330	
ν_d	0.00450	0.00427	–	
ν_p	3.2190	3.2190	–	3.213±0.032

The data of JENDL-3 and ENDF/B-VI are almost the same each other.

References

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De80) H.Derrien, J.P.Doat, E.Fort and D.Lafond: "Evaluation of ^{237}Np Neutron Cross-Sections in the Energy Range from 10^{-5} eV to 14 MeV", INDC(FR)-42/L (1980).
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Pl73) S.Plattard: Thesis (Orsay) (1973).
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Yo90) P.Young, E.Arthur and F.Mann: evaluation for ENDF/B-VI (1990).
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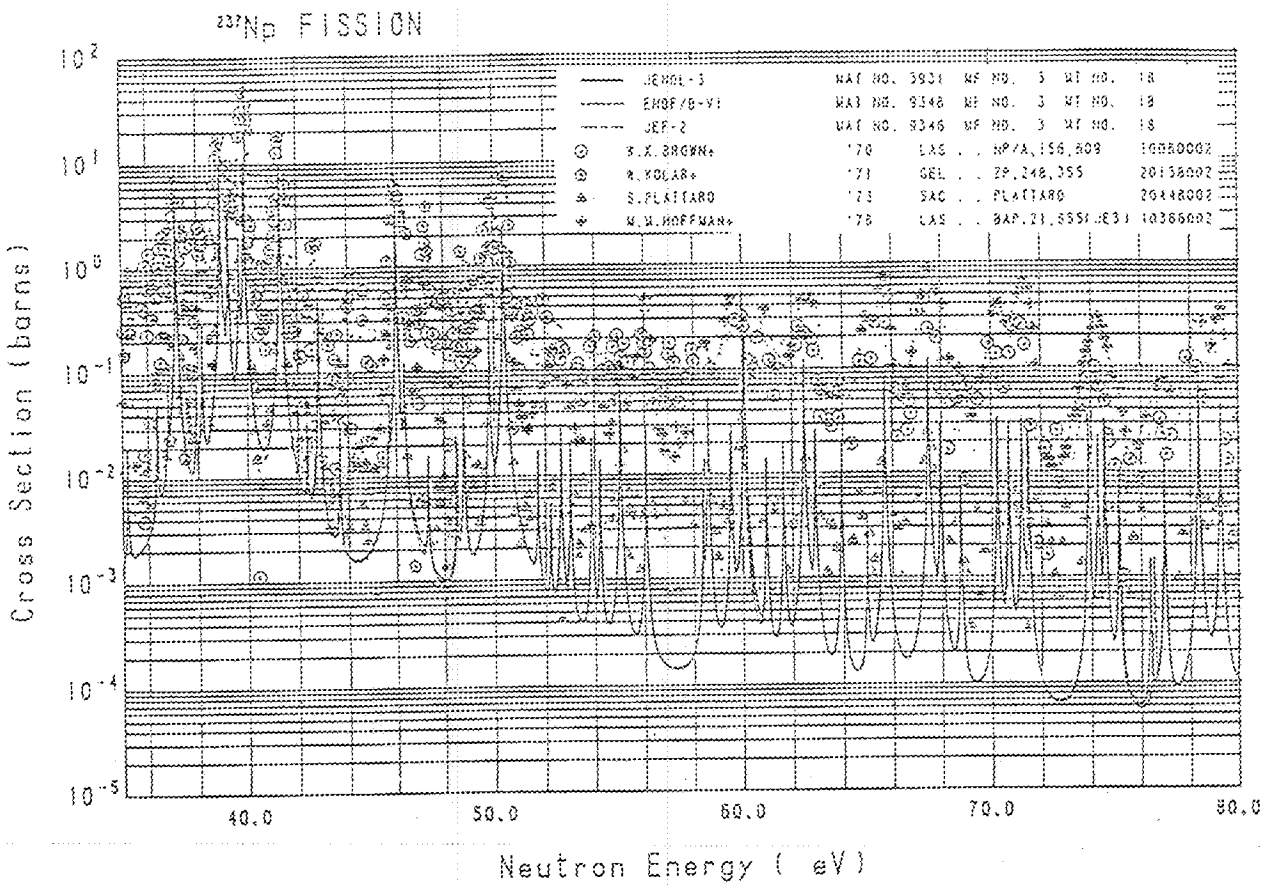

Fig. 1 Np-237 fission cross section (35 eV to 80 eV)

