PAUL SCHERRER INSTITUT

Wir schaffen Wissen – heute für morgen

PROTEUS FDWR-II (HCLWR) program summary for SG-39

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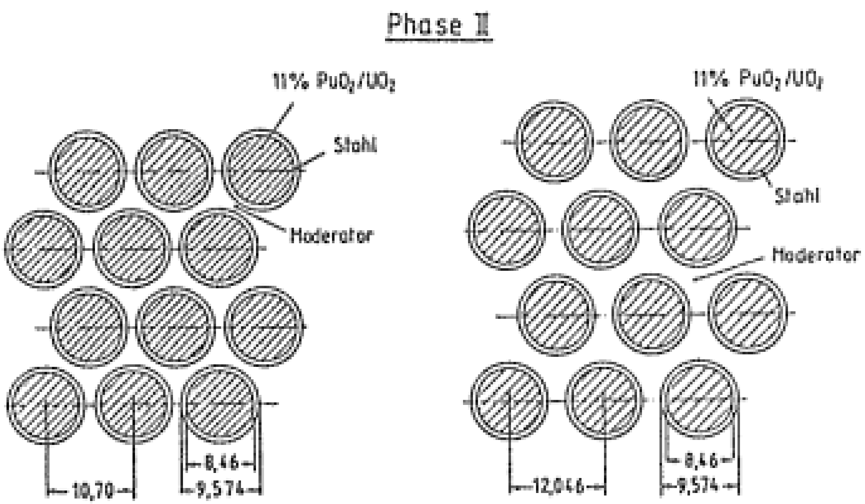
FDWR-II – Experimental Configurations



Kern	p/d	V_M/V_F	Moderator	Eff. Moderation
7	1.12	0.48	H_2O	0.48
8	1.12	0.48	ohne	0.00
9	1.12	0.48	Dowtherm	0.28
10	1.12	0.48	Dowtherm	0.28
11	1.12	0.48	ohne	0.00
12	1.12	0.48	H_2O	0.48
13	1.26	0.95	H_2O	0.95
14	1.26	0.95	ohne	0.00
15	1.26	0.95	Dowtherm	0.55
16	1.26	0.95	H_2O	0.95
17	1.26	0.95	ohne	0.00
18	a)	2.07	H_2O	2.07
19	1.26	0.95	H_2O	0.95
20	1.26	0.95	D_2O	-

FDWR Phase II

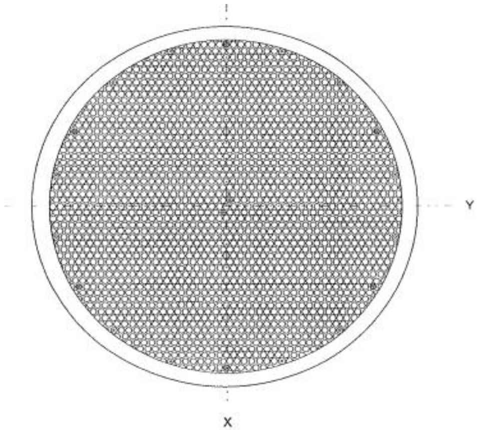
- From 1985 to 1990 in PROTEUS reactor

- PROTEUS is a driven system whose test zone contains the FDWR lattices

- UO_2/PuO_2 pellets with 11% PuO_2
- Pu(8/9/0/1/2): 1%, 64%, 23%, 8%, 4%
- Fuel diameter: 8.46mm
- Fuel total height: 84 cm
- 2 axial blankets:
    - Udep. 0.224w% ^{235}U
    - 28-cm high each

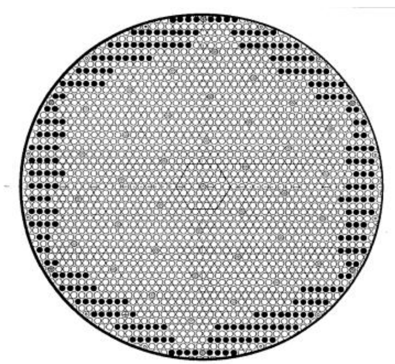
- Several moderation conditions
    - Two triangular pitches
    - Different moderators (water, downterm, air)

