The Review of Codes
Data for Target-Blanket Studies and Design

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RDIPE = Research and Development Institute
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(8 pers.)

RDIPE 's activities -

= Nuclear Power and Test Reactors
- conceptial design
- science and technology
- physics, codes and data
- thermo - hydrolics
- material studies
- structure design
- control systems
- supporting of NPP operate
- reconstruction, out-of-life duties
- isotopes problems
- RAW (transmutation, long-time storage)

= Nuclear Technology for Fusion
- ITER
- FW, blanket, shielding design
- neutronic calculations,
- physical base for design.
experimental program
(neutronic generator, radiation, nonradiation)

= Nuclear Test Reactors, Various Test Units

RDIPE's branch → Ural area, Ekaterinburg

Wide communications - KIAE, Nucl. PPs, ... foreign insts
Universities - Bawman TU, MIFI, MEI....

The Codes Unit in RDIPE for Blanket Design and Studies.

RDIPE' Activities := Nuclear Power and Test Fission Reactors =

- conceptial design
- science and technology
- physics, codes and data
- thermo-hydrolics
- materials
- structure design
- control systems
- supporting of operate (including reconstractions, out-of-Life duties)
- isotope problems
- RAW (transmutation, long-time storage)

≠ Nuclear Technology for Fusion

Fusion Blanket and Shield Activity

- supporting of designing -
- studies and optimisation

≠ Power density
≠ Breeding and Burn-up
≠ Neutron and γ Fluxes

Lab' expirience:

FBR (k?, &, Pb)
Test reactors, experiments
RBMK, BWR
HTGR
MSR
Hybrid Fusion Blanket
OTR/ITER Fusion Blanket
Acc.- Breeder
Inertial Conf. Blanket

Burn-up, Breeding,
Fuel cycles (U-232 problem)

TARGET: KASKAD (Dubna)
MARS (Serpukhov)
MONISTO (Minsk)
MMK-22-26 (ITEP-KIAE)

Approximative mod!:
- Radium Inst
- MRTI
- RDIPE

BLANKET: (MMC) — BLANK (KIAE)
BRAND (PNEI, Obninsk)

RDIPE: PRORAB
2D(RZ, XY); 14.1–0 MeV $\Phi = \Phi_0 + \sum_{k=1}^{n-1} \Phi_k + \frac{\Phi_N}{1-k}$
KERMA BLC (isotopes)

Parameters of Blanket Variants

Parameter	Type		
	Low-pressure, homogeneous	Pressurized tank	Pressurized channels
Linac:			
proton energy, GeV	1	1	1
beam current, A	0.3	0.3	0.3
Blanket:			
numbers	10	1	1
total power, MW$_t$	1350	1300	320-540
transmutation rate kg/y	532	511	125-215
type	two-sectionned tank		Channel
Dimensional, m			
height	5	5.5-6	5.5-6
diameter	3.6	4.4	3
Loops	2	3	3
The 1st loop:			
pressure, MPa	0.5	2.0-5.0	15
Heat using	Heat-supply	Heat-Supply	Steam-turbine cycle
Heat-exchanger:			
lenght, m		36-18	5.4
diameter, m		2.55	0.21
Amount of heavy water, t	140	320	80-85
Actinoid mass, t	1	1.8	0.025-0.05

Heavy-water radiolysis

3,6 - 4.1 mol/100 eV

$UO_2(NO_3)$ - analog -
- for 200 w/cc
$9.3 \cdot 10^{-4}$ litre/cc·s (H_2)
0,7 g/cc·s (H_2O_2)

W_t - 135 - 1300 MW →
→ 6050 e (H_2)/s (!)

Catalizators (Cu)

(R1) Spatial ununiformity of power (generation) density

by: — jets density
jet diameter
assembling step
cross section of beam
funnel, inclined surface etc