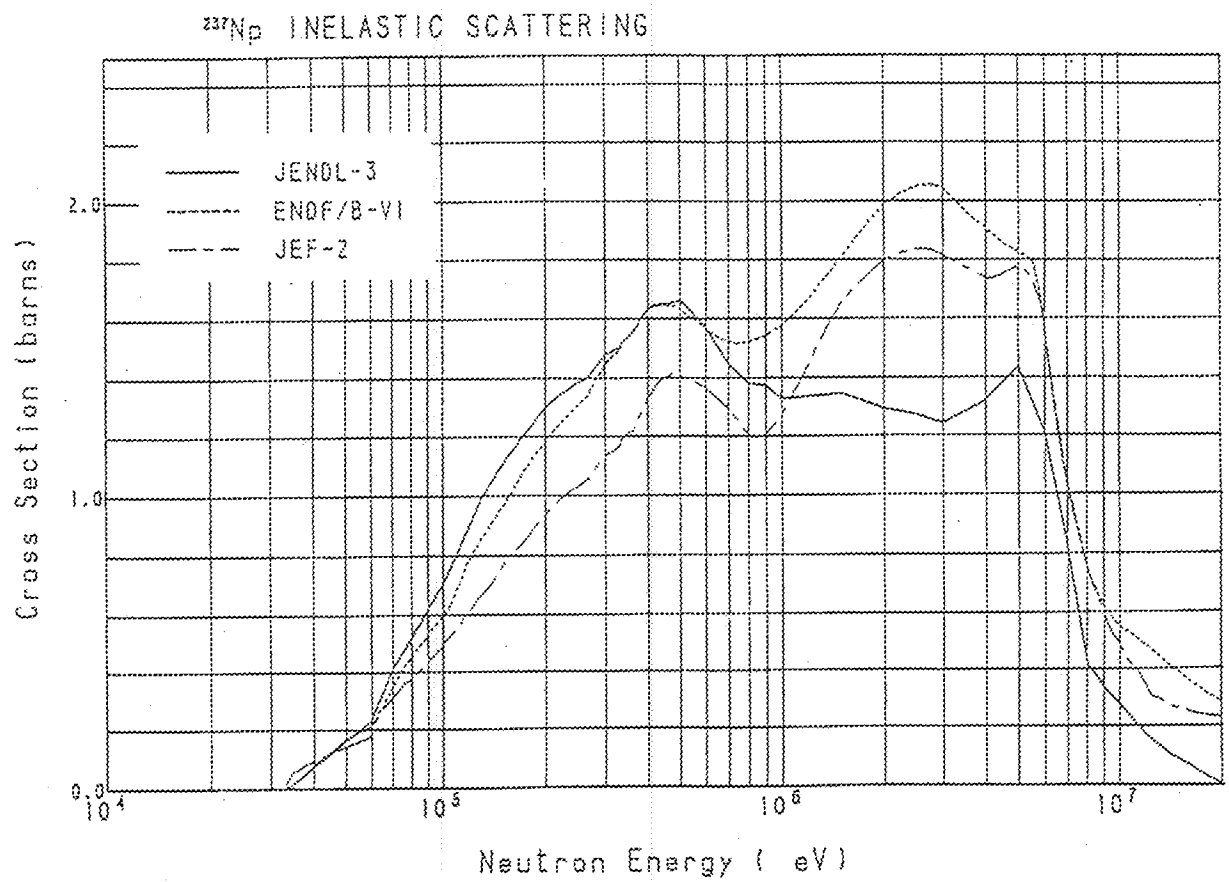

Fig. 2 Np-237 inelastic scattering cross section

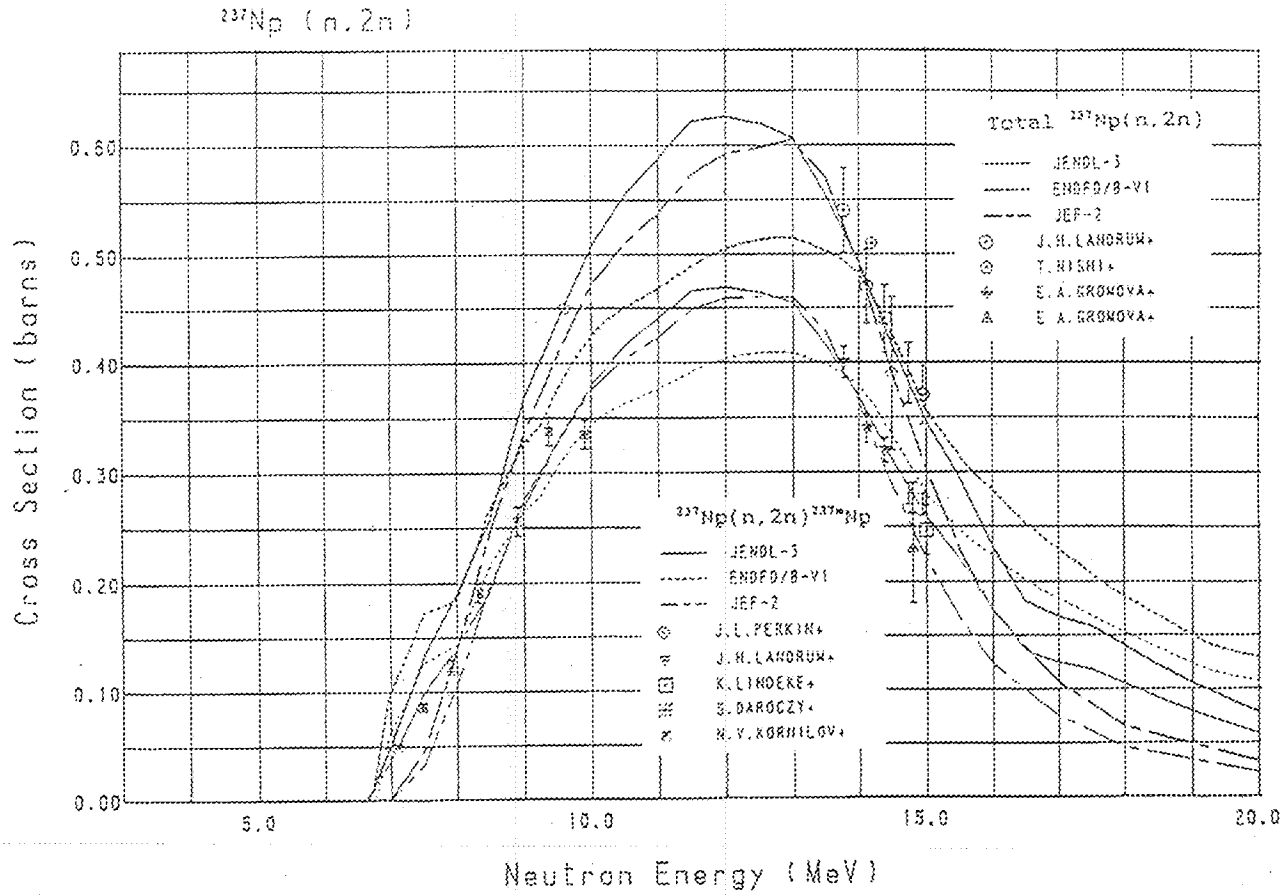

