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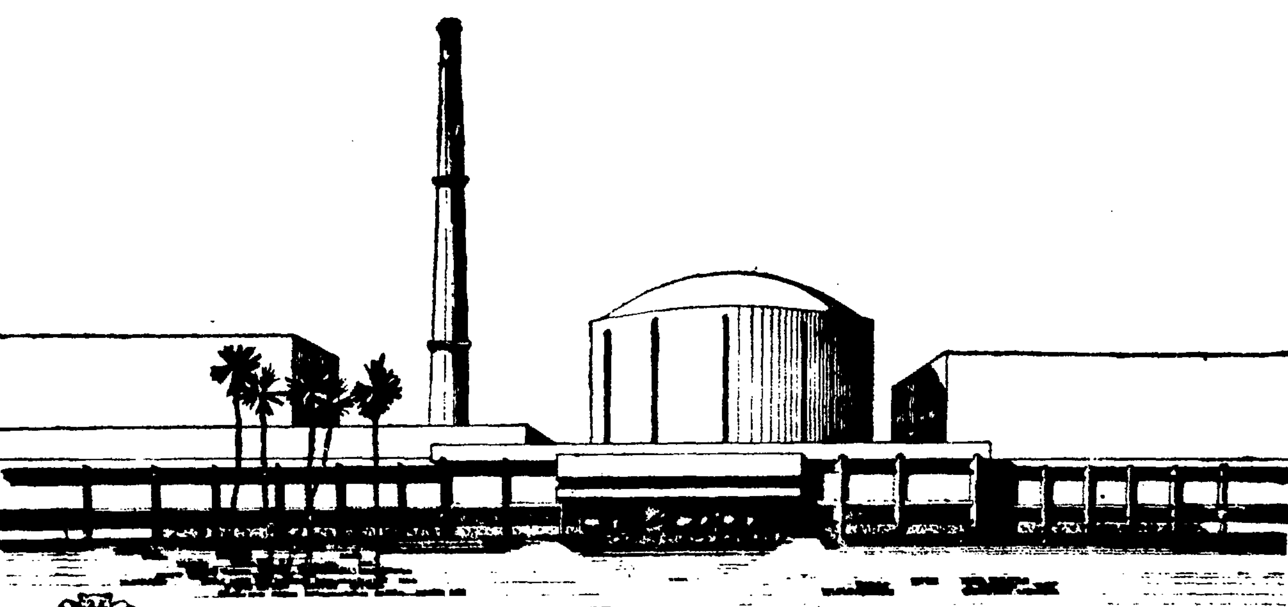

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ANALYSES OF SELECTED FAST CRITICAL ASSEMBLIES USING JENDL-2 BASED UNADJUSTED MULTIGROUP DATA

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ABSTRACT

In order to validate the non-adjusted multigroup cross section set recently prepared by us from the Japanese Evaluated Nuclear Data Library - Version 2 (JENDL-2), we analysed some of the integral parameters of several fast critical benchmark reactor assemblies, by comparing the measured values with those predicted using this cross section set and also by intercomparing the values predicted by various cross section sets. The observations of our analyses are presented in this report. We have chosen the benchmark assemblies such that there is a variety in core size, major fuel component, reflector used etc. One dimensional homogeneous diffusion theory model was used and suitable corrections were added. The assemblies considered were among the ones recommended by the Cross Section Evaluation Working Group (CSEWG), viz. ZPR-3-12, ZPR-3-48, ZPR-3-49, ZPR-3-50, ZPR-3-53, ZPR-3-54, ZPR-3-56B , ZPR-6-7 and ZPR-6-6A.

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ANALYSES OF SELECTED FAST CRITICAL ASSEMBLIES USING JENDL-2 BASED UNADJUSTED MULTIGROUP DATA

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I. INTRODUCTION

Most of the LMFBR core physics neutronics calculations, at IGCAR make use of the 1969 version of French adjusted 25 group neutron cross section library[1] called Cadarache (also called SETR) 25 group Version II set. Presently, it is our interest to create our own multigroup non-adjusted cross section set in suitable format for our neutronics codes for performing LMFBR core calculations, in order to study the impact of recent revisions in the basic data. We have created earlier a 25 group neutron cross section library in SETR format for several elements of interest to LMFBRs from the ENDF/B-IV (1974) data library. This multigroup library was found to predict the reactor integral parameters satisfactorily[2]. In 1985, we received the Japanese Evaluated Nuclear Data Library (1980) (JENDL-2) from IAEA and the generation of a 25 group neutron cross section library in the SETR format from JENDL-2 for materials of interest to LMFBRs was completed recently[3]. Analyses of fast critical benchmark assemblies, using this new multigroup library, was taken up to study how the more recent JENDL-2 data predicts the LMFBR core integral parameters. The integral parameters we considered in this study are effective multiplication factors, central reaction

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rate ratios and central reactivity coefficients. The results of our earlier[4] analyses are also included in this report.