FDWR-II – Experimental Configurations



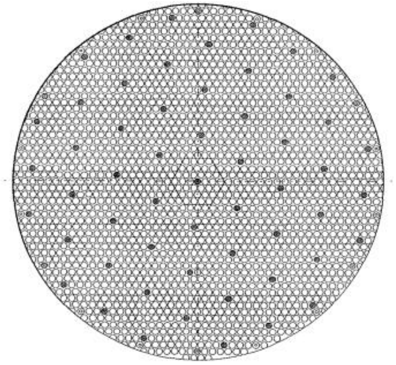
Core 7,8,9

- Homogeneous (Vm/Vf = 0.48)
- Water, air and downterm moderators
- B_4C central pin and moderator hole
- Axial MOX blanket interface in central pin



Core 10

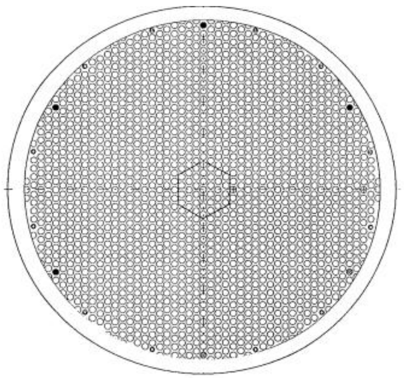
- Heterogeneous with water holes at the periphery and 37 B_4C absorber rods
- Downterm (41.4% void)

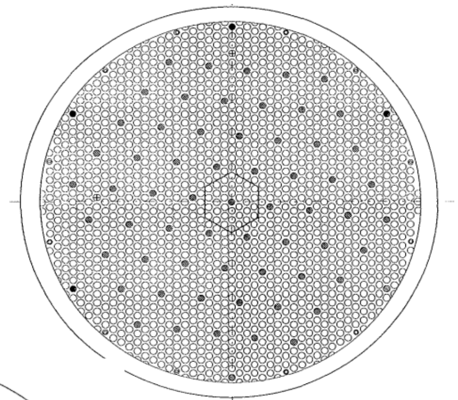


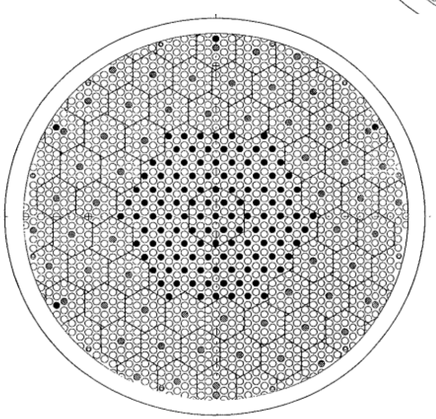
Core 11, 12

- Heterogeneous with 55 B_4C absorber pins
- Air und Wasser

FDWR-II – Experimental Configurations







Core 13,14,15

•Homogeneous (Vm/Vf = 0.95)
•Water, air and downterm moderators
•B_4C central pin and moderator hole
•Axial MOX blanket interface in central pin

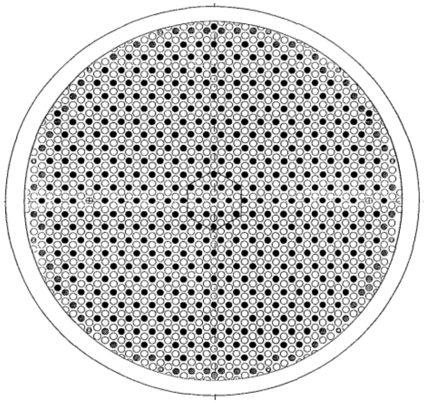
Core 16, 17

•Heterogeneous with 61 B4C absorber pins (Vm/Vf = 0.95)

Core 18

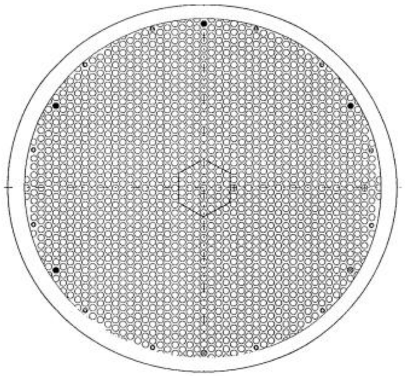
•Heterogeneous with 60 B_4C absorber pins and 121 water holes (Vm/Vf = 2.07)