Fig. 3 Np-237 (n,2n) reaction cross section

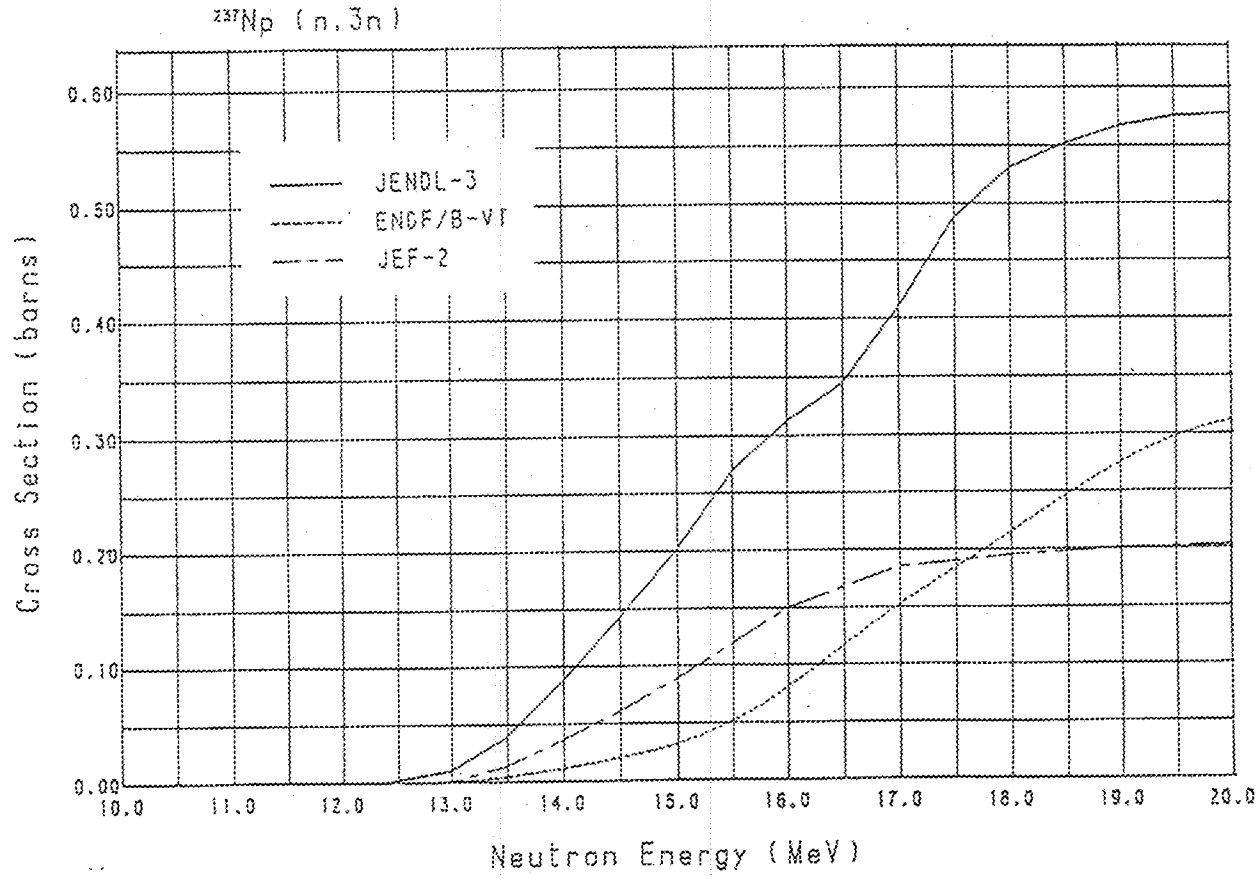