II. DESCRIPTION OF CRITICAL ASSEMBLIES

The Cross Section Evaluation Working Group (CSEWG) has recommended several benchmark fast critical assemblies[5] in simplified models, for testing the accuracy of prediction of a given integral parameter by using a multigroup set. For this study, we have selected nine assemblies covering a wide range in energy spectrum and core size. The assemblies ZPR-3-49, ZPR-3-50, ZPR-3-53 and ZPR-3-54 are non-CSEWG criticals and their composition and dimensions for the one dimensional models are taken from ref.6. The assemblies ZPR-3-48, ZPR-3-49, ZPR-3-50, ZPR-3- 53, ZPR-3-54 and ZPR-3-56 provide the opportunity for the examination of the effect of variation of a single parameter. The main characteristics of these nine assemblies[6] are given in Table I. The composition and dimensions for the one dimensional model of these assemblies are given in Table II.

III. CALCULATIONAL DETAILS

One dimensional homogeneous models in spherical geometry as recommended were used for the analyses. The code EFFCROSS[7] was used to generate temperature and composition dependent mixture cross sections for these assemblies from the multigroup data set[3]. The one dimensional diffusion - cum - perturbation code MUDE[8] was used to calculate effective multiplication factor, direct and adjoint fluxes, reactivity changes etc.

III a. Effective Multiplication Factor

The calculated effective multiplication factor for these nine assemblies are given in Table III. The corrections to k-eff (i.e. 1D to 2D, diffusion to transport and heterogeneity (see Table IV)), are already added in these values. A detailed comparison of reported k-eff's obtained with different cross section sets for these assemblies are also given in Table III. It is important to note that the correction factors mentioned above are not derived from the respective cross section sets but are those reported in Ref. 6 and are based on ENDF/B-III.

III.b Alternative Processing of Blanket Cross Sections

Normal EFFCROSS calculation uses a core spectrum shape for reflector slowing down cross section preparation. This is adequate for heavy metal reflectors like ^{238}U but may not be good for lighter reflectors like Fe or Ni. To improve this, use of 1/E spectrum for the reflector slowing down cross section preparation has been considered as an alternate for such reflectors.

III.c Bare Core Calculations

The bare core calculations were done to investigate how much core and reflector contribute to k-eff and to understand the nature of the differences between different cross section sets.

III.d Central Reaction Rate Ratios

We have calculated one dimensional central fission rates for ^{238}U, ^{239}Pu and ^{240}Pu , central capture rates for ^{238}U relative to ^{235}U fission rate and central capture rate for ^{238}U relative to ^{239}Pu fission rate. We have also compared in Tables VII.a - VII.e the C/E values of the parameters corresponding to JENDL-2 data with those corresponding to SETR and JENDL-1 sets.

III.e. Central Reactivity Worths

The CSEWG benchmark specifications give reactivity coefficients in units of $10^{-5}\,\Delta k/k$/mole obtained in this unit by a conversion factor from the measured worth in inhour unit. It should be kept in mind that the reported experimental worth in units of $10^{-5}\,\Delta k/k$/mole is dependent on the specific delayed neutron data used for the conversion. Hence, we have preferred to report the experimental worths in inhour unit from the reported experimental worths in $10^{-5}\Delta k/k$/mole using conversion factors[9] supplied by the original authors and are included in our tables. For conversion of our calculated worths to inhour unit, we have used the same conversion factors. A comparison of worths calculated in units of inhour/kg with the experimental worths in the same unit is made with JENDL-2, ENDF/B-IV and SETR sets for ^{235}U, ^{238}U, ^{239}Pu, Fe, Cr, Ni and Na. A model correction factor[6] is used to convert the one dimensional value to two dimensional value.

III.f Normalised Worths

We have also calculated the central reactivity worths of ^{235}U, ^{238}U, Fe, Cr, and Ni normalised to those of ^{239}Pu with JENDL-2 and SETR sets.

IV. RESULTS AND DISCUSSIONS

IV.a. Effective Multiplication Factor

It can be seen from Table.III that our JENDL-2 data set predicts the k-eff as well as the other data sets. The average absolute deviation in k-eff calculated with JENDL-2 is 0.55% where as with SETR set it is 0.57%. There is a difference of about 0.12% in the absolute deviation in k-eff between our

JENDL-2 multigroup data set with the reported JENDL-2 set[10] and this may be due to differences in the processing and the calculational model. It is noted that except for ZPR-3-54 SETR set overpredicts the k-eff of all the assemblies while other sets both overpredict and underpredict.

