JEF/DOC- 522

INDICES FROM THE MASURCA EXPERIMENTAL PROGRAMME CIRANO FOR THE VALIDATION OF CROSS-SECTION DATA.

G. RIMPAULT, P.SMITH, M. MARTINI, J.PIERRE.

CEA Cadarache, France

1. INTRODUCTION

The CIRANO experimental programme at the MASURCA facility has the major aim of validating nuclear data and methods for fast reactor burner cores. The CAPRA core has been designed to achieve this aim and hence has a significantly increased plutonium enrichment.

The CIRANO programme contains full reactor configurations with the following characteristics:

- steel reflectors,
- high plutonium enrichment,
- multi recycled plutonium.

Parametric studies have been performed to evaluate variations on these characteristics.

In the ZONA2 A core fission ratio measurements have been performed using fission chambers and detectors for a position at the core centre. Hence this provides detailed information for the flux characteristics of the ZONA2 cell, and so validates the cross section data for the higher isotopes of plutonium and other actinides.

The ZONA2 cell is a 25% enriched plutonium cell with a slightly degraded plutonium vector (18% Pu240 content for the total amount of plutonium). It is a highly enriched cell, even for a fast reactor configuration, and so provides early indications for the CAPRA plutonium burner cores.

2. INDICES AT THE CORE CENTER

Measurements by fission chambers (cylindrical with a 4 mm diameter) have been performed at the center of the ZONA2 A reference core in the North South radial channel.

Two chambers can be irradiated in the same time in this channel because of their small dimensions thus eliminating the uncertainties due to the reactor power and the spatial position.

Simultaneously, foil activation measurements were made to provide a U238 capture measurement.

The results, given in Table 1, are associated with uncertainties arising from the chamber calibration and counting rate statistics.

3. FISSION CHAMBER MEASUREMENTS

A precise determination of absolute fission rates has many implications, one of them being the validation or the improvement of nuclear data.

For the traditional deposition chambers (U235, U238, Pu239, N237) the threshold uncertainty is of the order of 3% when method errors and calibration uncertainties for the standard depositions are taken into account. However the analytical techniques used for these chambers impose precautions for future measurement campaigns which are envisaged to take place over several years.

The hypothesis that is used here is that the spectrum is not dependant on the type of irradiation performed, and that this holds true throughout the entire life of the fission chamber. Hence it is necessary now to develop a system of intercomparable measurements using calibrated 'reference' chambers to regularly check this hypothesis [1].

For the fission chambers with transurannic depositions the uncertainties are slightly increased (between 2-5%) due to several factors :

- the presence in the chamber of competing fissioning isotopes,

- the deposition mass (sometimes of the order of μg), which makes the analysis using the three threshold method (see Figure 1) increasingly inaccurate,

- the use of averaged σ in the fission spectrum for absolute calibration, which are influenced by increased uncertainties (between 3-5%) - see Tables 2 and 3.

A difficulty with the calibration of the Cm244 chamber can also be mentioned here. The low level of the rapid high energy flux does not allow an accurate discrimination between the noise spectrum (due to α and spontaneous fissions) and the signal spectrum. Also, the absence of information concerning the isotopic composition prevents the calibration of the thermal flux.

the correct interpretation of the results already obtained.

4. EXPERIMENT / CALCULATION RESULTS

Calculations have been performed with the current formulaire CARNAVAL IV processed with the HETAIRE cell code, and with the JEF2 Library processed by the ECCO cell code, whose description has been given in previous papers (2, 3). It can be noted that detailed fine group and self shielding calculations enable a precise calculation with an accurate representation of energy thresholds. The results are given in Table 4.

The CARNAVAL IV results do not look satisfactory for some of the minor actinides such as Pu238, Np237, Am241 and Am243. This is surprising as very good aggreements were found during previous experiments (4), also used in the past to qualify cross section data. Flux uncertainties were reduced by the use of adjusted cross sections for the isotopes contributing significantly to the cell neutron balance.

