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CONTRIBUTION TO JEF.2 QUALIFICATION OF Pu SOLUTION CALCULATIONS

A. SANTAMARINA - B. ROQUE
CEA- Cadarache

Although MOX fuelled lattice experiments are well predicted by codes using JEF2.2 library, the calculations of plutonium nitrate solutions seem to be discrepant : the AEA calculations of Pu solution experiments point out a strong overestimation of the reactivity with an average calculated Keff = 1.015 [1].

In order to check this trend and to contribute to JEF2 validation, we analysed the recent Pu-U solution experiments conducted at PNL-Critical Mass Laboratory [2], in the framework of the joint exchange program between the US-DOE and the Japanese PNC corporation.

Experiments were conducted to evaluate the limiting critical concentration of aqueous solutions with Pu/Pu + U ratios of 0.5 and 0.2. To minimize neutron leakage, a large (68.68-cm-i.d.) cylinder was used. The solution concentration was adjusted to yield critical configurations where the height-to-diameter ratio was > 1.0. Also, to minimize neutron leakage, all experiments were reflected by water. The height of the water was 1.27 cm below the top of the cylinder. The water extended at least 14 cm around the cylinder. The experiments were performed in the large cylinder mounted on pedestal B described in figure 1.

The experimental results, summarised in table I, show the same critical height (about 80 cm) for the two kinds of fissile solution :

- Pu = 11.8 g/l and U = 11 g/l
- Pu = 12.2 g/l and U = 41 g/l

TABLE I

Criticality Data with Pu+U Nitrate Solution in a Large-Diameter Cylinder*

Run Date	CML Experiment	Reflector	Sample	Plutonium (g/ℓ)	Uranium (g/ℓ)	Density (g/cm³)[a]	Free Acid (*M*)	Critical Height (cm)
November 1, 1985	058	Water	1130	11.88	11.05	1.0501	0.50	76.80
November 6, 1985	059	Water	1131	11.73	10.78	1.0491	0.49	83.14
December 5, 1985	061	Water	1135	12.19	41.04	1.0922	0.54	81.72

*68.68-cm-i.d. cylinder.
[a]Density measured at 23°C.

The isotopic Plutonium composition is the following (wt %) :

Pu239 = 91.1 Pu240 = 8.3 Pu241 = 0.46 Pu242 = 0.09

These experiments were calculated with the APOLLO2-TRIMARAN2 package based on the CEA93 multigroup library (synoptic presented on the next page). The CEA93 cross-sections were obtained by NJOY/THEMIS processing of the JEF2.2 library.

The self-shielded cross-sections are obtained from APOLLO2 calculations performed using the P_{IJ} method. Cell homogenization or/and group condensation can be carried out within this step. The corresponding output cross-section sets are automatically handled by the S_N modules of APOLLO2, or by the multigroup Monte-Carlo code TRIMARAN2.