IV.b. Alternative Processing of Blanket Cross Sections

Using the blanket slowing down cross sections prepared with 1/E spectrum for assemblies having lighter reflectors, k-eff's are calculated for these assemblies and are given in Table V. This option is found to improve agreement of the JENDL-2 results with the measured values for ZPR-3-54 with Fe reflector and ZPR-3-56B with Ni reflector.

IV.c. Bare Core Calculations

The difference in k-eff's calculated with JENDL-2 and SETR sets for bare core and with reflectors are given in Table VI. It is seen that with reflector SETR set predicts k-eff higher than JENDL-2 except for ZPR-3-12, ZPR-3-54 and ZPR-6-6A and the difference is less than 750 pcm except for ZPR-3-54 and ZPR-6-6A. It should be noted that the assemblies ZPR3-12 and ZPR6-6A have ^{235}U cores and ZPR-3-54 is Fe reflected. The assemblies ZPR-3-54 and ZPR-3-53 have identical cores but different reflectors, and remarkably large difference in k-eff is observed for ZPR-3-54. Following important points are observed from the bare core calculations:

i. For ZPR-3-54, about half the difference in k-eff is due to the core and the other half is due to the reflector and the differences act in the direction of making the total difference larger.

ii. In all the other cases, the difference due to the core and that due to the reflector act in the opposite direction so that the total difference reduces or changes sign.

It should be noted that the SETR set is an adjusted set for oxide fuelled Pu cores with ^{238}U blanket and this could cause a systematic difference in the contribution to error in k-eff from core and from blanket.

IV.d. Central Reaction Rate Ratios

The central reaction rates in ^{238}U, ^{239}Pu, and ^{240}Pu normalised to those of ^{235}U are given in Tables VII.a to VII.e. The average absolute deviation of C/E values of ^{238}U fission, ^{239}Pu fission, ^{240}Pu fission and ^{238}U capture normalised to those of ^{235}U fission , calculated with JENDL-2 set, are 7.3, 4.8, 14 and 3.2% whereas SETR set give 7.7, 2.5, 13.4 and 4.6% respectively.

IV.e. Central Reactivity Worths

The central reactivity worths of ^{235}U, ^{238}U, ^{239}Pu, Fe, Cr, Ni and Na are given in Tables VIII.a to VIII.g. In general, the central reactivity worths are found to be overpredicted for these nuclides with all cross section sets. The average absolute deviation of C/E values of ^{235}U, ^{238}U and ^{239}Pu the worths calculated with JENDL-2 is 17.6, 8.5 and 17.3 % whereas SETR set gives 13.5, 7.8 and 15% respectively. For structural materials, the worths are found to overpredict with all sets except for Ni worth calculated with SETR set. The SETR set is found to predict well the Fe, Cr and Ni worths. A large discrepency in the calculated sodium worth is found with all cross section sets.

IV.f. Normalised Worths

The central reactivity worths of ^{235}U, ^{238}U, Fe, Cr and Ni normalised to those of ^{239}Pu calculated with JENDL-2 and SETR sets are given in Tables IX.a to IX.f. For comparing these calculated results , the reported normalised worths with JENDL-1 are also included in these tables. In general, our JENDL-2 set is found to predict well the normalised worths. The average absolute deviation of C/E values of ^{235}U, ^{238}U, Fe, Cr and Ni worths normalised to those of ^{239}Pu, calculated with JENDL-2 set, are 4, 9.4, 9.44, 10.0 and 9.72% and with SETR set give 3.6, 12.03, 12.92, 9.8 and 21.14% respectively. The large discrepency for Ni normalised worth in case of SETR set is worth mentioning. For sodium , a large discrepency is found in the C/E values with all sets.

Table X gives the summary of the results of the analyses carried out for the nine assemblies.

V. CONCLUSIONS

From the analyses of the nine benchmark fast critical assemblies, it is found that our 25 group cross section set derived from the JENDL-2 point data library predicts the effective multiplication factor as well as the adjusted SETR set. However, the central reactivity worths are in general better predicted by the SETR set while the prediction of central reaction rate ratios is found to vary with the nuclide and critical assembly, sometimes the SETR set performing better and sometimes the JENDL-2 set. The normalised reactivity worths are found to be better predicted by the JENDL-2 set than by the SETR set except for ^{235}U. Probably, a detailed sensitivity analysis can explain the impact of individual cross section to the integral parameters. It is clear from Table X that our JENDL-2 set is capable of predicting the integral parameters as close as to that predicted by the adjusted SETR set. Hence it is concluded, subject to the few remarks that follow, that the present analysis has enabled a satisfactory validation of the new multigroup set derived from JENDL-2.