However, the JEF2 results look very good for these recent experiments for all of the isotopes (the calculated values are within the experimental error margins). The Pu238 and Am241 values can be seen to be significantly discrepant from the previous experimental results (4). The reason for this is unclear, but might possibly arise from the use of better measurement techniques. However, it remains possible that previous experiments could be sensitive to another part of the energy spectrum. This issue should be resolved by the examination of sensitivity values which have been calculated using perturbation theory for use in adjustment techniques.

5 - CONCLUSION

The CIRANO experimental programme at the MASURCA facility has the major aim of validating nuclear data and methods for fast reactor burner cores.

In the ZONA2 A core fission ratio measurements have been performed using fission chambers and detectors for a position at the core centre. Hence this provides detailed information for the flux characteristics of the ZONA2 cell, and so validates the cross section data for the higher isotopes of plutonium and other actinides.

Measurements by fission chambers (cylindrical with a 4 mm diameter) have been performed at the center of the ZONA2 A reference core in the North South radial channel.

Two chambers are irradiated in the same time in this channel because of their small dimensions thus eliminating the uncertainties due to the reactor power and the spatial position.

Simultaneously, foil activation measurements were made to provide a U238 capture measurement.

Attention has been given to precise calibration of the fission chambers therefore giving very good confidence in the experimental results.

The JEF2 results look very good for these recent experiments for all of the isotopes (the calculated values are within the experimental error margins).

The adequacy of the results to other fast reactor spectrum will be resolved by the examination of sensitivity values which have been calculated using perturbation theory for use in adjustment techniques.

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Table 1 : The Ratio Between Nuclides Measured In Thermal And Fast Fluxes

N° chambre	Type	Isotope principal	Rapport nuclide N1/N2	
			Flux thermique	Flux rapide
531 931	ϕ 23	U235 Pu239	.8901	.9050
531 051	ϕ 23	U235 U238	.1731	.1725
558 954	ϕ 8	U235 Pu239	2.201	2.205

Table 2 : Cross Sections Used In The Current Analysis

N° Chambre	Isotope	$\bar{\sigma}$ (mb)[a] (2)	$\bar{\sigma}$ (mb)[a] JEF2	$\bar{\sigma}_{eq}$ [b]	$1 - \frac{\bar{\sigma}_{eq}}{\bar{\sigma}}$ [c]	Incertitude [d] %
558	U235	1200	1219	1207.6	.006	< .1
051	U238	312	304	320.7	.028	.14
1115	Pu238		1963	2361	.203	0.9
954	Pu239	1818	1798	1828	.006	< .1
1036	Pu240		1332	1360	.021	.1
1956	Pu241		1616	2808	.738	2.2
1051	Pu242		1137	1158	.018	.1
1055	Am241		1314	1314	0	0
1950	Am243		1092	1238	.134	0.6
1970	Cm244		1601	? *	?	?
764	Np237	1359	1284	1359	0	0

a) averaged cross section of the main isotope in a fission spectrum
b) equivalent cross section with contribution of other isotopes
c) fissions from the other isotopes (normalised to the fission of the main isotope)
d) uncertainty on the mass of the main isotope due to other isotope contributions

* isotopic composition not known

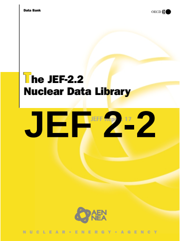


Table 3 Experimental Results Of Fission Chamber Indices For The ZONA2 Cell Of The CIRANO Programme

	Experimental Result and Uncertainty
$\sigma_{c_{U238}} / \sigma_{f_{U235}}$	0.1269 ± 3.0 %
$\sigma_{f_{U238}} / \sigma_{f_{U235}}$	0.0447 ± 2.4 %
$\sigma_{f_{Pu238}} / \sigma_{f_{U235}}$	0.702 ± 4.9 %
$\sigma_{f_{Pu239}} / \sigma_{f_{U235}}$	1.0554 ± 1.8 %
$\sigma_{f_{Pu240}} / \sigma_{f_{U235}}$	0.286 ± 4.5 %
$\sigma_{f_{Pu241}} / \sigma_{f_{U235}}$	1.310 ± 3.9 %
$\sigma_{f_{Pu242}} / \sigma_{f_{U235}}$	0.218 ± 4.6 %
$\sigma_{f_{Np237}} / \sigma_{f_{U235}}$	0.273 ± 2.9 %
$\sigma_{f_{Am241}} / \sigma_{f_{U235}}$	0.223 ± 4.5 %
$\sigma_{f_{Am243}} / \sigma_{f_{U235}}$	0.175 ± 4.6 %