FDWR-II – Experimental Configurations



Core 19

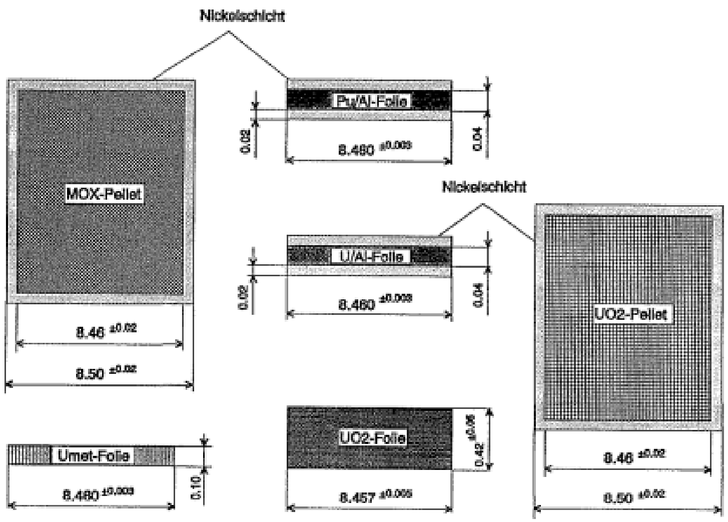
- Heterogeneous with a 2:1 ratio of PuO_2/UO_2 and UO_2 0.22w% pins (Vm/Vf = 0.95)
- Water, air and downterm moderators
- B_4C central pin and moderator hole
- Axial MOX blanket interface in central pin



Core 20

- Homogeneous
- D_2O moderator
- B_4C central pin and moderator hole
- Axial MOX blanket interface in central pin

FDWR-II – Measurement types

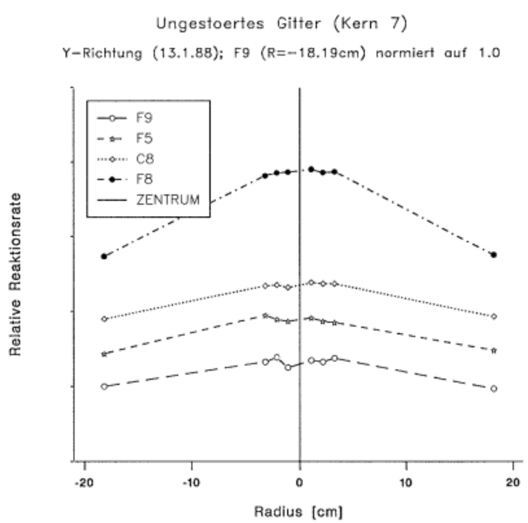


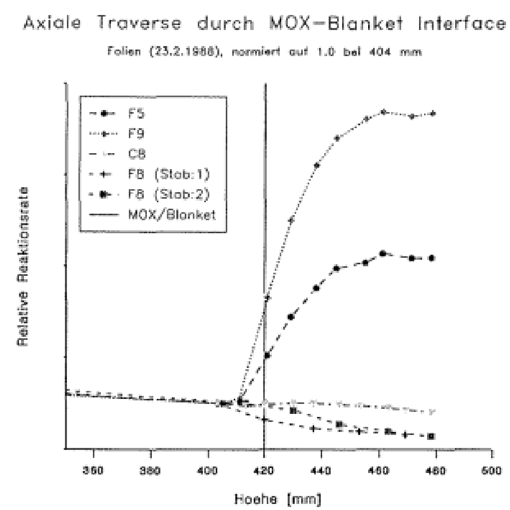
Spectral index measurements (core 13 - ref)

- F5/F9 ~0.72 F1/F9 ~ 1.50
- F8/F9 ~0.89 C2/F9 ~ 0.94
- C8/F9 ~5.1e-2
- Typical uncertainties