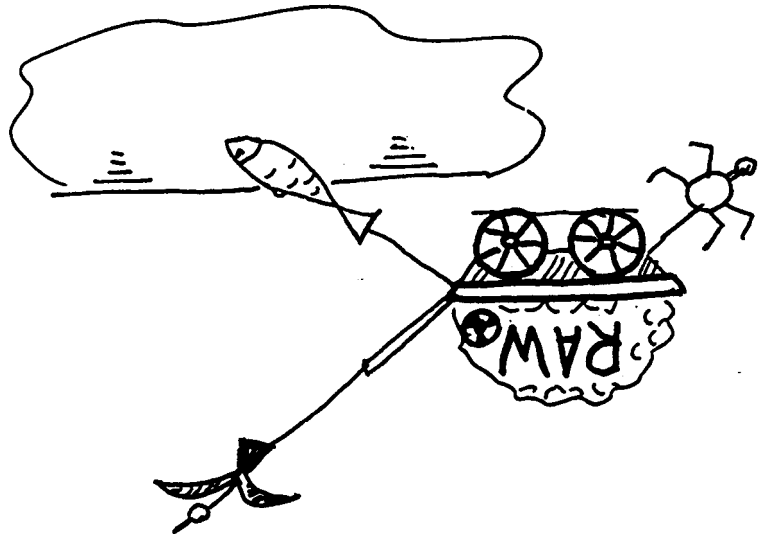
$$q_n(z) = a\,\Sigma(z)\,\Phi_0 \exp\left(-\int_0^z \Sigma(z')\,dz'\right)$$

$q_n(z) = \text{const}$, if $\Sigma(z) = \dfrac{\Sigma_0}{1 - z\Sigma_0}$

$$0 \le z \le \frac{1}{\Sigma_0} - \frac{1}{\Sigma_{max}}$$

Σ_0 - input Σ_{max} - possible Σ.

(R2) $(n, 2n) \ldots (n, 7n)$

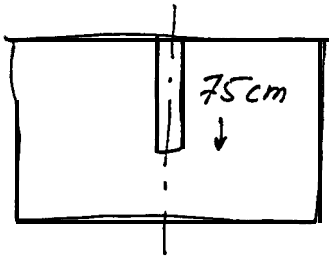


Target: (with uranium)

Needs: = 1st generation of neutrons
(for multiply systems)
= large-scale targets
= mixtures

Experiments has to be confirmed by calculation experiments:

U^{235} (0,3%) 2m (dia) . 2m (H)

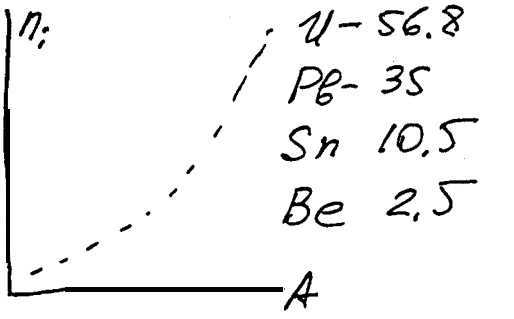


	x (E > 0,8 MeV)
52.8 ± 0.6	0,787
56.Y ± Y.5	0,800
61,1 ± 1	0,820

Mixtures (+ structure, coolant..)

$$\bar{N} = \sum_i n_i p_i = \frac{\sum n_i \varrho_i A_i^{5/7}}{\sum \varrho_i A_i^{5/7}} \qquad p_i = \frac{\varrho_i \sigma_{in}}{\sum \varrho_i \sigma_{in}}$$

$\sigma_{in} \simeq 38,5\, A^{5/7}$
(E > 80 MeV)



Sensitivity analisis

$$\frac{d\bar{N}}{\bar{N}} = S_i \frac{dn_i}{n_i} \qquad S_i = \frac{\rho_i A_i^{5/7}}{\sum \rho_i A_i^{5/7}} \frac{n_i}{\bar{N}}$$

Example: U^8 - Fe (50-50% vol)

$\bar{N} = 36,2$ $\quad S_{Fe} = 0,06$

$$\frac{\delta N}{N} = 1\% \leftrightarrow \frac{\delta n_{Fe}}{n_{Fe}} = 17\%$$

n_{Fe} : 5,6 → 11.2 (200%) $\quad \bar{N}$: 36,2 → 38,4 (1%)

A↓ S↓

	PRORAB	RIYaD	%
U_{met}	45	45 ± 0,7	-
UO_2	35,4	37,7 ± 0,8	- 6,1
UN	40	41.6 ± 0.9	- 3,8
UC	40,5	40,6 ± 0,7	- 0.2
UC_2	36.8	38.2 ± 0,9	- 3,7
USi	37.5	40,2 ± 1,4	- 6,7
USi_2	32,5	37.0 ± 1.6	- 12,7
$U+Al+H_2O$	41.2	42,9 ± 2,3	- 4.0
$U+Na+SS$	37.1	37.6 ± 0,7	- 1.3