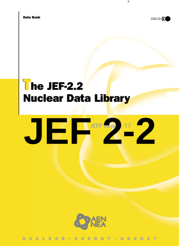


Table 4 Experiment/Calculation Descrepancies For Fission Chamber Indices In The ZONA2 Cell Of The CIRANO Programme

	CARNAVALIV	JEF2
$\sigma_{c_{U238}} / \sigma_{f_{U235}}$	-1.5%±3.0%	+1.7%±3.0%
$\sigma_{f_{U238}} / \sigma_{f_{U235}}$	+5.1%±2.7%	0.0%±2.7%
$\sigma_{f_{Pu238}} / \sigma_{f_{U235}}$	-9.8%±4.9%	-3.3%±4.9%
$\sigma_{f_{Pu239}} / \sigma_{f_{U235}}$	+1.3%±1.8%	-1.7%±1.8%
$\sigma_{f_{Pu240}} / \sigma_{f_{U235}}$	-1.4%±4.5%	-4.3%±4.5%
$\sigma_{f_{Pu241}} / \sigma_{f_{U235}}$	+0.1%±3.9%	-1.7%±3.9%
$\sigma_{f_{Pu242}} / \sigma_{f_{U235}}$	+3.8%±4.6%	-4.4%±4.6%
$\sigma_{f_{Np237}} / \sigma_{f_{U235}}$	-8.7%±2.9%	+0.4%±2.9%
$\sigma_{f_{Am241}} / \sigma_{f_{U235}}$	-12.2%±4.5%	-5.1%±4.5%
$\sigma_{f_{Am243}} / \sigma_{f_{U235}}$	-13.4%±4.6%	-5.4%±4.6%

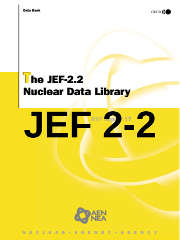
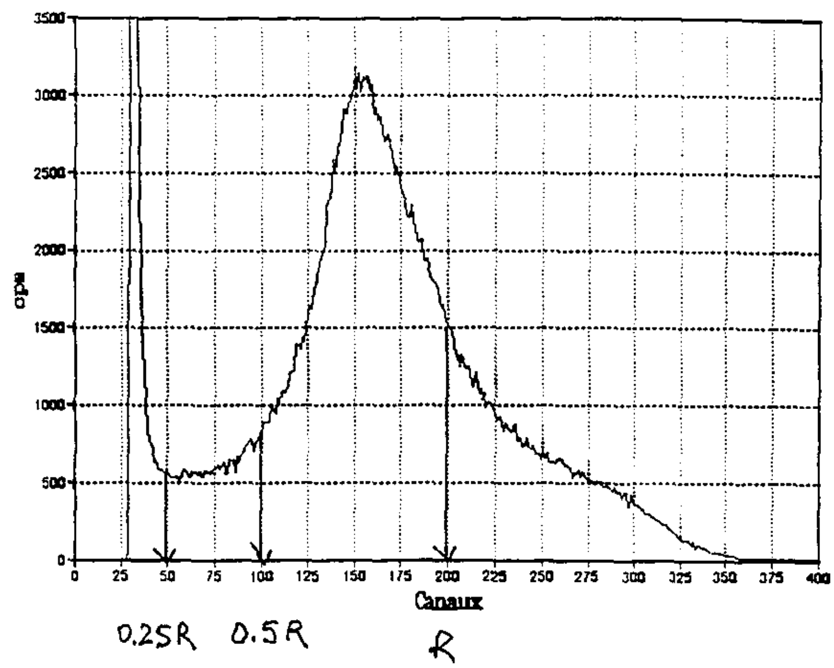


Figure 1 : The Three Threshold Technique

CHAMBRE : Np-237 Diametre: 8 N. d'inventaire : 766C

Date de la mesure : 09-Jun-94



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