Fig. 4 Np-237 (n,3n) reaction cross section

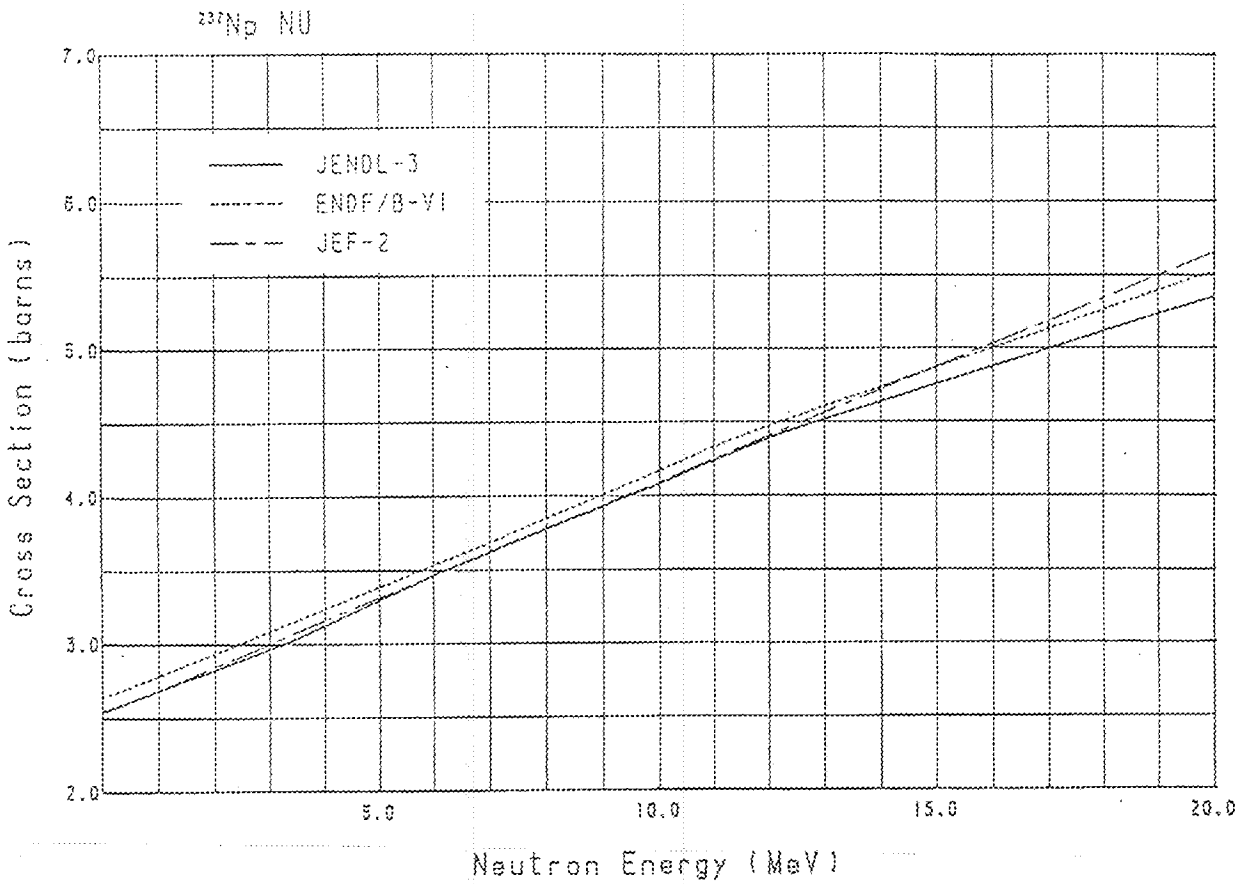

Fig. 5 Np-237 number of neutrons per fission