Surface 45 (1 GeV) Deep - 61 neutrons

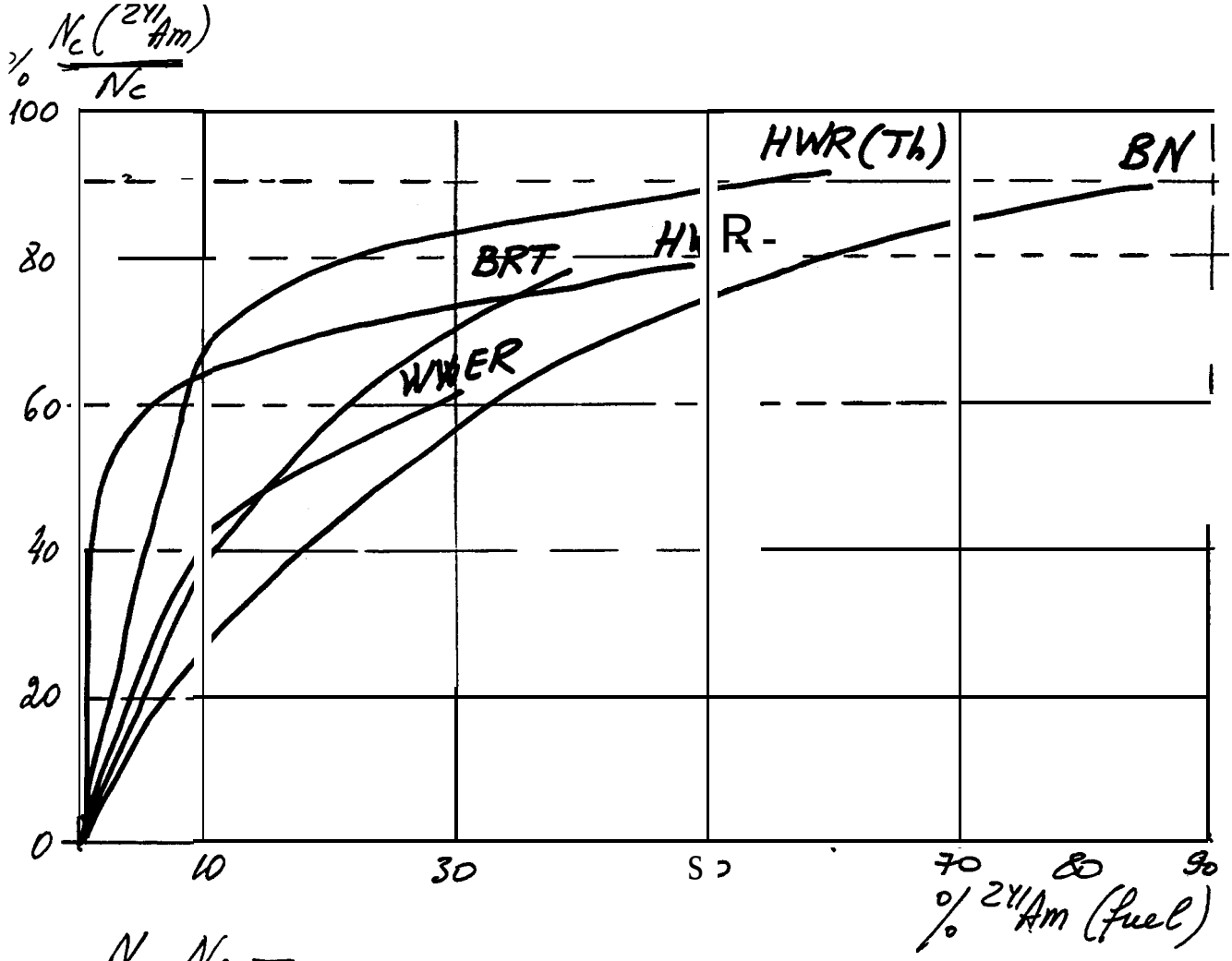
$$q_n(z,\tau) = q_n^0\left(z\frac{\Sigma_{in}}{\Sigma_0}; \tau\frac{\Sigma_{in}}{\Sigma_0}\right)$$

Actinoid's participation in fission (F%) and capture

Nuclide	F(%) / C(%)				
	PWR	HWR	HWR(Th)	BN-600	BRT
^{241}Am	8/62	9/78	12/92	60/90	80/48
^{242m}Am	93/12	95/12	99/11	88/5	68/2
^{244}Cm	30/80	34/92	33/95	96/78	70/36
^{238}Pu	50/80	41/87	45/95	92/41	71/16
^{237}Np	7/61	12/82	13/93	65/89	83/71