1. The first order perturbation model is not sufficient for sodium worth calculations.

2. A large deviation of the normalised worth of Ni with SETR set suggests some problems in the SETR Ni cross sections.

3. Large deviations of k-effs for ZPR-3-54, an iron reflected assembly, and ZPR-3-56B which is predominantly nickel reflected are observed. This may be due to the inadequacy of the reflector cross section preparation by the code EFFCROSS.

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Table 1

Characteristics of critical assemblies

Assembly	Fissile fuel	Fertile to fissile ratio	Approximate core volume (litres)	Reflector	Comments
ZPR-3-12	U	3.8	100	U-238	C added to soften spectrum
ZPR-3-54	Pu	1.6	190	Fe	Similar to assembly 53, except an Fe reflector
ZPR-3-53	Pu	1.6	220	U-238	Similar to assembly 54, except an U reflector
ZPR-3-50	Pu	4.5	340	U-238	Similar to assembly 49, except an additional C
ZPR-3-48	Pu	4.5	410	U-238	C added to soften spectrum
ZPR-3-49	Pu	4.5	450	U-238	Similar to assembly 48, except Na removed
ZPR-3-56B	Pu	4.6	610	Ni	Predominantly Ni reflector
ZPR-6-7	Pu	6.5	3100	U-238	L/D = 0.9
ZPR-6-6A	U	5.0	4000	U-238	L/D = 0.8

Table II

Composition of critical assemblies atom densities (atom/barn-cm) and dimensions

	ZPR-3-12		ZPR-3-54		ZPR-3-53	
	Core	Reflector	Core	Reflector	Core	Reflector
U-234	.000046	-	-	-	-	-
U-235	.004516	.000089	.000006	-	.000006	.000083
U-238	.016948	.040026	.002615	-	.002615	.039770
Pu-239	-	-	.001669	-	.001669	-
Pu-240	-	-	.000107	-	.000107	-
Pu-241	-	-	.000008	-	.000008	-
Pu-242	-	-	-	-	-	-
O	-	-	-	-	-	-
C	.026762	-	.055898	.001587	.055898	.000024
Na	-	-	-	-	-	-
Al	-	-	.000111	-	.000111	-
Cr	.001419	.001237	.002081	.001334	.002081	.001311
Fe	.005704	.004971	.007134	.074805	.007134	.004496
Ni	.000621	.000541	.000970	.000629	.000970	.000611
Mo	-	-	.000208	.000512	.000208	-
Mn	.000059	.000052	-	-	-	-
Si	.000069	.000060	-	-	-	-
Radius (cm)	28.76	59.26	35.889	73.232	37.546	74.876

Table II (continued)

Composition of critical assemblies atom densities (atom/barn-cm) and dimensions

	ZPR-3-50		ZPR-3-48		ZPR-3-49	
	Core	Reflector	Core	Reflector	Core	Reflector
U-235	.000016	.000083	.000016	.000083	.000016	.000083
U-238	.007404	.039613	.007405	.030690	.007406	.039556
Pu-239	.001645	-	.001645	-	.001644	-
Pu-240	.000106	-	.000106	-	.000106	-
Pu-241	.000011	-	.000011	-	.000011	-
Pu-242	.0000004	-	.0000004	-	.0000004	-
O	-	-	-	-	-	-
C	.045940	-	.020770	-	.020766	-
Na	-	-	.006231	-	-	-
Al	.000110	-	.000109	-	.000109	-
Cr	.001816	.001161	.002531	.001225	.002508	.001248
Fe	.007300	.004671	.010180	.004925	.010083	.004626
Ni	.000796	.000508	.001119	.000536	.001121	.000611
Mo	.000205	-	.000206	-	.000206	-
Mn	.000076	.000048	.000106	.000051	.000105	-
Si	-	-	.000124	.000060	-	-
Radius (cm)	43.43	83.77	45.245	75.245	47.53	83.96

Table II (continued)