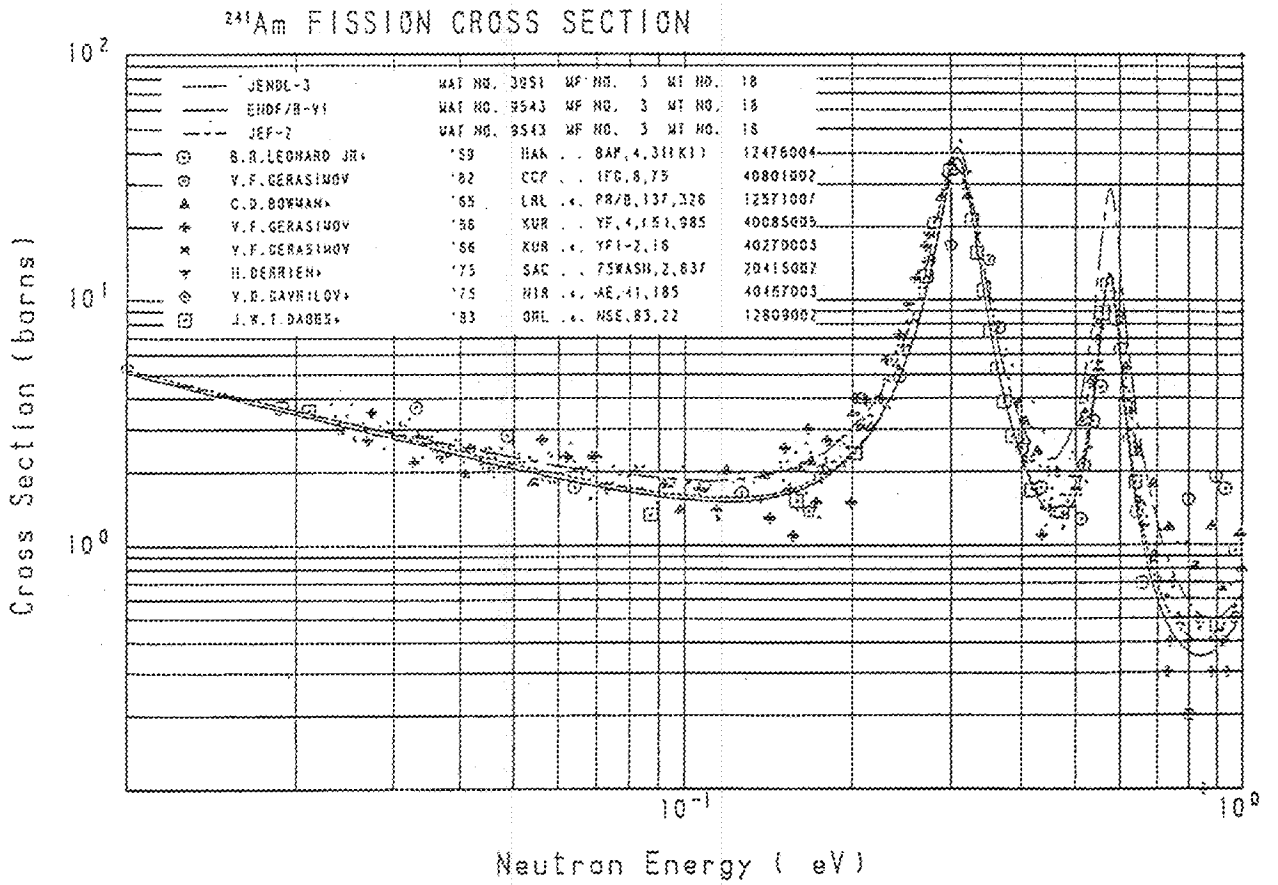

Fig. 6 Am-241 fission cross section (0.01 eV to 1 eV)