Sencitivity factors

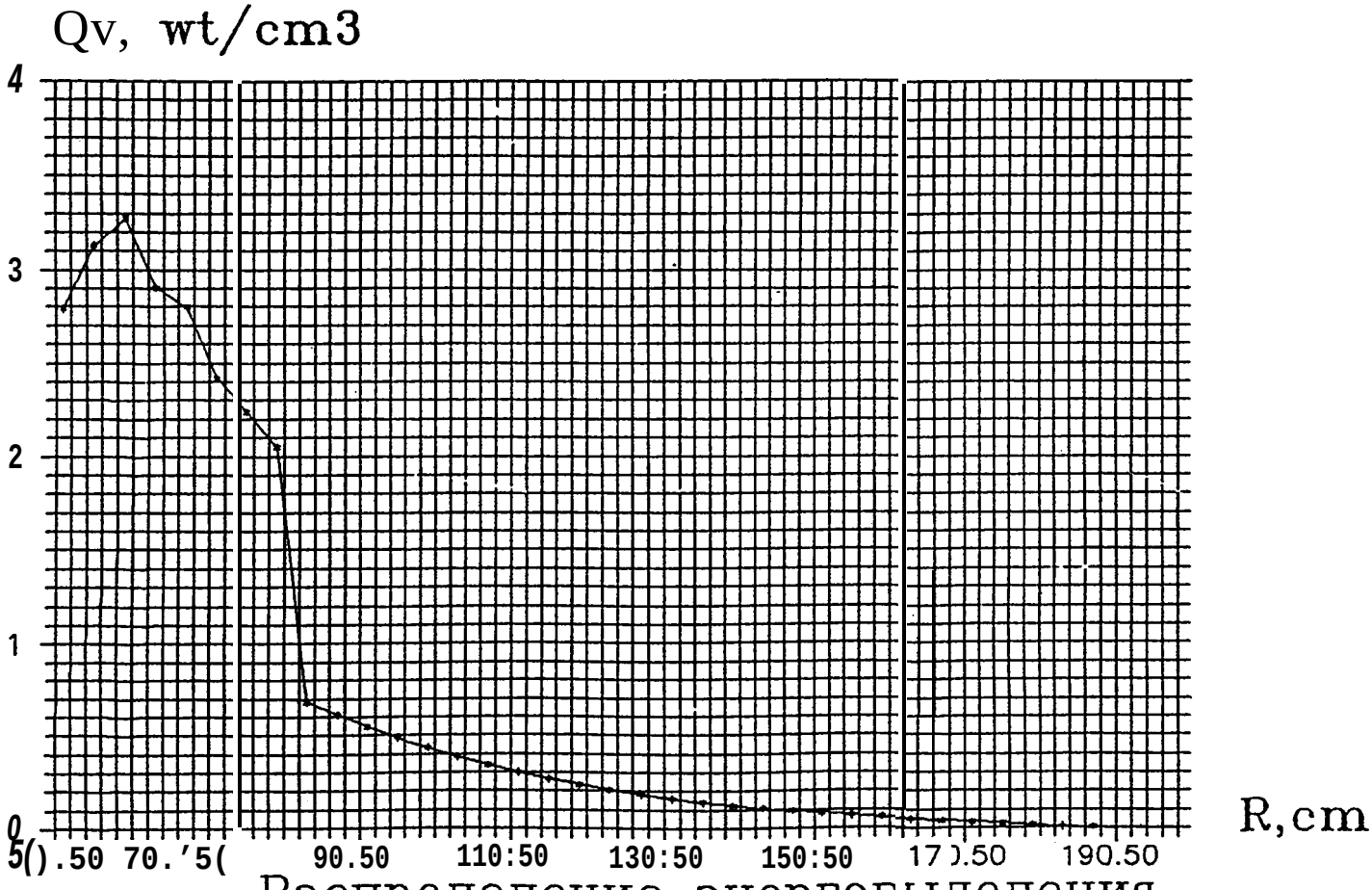
	dF/dN dε/dN				
	PWR	HWR	HWR(Th)	BN-600	BRT
^{241}Am	0.26/0.91	0.2/0.3	0.2/0.24	0.45/0.3	2/0.85
^{242m}Am	7760/564	2180/290	1390/126	24/1.4	36/0.9
^{244}Cm	0.46/0.71	0.34/0.42	0.3/0.6	1.6/0.7	44/2
^{238}Pu	0.7/0.6	0.5/0.4	0.5/0.3	3.2/1.3	11/2
^{237}Np	0.2/1	0.2/0.3	0.2/0.3	0.6/0.3	1.7/1