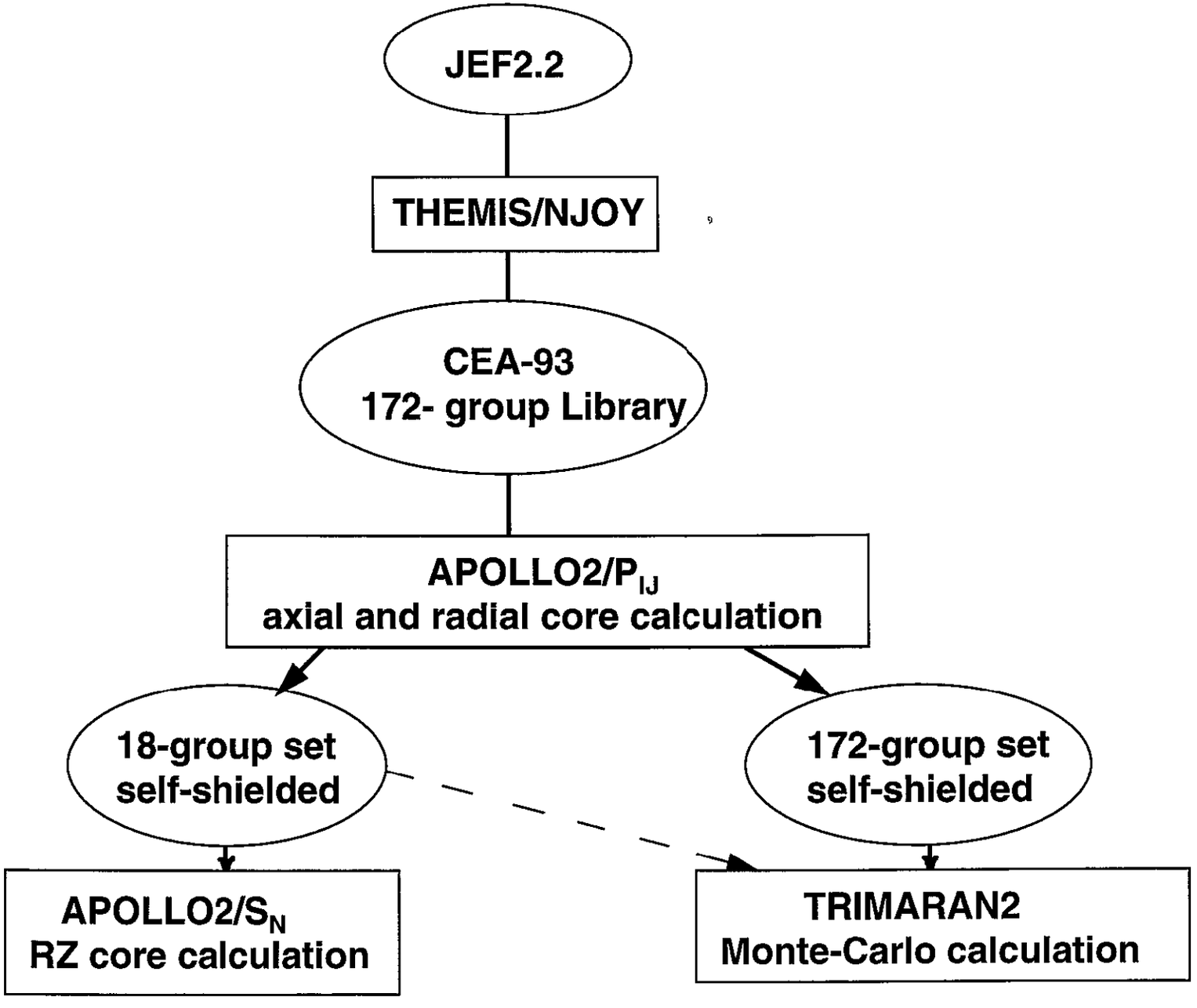
The Calculation-Experiment comparison is summarised in table II.

TABLE II : JEF2 Calculational results of Pu solutions in PNL Experiments

PNL-CML Experiment	TRIMARAN2 172-group	TRIMARAN2 18-group	APOLLO2/S_N
Pu=11.8 g/l, U=11 g/l Exp. 58	1.0094 ± 0.0010	1.0109 ± .0.0010	1.0108
Pu=12.2 g/l, U=41 g/l Exp 61	1.0078 ± 0.0010	1.0095 ± 0.0010	1.0092

The 172-group reference calculations show an overestimation of the K_{eff} calculations based on the JEF2 library. The C/E disagreement amounts to +800, 900 pcm (10^{-5} in $\Delta K/K$). This result confirms the trend of overestimation of Pu solution reactivity calculated with JEF2 cross-sections ; however the K_{eff} overestimation is limited to 1%, which is less than the 1.5% suggested by the AEA study.

