NEA CRP L-240

KEMA	Document: IV Author: W.J. Oosterkamp Dept.: RF	Ref.: 6239-79 Page 1 of: Annexes:

Contribution to steering committee for nuclear energy 22nd meeting NEACRP Part B technical sessions 1.2 criticality problems in storage and transportation

Subject:

Calculations for compact storage racks for PWR fuel

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Summary

A number of calculations using the WIMS code package has been performed on compact storage racks of PWR fuel. The main emphasis has been put on the design for the Borssele plant. In order to obtain a check on the overall accuracy of the calculations the KWU benchmark has been calculated using the same methods.

The WIMS code package has a number of options for a two dimensional calculation. Of these the CLUP collision probability option and the Sn-TWOTRAN option are the most suited to treat highly absorbing regions as they occur in compact storage racks. The collision probability option treats more accuratedly the absorption process in a coarse mesh but neglects the angular correlation between different collisions of the neutrons. This latter effect is accounted for by the TWOTRAN option but this code assumes linear absorption between the mesh points. A mesh of 3 mm has been used for the water and borium steel regions. A mesh of about 15 mm had to be used for the cells with the fuel pins. The GOG options uses diffusion theory and the D-mod options uses modified diffusion coefficients to approximate the one dimensional collision probability solution.

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The calculations for KCB-racks similar to the benchmark have been performed in one and two dimensions. The results (table 1) differ by less than 5 0/00.
The two dimensional calculations show that from s-4 onwards the TWOTRAN solution converges. The CLUP solution and the TWOTRAN solution are the result of two independent calculational methods. From the difference between the two calculations the uncertainty (one sigma) due to the methods can be estimated to be 5 0/00. An uncertainty due to the statistical combination of the uncertainties gives us as most likely value for k_∞ of the compact racks $k_\infty = .920 \pm .007$ (one sigma). Thus it can be stated that with 95% confidence (two sigma limit) the value of $k_\infty = .935$ will not be exceeded.

The calculational results of the KWU benchmark/1/ are summarized in table 2. Different cross section sets and different calculational schemes have been used. A standard deviation of 6 0/00 is obtained. This is in agreement with the one sigma valve of the uncertainty of 7 o/00 given for the KCB calculations. The average value for the published results is than $k_\infty = .903 \pm .003$ (one sigma). The WIMS value for the S-8 calculation of $k_\infty = .905$ compares quite well with the average of the benchmark.

It is felt that adoption of a truely international benchmark for compact storage racks would be quite worthwile. The KWU benchmark is for our purposes a good starting point. What we really do need is a good set of experiments in compact storage rack geometry. Criticality could be achieved by increasing appropriately the enrichment.

/1/ K. Roth-Saefrid, H. Raum and F. Born "Kritikalitätsrechnungen für ein KWU-kompaktbecken-Benchmark-problem" Reaktortagung 1977 p 83-66.

Table 1 KCB-compact racks

2 Dim		k_∞	t
Extended	D-mod	.909	60
	CLUP	.915	550
	S-2	.884	120
	S-4	.927	160
	S-8	.922	320
	S-16	.921	890

1 Dim		
Extended	D-mod	.915
	GOG	.876
	S-16	.908
	Minos	.918

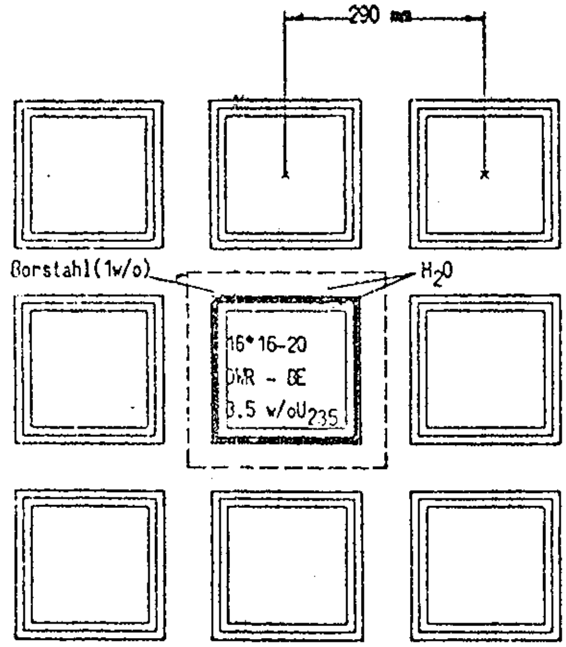

Figure 1 KWU-compact racks

Table 2 KWU-Benchmark

	x-sections	k_∞
Monte Carlo Moca	HOBBI, INGRAM	.901
Monte Carlo Moca	GGC4, DTF IV	.912
Monte Carlo EMC	ENDFB IV	.895
S-N DOT2	CEPAK	.903
S-8 WIMS	WIMS	:905