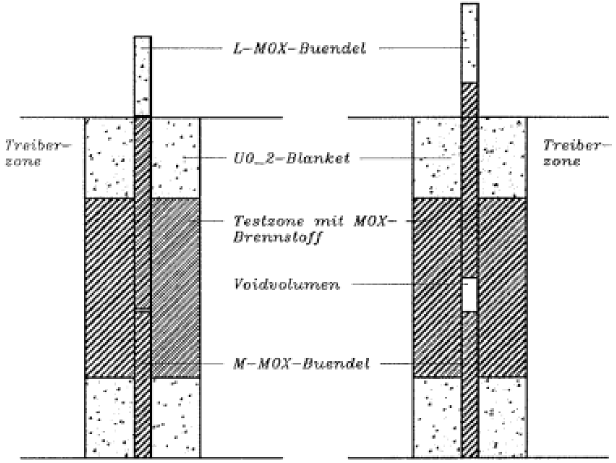
F5: 1.4%, F8: 2.0%, F9:1.4%, C8: 1.8%

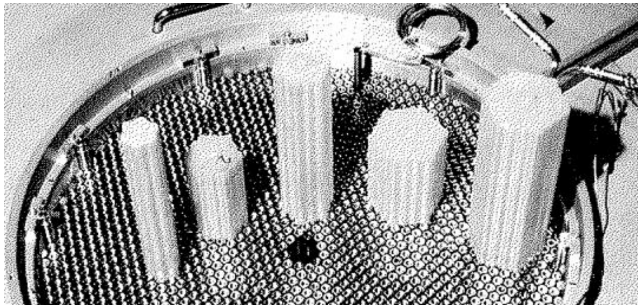
Reaction rate radial and axial traverses

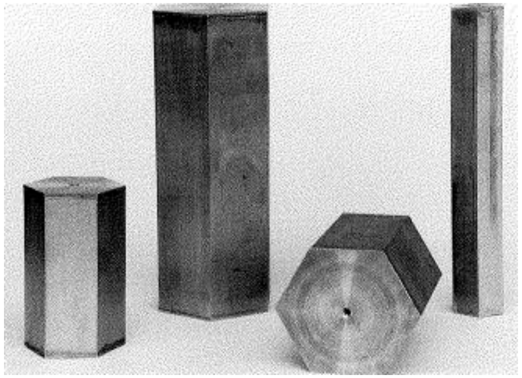




FDWR-II – Measurement types







- K∞ measurements

$$k_\infty = 1 + B^2 \cdot M^2$$

$$\frac{\rho_Z}{\rho_S}\frac{S}{R_f} = \bar{\nu}\frac{\overline{\Phi^+}^X}{\overline{\Phi^+}^S}\left(1 - \frac{1}{k^+}\right)$$

  - Using axial and radial bucklings
  - Using compensation methods with auto-rod and a ^{252}Cf sources

- Reactivity effects of
  - Void volume
  - Moderator volume
  - Absorber rods

Absorber	Form	Durchmesser	Cladding	Bemerkung
B_4C(nat)	Pellet	7.473	ja	Referenzabsorber
B_4C(nat)	Pulver	7.430	ja	
B_4C(93%) ^{10}B	Pellet	7.430	ja	
Ag15In5Cd	Legierung	8.830	nein	
Hafnium	Metall	8.350	ja	
Gd_2O_3	Pellet	8.310	ja	
Sm_2O_3	Pellet	7.000	ja	
Tantal	Metall	8.290	ja	
Eu_2O_3	Pellet	8.243	ja	
Zircaloy-2	Legierung	8.300	nein	Strukturmaterial
Stahl	Metall	8.240	nein	Strukturmaterial

FDWR-II – Calculation tools

PSI

- Cell calculations: WIMSD4 with the WIMS-1981 data library
- Whole reactor calculations: ONEDANT (one dimension transport)
- Macroscopic cross-sections generation:
    - WIMSD4 (P0 transport corrected) → DSNXSL →XSLIB

KfK

- Cell calculations: KAPER4 with the G69P1V02 data library (69 Groups)
- Whole reactor calculations: 2D DIXY2 diffusion and TWODANT transport codes
- Macroscopic cross-sections with transport corrected P0 and P1, S4

TUBS

- XS preparation: modified WIPRO, NJOY (ENDF/B-V, JEF-1), various DATUBS-nn
- Cell calculations: SPEKTRA (various libraries)
- Whole reactor calculations: DITUBS (2D diffusion, 35 groups)

FDWR-II – Calculation tools

Plans:

In addition to ERANOS, recalculation of these experiments by means of SERPENT-2.

Testing of the new built-in adjoint-weighting sensitivity coefficient methodology by investigating these reactivity effects.
Detailed testing is currently undergoing for the sodium void in the framework of ESNI+ leading to promising results. GPT will be available in the next official release of the code (Manuele Aufiero).

Inclusion of SERPENT-2 based sensitivity coefficients and these experiments in data assimilation studies, e.g. the SG33 benchmark.

(Question: what should be used in multi-group cross-section adjustment studies, namely "complete" or explicit sensitivity coefficients ?)