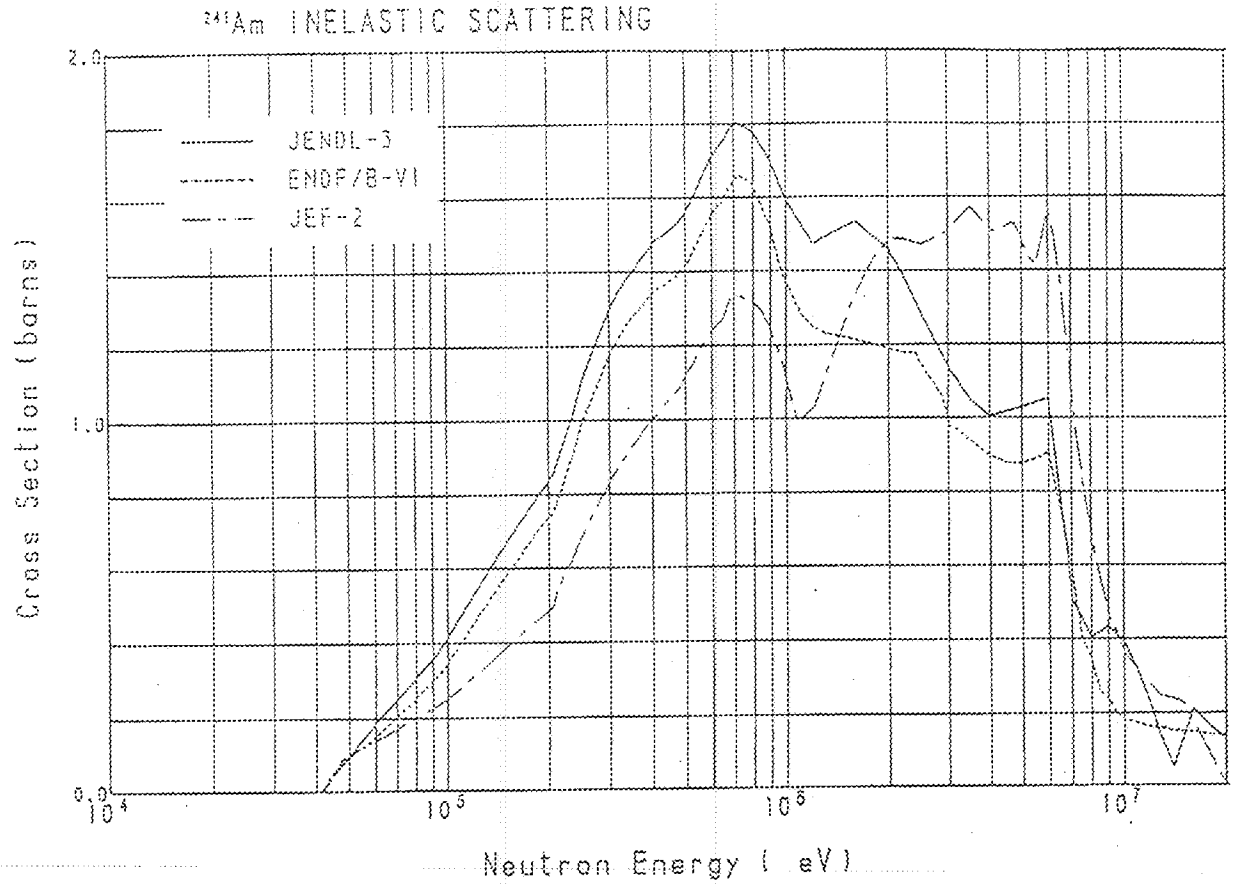

Fig. 7 Am-241 inelastic scattering cross section

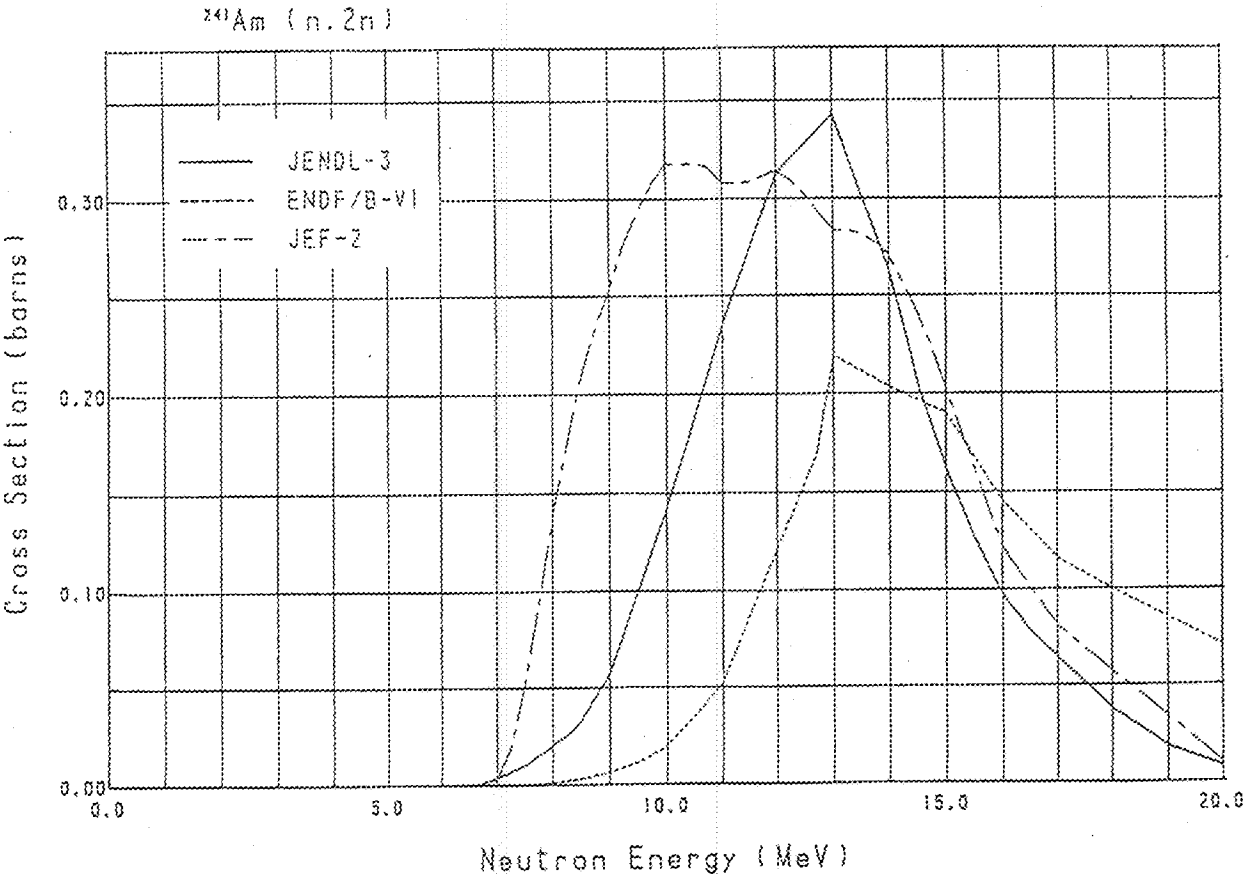