Calculation scheme based on APOLLO2-TRIMARAN2 package



REFERENCES

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Personal communication

[2] G. R. SMOLEN, R. C. LLOYD, H. FUNABASHI
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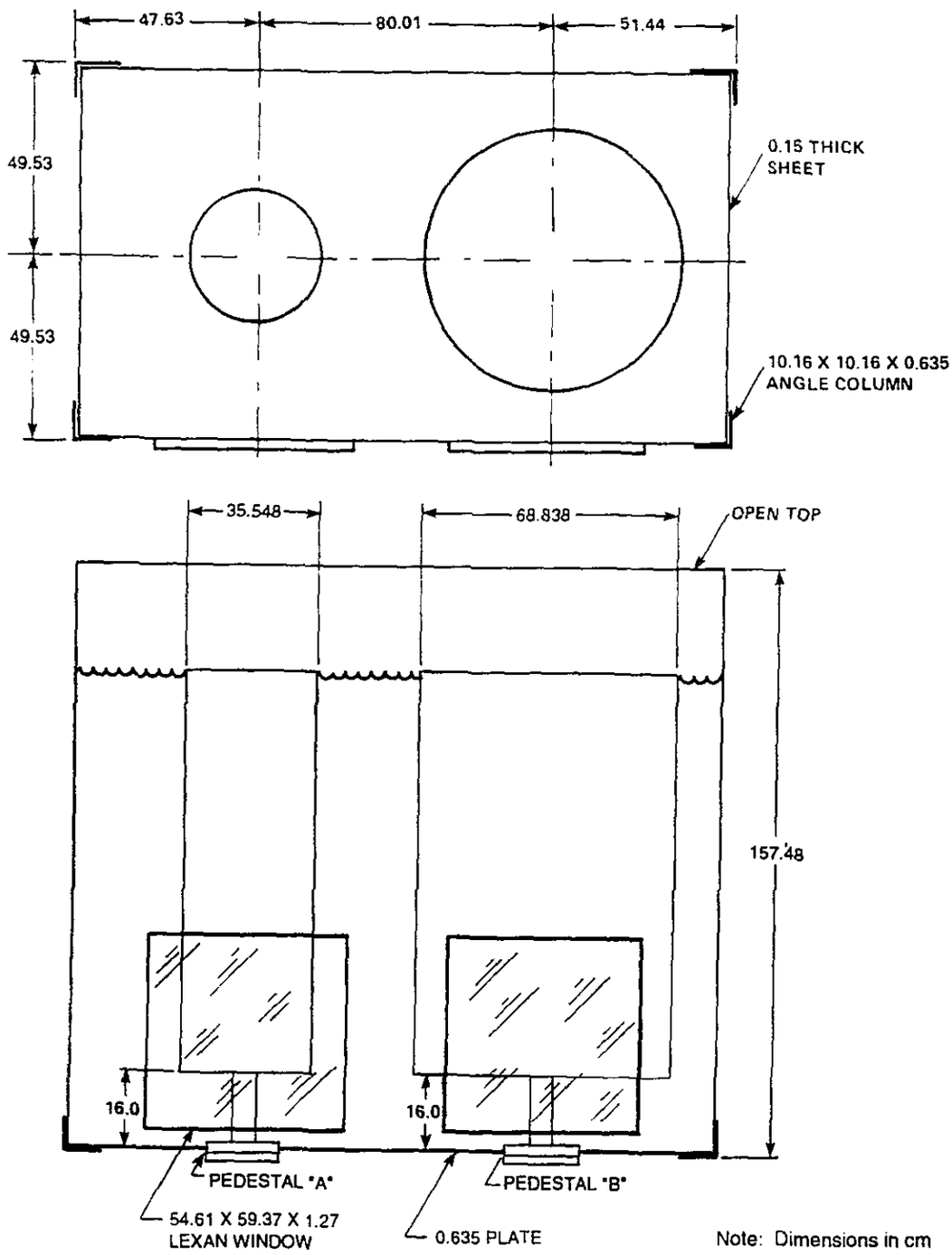

Fig. 1. Schematic of dual cylinder tank system.