Composition of critical assemblies atom Densities (atom/barn-cm) and dimensions

	ZPR-3-56B		ZPR-6-7		ZPR-6-6A	
	Core	Reflector	Core	Blanket	Core	Reflector
U-235	.000014	-	.0000126	.0000856	.001153	.0000855
U-238	.006195	-	.00578036	.0396179	.0058176	.0395508
Pu-239	.001358	-	.00088672	-	-	-
Pu-240	.000181	-	.00011944	-	-	-
Pu-241	-	-	.0000133	-	-	-
Pu-242	-	-	-	-	-	-
O	.015	-	.01398	.000024	.01390	.000023
C	.00103	-	-	-	-	-
Na	.008669	.007879	.009204	-	.0092904	-
Al	-	-	-	-	-	-
Cr	.0025	.001941	.002709	.001295	.002842	.001247
Fe	.0137	.007824	.01297	.004637	.013431	.0044669
Ni	.00109	.042261	.001240	.005635	.001291	.0005407
Mo	.000343	-	.0002357	.0000038	-	-
Mn	.00022	.0003	.000212	.0000998	.000221	.000096
Radius (cm)	52.72	87.06	88.16	121.97	95.67	129.48

Table. III

Comparison of calculated values of k-eff of experimental critical assemblies

Assembly	Corrected k-eff				
	JENDL-1[9]	JENDL-2[10]	JENDL-2	FRENCH	ENDF/B-IV[6]
ZPR3-12	1.0061	1.00630	1.01030	1.00566	1.0055
ZPR3-54	1.0217*	0.96373*	1.03305*	0.99839*	0.9620*
ZPR3-53	0.9994	0.99585	1.00156	1.00180	0.9955
ZPR3-50	0.9974	1.00025	0.99958	1.00138	0.9948
ZPR3-48	1.0005	1.00627	1.00110	1.00688	1.0015
ZPR3-49	1.0001	1.00896	0.99977	1.00726	1.0021
ZPR3-56B	0.9957	0.99622	1.01341	1.01640	0.9882
ZPR6-7	0.9983	0.99919	0.99884	1.00491	0.9917
ZPR6-6A	1.0139	1.00408	1.01609	1.00159	0.9967
Av. of $\lvert k_{eff}-1 \rvert$	0.00373	0.00433	0.00553	0.00574	0.00528

* Omitted from the statistical analysis.

Table IV

Correction factors applicable to k-eff determined by homogeneous one-dimensional diffusion calculations (from ref. 6).

Assembly	1D to 2D	Diffusion to Transport(S_8)	Heterogeneity	Total
ZPR3-12	-0.0009	0.0099	0.0*	0.0090
ZPR3-54	-0.0164	0.0144	0.0230	0.0210
ZPR3-53	-0.0150	0.0087	0.0230	0.0167
ZPR3-50	-0.0133	0.0056	0.0220	0.0143
ZPR3-48	-0.0009	0.0064	0.0183	0.0238
ZPR3-49	-0.0139	0.0068	0.0158	0.0067
ZPR3-56B	-0.0166	0.0065	0.0102	0.0001
ZPR6-7	-0.0020	0.0016	0.0166	0.0162
ZPR6-6A	-0.0013	0.0013	0.0073	0.0073

* The atom densities and/or size were adjusted to account for heterogeneities.

Table V

Corrected k-eff with blanket slowing down option change

Assembly	JENDL-2		FRENCH	
	Normal	With 1/E Spectrum	Normal	With 1/E spectrum
ZPR3-54	1.03305	1.02980	0.99839	0.99680
ZPR3-56B	1.01349	1.00943	1.01640	1.01176

Table VI

The difference in k-eff's calculated with JENDL-2 and SETR set

Assembly	Fissile Fuel	Reflector Type	(kJ - kS)* in pcm	
			With Reflector	Bare Core
ZPR3-12	U	U-238	+464	+1189
ZPR3-54	Pu	Fe	+3466	+1600
ZPR3-53	Pu	U-238	-24	+1606
ZPR3-50	Pu	U-238	-180	+918
ZPR3-48	Pu	U-238	-578	+658
ZPR3-49	Pu	U-238	-749	+613
ZPR3-56B	Pu	Ni	-291	+833
ZPR6-7	Pu	U-238	-607	-0.3
ZPR6-6A	U	U-238	+1450	+2004

* kJ = k-eff calculated with JENDL-2 set.

kS = k-eff calculated with SETR set.