Fig. 8 Am-241 (n,2n) reaction cross section

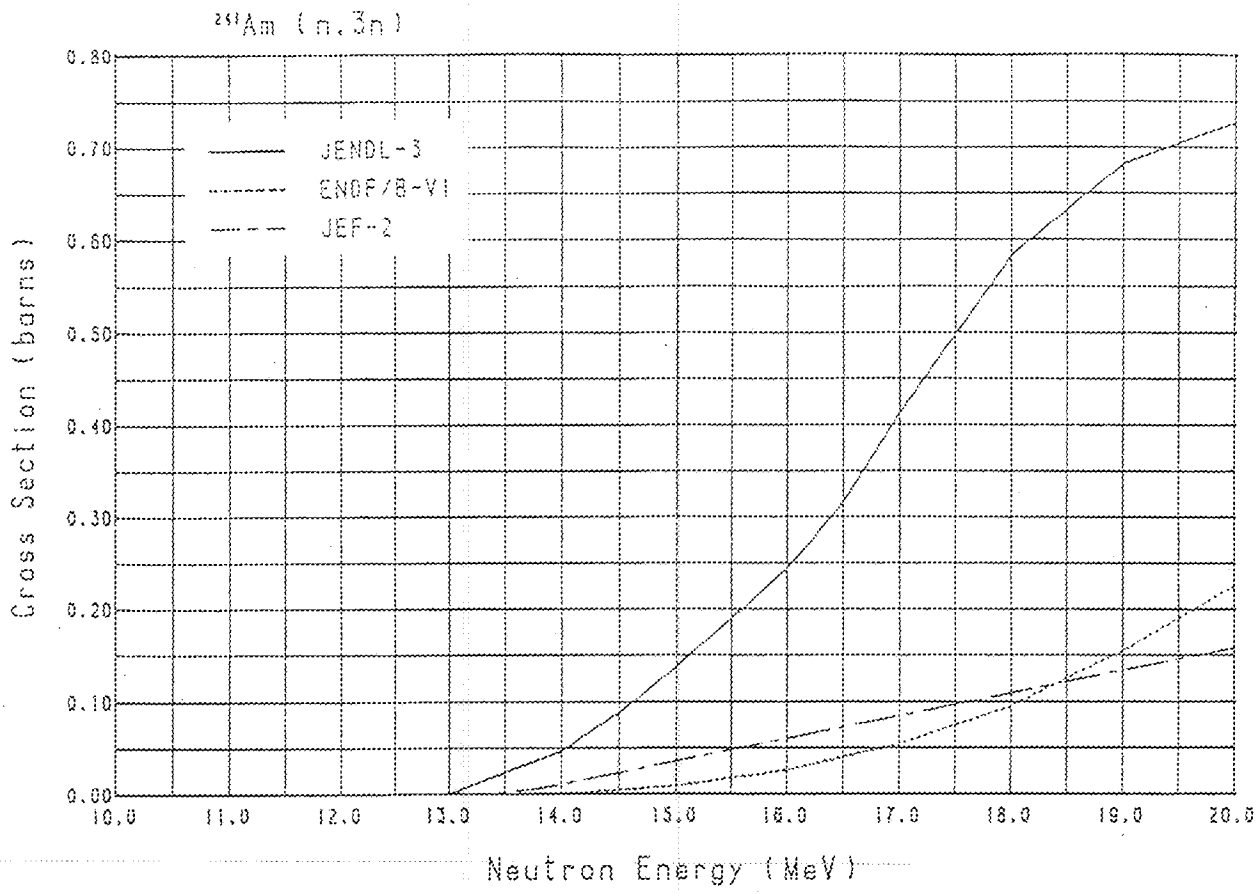