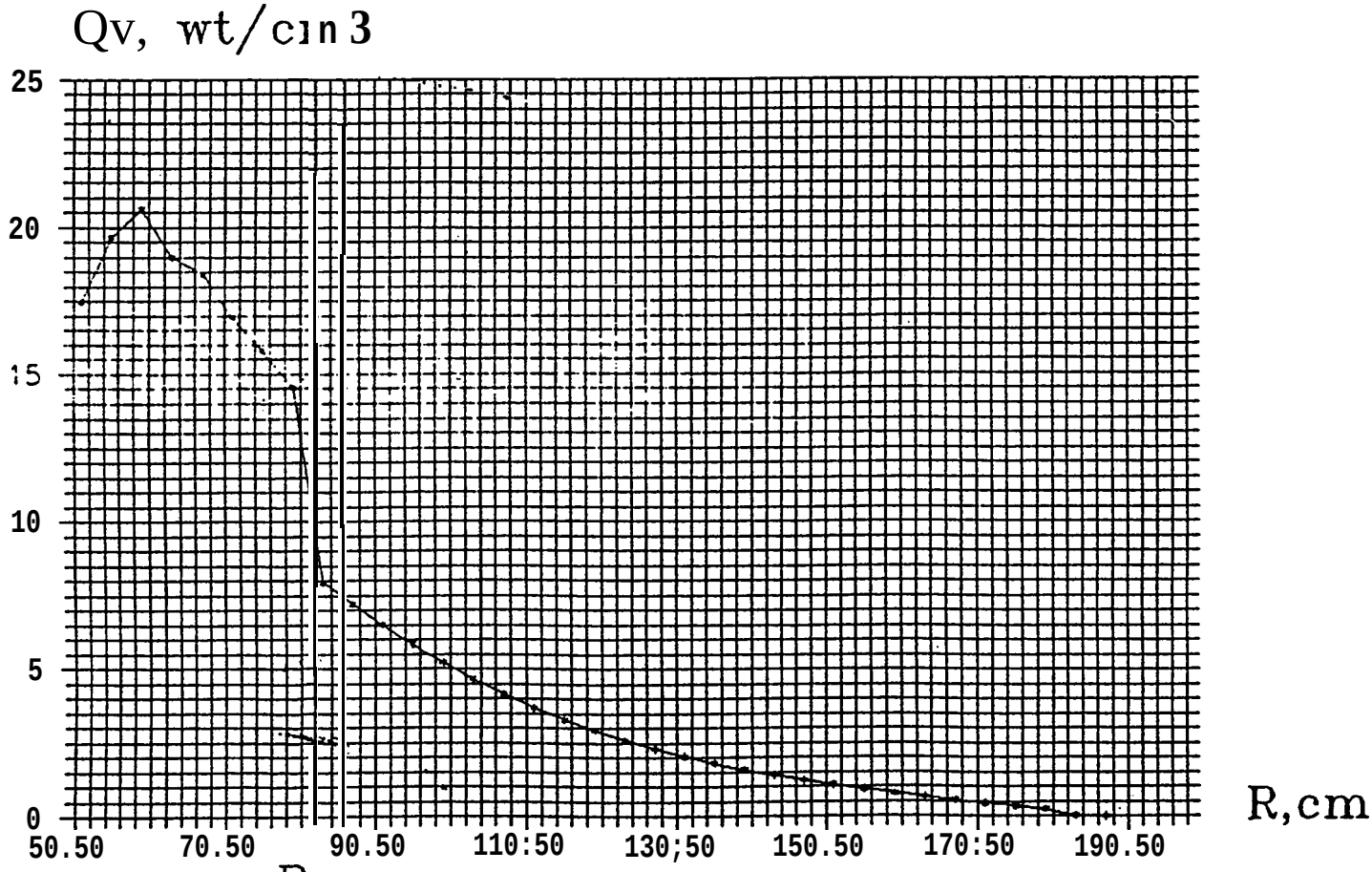
N_c, N_f — $Am-241$, $Am-242m$, $Cm-244$, $Np-237$, $Pu-238$

Reactors: PWR (ВВЭР-1000)
HWR (Bruce-8, CANDU 600)
HWR-Th
BN-600
BRT-1600

Tables: $\%_{(i)}$, E_M, Φ, k_{ef}, $x\%$, $\bar{\sigma}_{c,f}$, $C_{(i)}, F_{(i)}-\%$
$C_5, C_8, F_5, F_8, \bar{\sigma}_{5,8}, \nu_f$.



Распределение энерговыделения по радиусу в 1 и 3 301 ах



Распределение энерговыделения
110 радиусу во 2 зоне