Table VII.a

Ratio of ^{238}U fission rate to ^{235}U fission rate at core centre

Assembly	Experimental	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-12	0.04700	0.9750	1.0103	0.9851
ZPR3-54	0.02540	1.1290	1.0911	1.0724
ZPR3-53	0.02540	1.1460	1.1120	1.0648
ZPR3-50	0.02510	1.1200	1.0869	1.0546
ZPR3-48	0.03260	0.9970	0.9715	0.9335
ZPR3-49	0.03450	1.0380	1.0211	0.9576
ZPR3-56B	0.03080	0.9340	0.8945	0.8605
ZPR6-7	0.02300	0.9110	0.8851	0.8714
ZPR6-6A	0.02450	0.9030	0.9105	0.8915
Average of $\lvert (C/E)-1 \rvert$:		0.0792	0.0733	0.0769

Table VII. b

Ratio of ^{239}Pu fission rate to ^{235}U fission rate at core centre

Assembly	Experimental	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-54	0.92800	0.9300	0.9102	0.9675
ZPR3-53	0.92800	0.9320	0.9128	0.9664
ZPR3-50	0.90300	0.9740	0.9662	1.0082
ZPR3-48	0.97600	0.9730	0.9809	0.9912
ZPR3-49	0.98600	0.9840	0.9966	0.9998
ZPR3-56B	1.02800	0.9270	0.9395	0.9386
ZPR6-7	0.95300	0.9460	0.9548	0.9689
Average of $\lvert (C/E)-1 \rvert$:		0.0477	0.0484	0.0251

Table VII. c

Ratio of ^{240}Pu fission rate to ^{235}U fission rate at core centre

Assembly	Experimental	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-54	0.17400	1.1340	1.1024	1.1033
ZPR3-53	0.17400	1.1460	1.1179	1.0962
ZPR3-50	0.15900	1.2620	1.2379	1.2441
ZPR3-48	0.24300	0.9880	0.9808	0.9929
ZPR3-56B	0.28200	0.7930	0.7784	0.7791
Average of $\|(C/E)-1\|$:		0.1522	0.1398	0.1343

Table VII.d

Ratio of ^{238}U capture rate to ^{235}U fission rate at core centre

Assembly	Experimental	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-12	0.12300	0.9840	0.9746	0.9248
ZPR3-48	0.13800	0.9530	0.9351	0.9302
ZPR6-7	0.13600	1.0160	0.9876	0.9974
ZPR6-6A	0.13900	1.0050	0.9765	0.9655
Average of $\lvert (C/E)-1 \rvert$:		0.0210	0.0316	0.0455

Table VII.e

Ratio of ^{238}U capture rate to ^{239}Pu fission rate at core centre

Assembly	Experimental	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-48	0.14100	0.9830	0.9559	0.9411
ZPR6-7	0.14300	1.0720	1.0322	1.0272

Table VIII.a

Central reactivity worths of ^{235}U

Assembly	Experimental Inhour/Kg	Factor 1D -->2D	Inhour / %Δk/k	Calculated (C/E) ENDF/B-IV[6]	Calculated (C/E) JENDL-2	Calculated (C/E) FRENCH
ZPR3-12	285.0	0.996	427.6	0.952	0.926	0.894
ZPR3-54	567.0	1.047	968.8	1.552	1.178	1.282
ZPR3-53	520.0	1.045	950.3	1.338	1.303	1.225
ZPR3-50	464.0	1.049	930.1	1.169	1.178	1.100
ZPR3-48	334.0	0.994	932.5	1.189	1.236	1.148
ZPR3-49	282.0	1.049	934.4	1.205	1.234	1.141
ZPR3-56B	295.0	1.063	975.6	1.239	1.123	1.057
ZPR6-7	133.0	1.004	972.5	1.204	1.228	1.136
ZPR6-6A	42.0	1.003	431.9	1.081	1.034	1.020
Average of |(C/E)-1| :				0.2250	0.1764	0.1350

Table VIII.b

Central reactivity worths of ^{238}U

Assembly	Experimental Inhour/Kg	Factor 1D -->2D	Inhour / %Δk/k	Calculated (C/E) ENDF/B-IV [6]	JENDL-2	FRENCH
ZPR3-12	-12.0	0.991	427.6	1.187	0.969	0.901
ZPR3-54	-82.0	1.006	968.8	1.019	0.938	0.892
ZPR3-53	-75.1	1.011	950.3	1.019	0.984	0.884
ZPR3-50	-42.1	1.017	930.1	0.941	0.991	0.916
ZPR3-48	-23.6	0.991	932.5	1.029	1.133	1.050
ZPR3-49	-18.5	1.008	934.4	1.033	1.121	1.041
ZPR3-56B	-18.4	1.018	975.6	1.221	1.221	1.145
ZPR6-7	-10.9	0.997	972.5	1.013	1.061	0.990
ZPR6-6A	-3.5	0.998	431.9	1.118	1.113	1.051
Average of |(C/E)-1| :				0.0776	0.0852	0.0782