Fig. 9 Am-241 (n,3n) reaction cross section

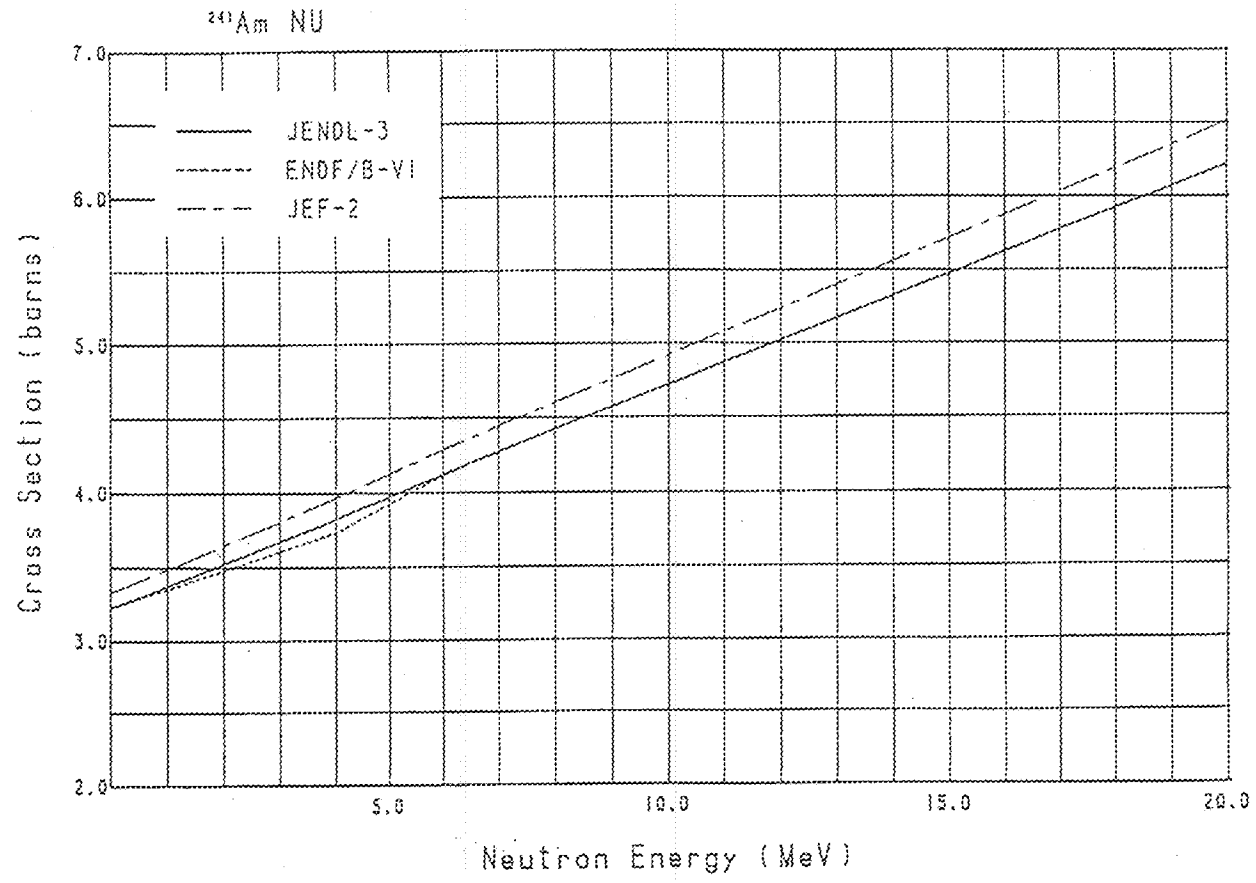

Fig.10 Am-241 number of neutrons per fission