Table VIII.c

Central reactivity worths of ^{239}Pu

Assembly	Experimental Inhour/Kg	Factor 1D -->2D	Inhour / %Δk/k	Calculated (C/E) ENDF/B-IV [6]	JENDL-2	FRENCH
ZPR3-54	738.0	1.048	968.8	1.475	1.117	1.240
ZPR3-53	681.0	1.043	950.3	1.247	1.225	1.173
ZPR3-50	564.0	1.049	930.1	1.158	1.156	1.116
ZPR3-48	445.0	0.994	932.5	1.178	1.209	1.156
ZPR3-49	415.0	1.049	934.4	1.102	1.119	1.066
ZPR3-56B	372.0	1.064	975.6	1.290	1.156	1.120
ZPR6-7	158.0	1.004	972.5	1.222	1.231	1.182
Average of $\|(C/E)-1\|$:				0.2389	0.1733	0.1504

Table VIII.d

Central reactivity worths of Fe

Assembly	Experimental Inhour/Kg	Factor 1D -->2D	Inhour / %Δk/k	Calculated (C/E)		
				ENDF/B-IV [6]	JENDL-2	FRENCH
ZPR3-12	-11.5	0.990	427.6	1.096	1.035	1.100
ZPR3-53	-4.5	0.969	950.3	2.262*	2.305*	2.274*
ZPR3-50	-13.2	1.018	930.1	1.329	1.361	1.260
ZPR3-48	-12.2	0.992	932.5	1.250	1.243	1.120
ZPR3-49	-14.1	1.024	934.4	1.016	1.010	0.869
ZPR3-56B	-12.3	1.028	975.6	1.038	0.962	0.849
ZPR6-7	-4.3	1.004	972.5	1.207	1.201	1.101
Average of |(C/E)-1| :				0.1560	0.1480	0.1438

* Omitted from the statistical analysis

Table VIII.e

Central reactivity worths of Cr

Assembly	Experimental Inhour/Kg	Factor 1D -->2D	Inhour / %Δk/k	Calculated (C/E)		
				ENDF/B-IV[6]	JENDL-2	FRENCH
ZPR3-53	-10.1	0.997	950.3	2.009	1.462	0.726
ZPR3-50	-13.1	1.022	930.1	1.766	1.366	1.191
ZPR3-48	-12.3	0.989	932.5	1.529	1.209	1.081
ZPR3-49	-11.8	1.027	934.4	1.467	1.162	1.067
ZPR3-56B	-12.7	1.030	975.6	1.271	0.929	0.852
ZPR6-7	-4.5	1.004	972.5	1.489	1.167	1.065
Average of $\lvert (C/E)-1 \rvert$.				0.5885	0.2395	0.1377

Table VIII.f

Central reactivity worths of Ni

Assembly	Experimental	Factor	Inhour	Calculated (C/E)		
	Inhour/Kg	1D -->2D	Inhour / % Δk/k	ENDF/B-IV[6]	JENDL-2	FRENCH
ZPR3-12	-20.0	0.989	427.6	1.083	0.985	0.929
ZPR3-53	-20.5	0.996	950.3	1.375	1.435	0.654
ZPR3-50	-21.6	1.020	930.1	1.335	1.357	0.885
ZPR3-48	-18.2	0.991	932.5	1.391	1.342	0.934
ZPR3-49	-20.7	1.022	934.4	1.183	1.168	0.829
ZPR3-56B	-16.8	1.028	975.6	1.300	1.200	0.845
ZPR6-7	-6.5	1.004	972.5	1.284	1.299	0.904
Average of $\lvert (C/E)-1 \rvert$:				0.2787	0.2594	0.1456

Table VIII.g

Central reactivity worths of Na

Assembly	Experimental Inhour/Kg	Factor 1D -->2D	Inhour / % $\Delta k/k$	Calculated (C/E)		
				ENDF/B-IV[6]	JENDL-2	FRENCH
ZPR3-48	-6.3	0.988	932.5	2.053	1.988	2.159
ZPR3-56B	-8.9	0.983	975.6	1.905	2.193	2.345
ZPR6-7	-6.8	0.989	972.5	1.128	1.264	1.365
Average of $\lvert (C/E)-1 \rvert$:				0.6953	0.8150	0.9563

Table IX.a

Central reactivity worths of ^{235}U normalised to those of ^{239}Pu

Assembly	Experimental**	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-54	0.75500	1.052	1.056	1.036
ZPR3-53	0.75100	1.058	1.062	1.042
ZPR3-50	0.80900	1.020	1.019	0.986
ZPR3-48	0.73800	1.030	1.022	0.993
ZPR3-49	0.67500	1.108	1.092	1.060
ZPR3-56B	0.77900	0.985	0.973	0.945
ZPR6-7	0.82700	1.005	0.999	0.962
Average of $\|(C/E)-1\|$:		0.0411	0.0400	0.036

** Worths are in units of Inhour/mole.

Table IX.b

Central reactivity worths of ^{238}U normalised to those of ^{239}Pu

Assembly	Experimental	Calculated (C/E)**		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-54	-0.11060	0.910	0.876	0.750
ZPR3-50	-0.07430	0.914	0.885	0.847
ZPR3-48	-0.05280	0.970	0.940	0.910
ZPR3-49	-0.04480	1.059	1.033	1.007
ZPR3-56B	-0.04930	1.099	1.103	1.067
ZPR6-7	-0.06860	0.913	0.869	0.845
Average of $\left|(C/E)-1\right|$:		0.0752	0.0943	0.1203

** Worths are in units of Inhour/mole.

Table IX.c

Central reactivity worths of Fe normalised to those of ^{239}Pu

Assembly	Experimental**	Calculated (C/E)		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-50	-0.00547	1.027	1.215	1.164
ZPR3-48	-0.00646	0.924	1.022	0.964
ZPR3-49	-0.00802	0.854	0.916	0.827
ZPR3-56B	-0.00772	0.766	0.863	0.786
ZPR6-7	-0.00630	0.869	0.986	0.941
Average of |(C/E)-1|		0.1226	0.0944	0.1292

** Worths are in units of Inhour/mole.

Table IX.d

Central reactivity worths of Cr normalised to those of ^{239}Pu

Assembly	Experimental [**]	Calculated (C/E)		
		JENDL-1 [9]	JENDL-2	FRENCH
ZPR3-50	-0.00505	1.208	1.216	1.097
ZPR3-48	-0.00602	1.033	1.005	0.940
ZPR3-49	-0.00625	1.099	1.051	1.014
ZPR3-56B	-0.00745	0.852	0.828	0.784
ZPR6-7	-0.00623	1.002	0.944	0.897
Average of $\|(C/E)-1\|$:		0.0980	0.1000	0.0980

** Worths are in units of Ihour/mole.

Table IX.c

Central reactivity worths of Ni normalised to those of ^{239}Pu

Assembly	Experimental	Calculated (C/E) **		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-50	-0.00940	1.179	1.210	0.817
ZPR3-48	-0.01006	1.125	1.112	0.809
ZPR3-49	-0.01283	0.997	1.024	0.763
ZPR3-56B	-0.01109	1.013	1.076	0.782
ZPR6-7	-0.01003	0.975	1.064	0.772
Average of $\lvert (C/E)-1 \rvert$:		0.0690	0.0972	0.2114

** Worths are in units of Inhour/mole.

Table IX.f

Central reactivity worths of Na normalised to those of ^{239}Pu

Assembly	Experimental	Calculated (C/E)**		
		JENDL-1[9]	JENDL-2	FRENCH
ZPR3-48	-0.00137	1.510	1.645	1.868
ZPR3-56B	-0.00231	1.732	2.046	2.258
ZPR6-7	-0.00412	0.909	1.048	1.179
Average of $\|(C/E)-1\|$:		0.4443	0.5800	0.7683

** Worths are in units of Inhour/mole.

Table X

Average absolute deviation (|(C/E)-1|) of integral parameters for nine assemblies

Parameter	JENDL-2	SETR	ENDF/B-IV
k-eff	0.00553	0.00574	0.00528
Central reaction rate normalised to U-235 fission :			
U-238 fission	0.0733	0.0769	—
Pu-239 fission	0.0484	0.0251	—
Pu-240 fission	0.1398	0.1343	—
U-238 capture	0.0316	0.0455	—
Central material worth:			
U-235	0.1764	0.1350	0.2250
U-238	0.0852	0.0782	0.0776
Pu-239	0.1733	0.1504	0.2389
Fe	0.1480	0.1438	0.1560
Cr	0.2395	0.1377	0.5885
Ni	0.2594	0.1456	0.2787
Na	0.8150	0.9563	0.6953

Table X (contd.)

Average absolute deviation (|(C/E)-1|) of integral parameters for nine assemblies

Parameter	JENDL-2	SETR	ENDF/B-IV
<u>Worth normalised to those of Pu-239</u>:			
U-235	0.0400	0.0360	___
U-238	0.0943	0.1203	___
Fe	0.0944	0.1292	___
Cr	0.1000	0.0980	___
Ni	0.0972	0.2114	___
Na	0.5800	0.7683	___