An Investigations of the Local Non Uniformities in the Ignalina RBMK-1500 Reactor Core Characteristics.

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1 Introduction.

The Ignalina nuclear power plant (INPP), in Lithuania, consist of two of the highest power (1500 MWe each) RBMK reactors. Essentially, these reactors employ, the same core configuration as the 1000 MWe RBMK plants, but have higher volumetric and linear power densities. After the Chernobyl accident, modifications were introduced, in the RBMK core configurations, to substanially reduce the large positive void coefficient, innerent in these cores. The major modifications were a) a much faster shut-down system b) the introduction of the additional absorbers in the core and
(c) an increase of U^{235} fuel enrichment from 2.0w% to 2.4w%. The latter modifications, responsible for the reduction of the positive void coefficient, also lead to greater heterogeneity in the core, and perhaps, to larger local variations in the core characteristics. In this study, one of our objectives is to understand the spatial characteristics of the core, e.g., the radial and axial variations of power, of reactivity coefficients, of control rod worths etc. Another objective is to assess the change in core characteristics due to the progressive loading of the Erbium-poisoned 2.4w% U^{235} enriched fuel in the Ignalina core. It should be mentioned that the 2.4w% fuel was not introdused in the Ignalina core earlier in order not to decrease the thermal margin. The calculations are performed with the STEPAN code [1].

2 Description of the STEPAN code.

The STEPAN code as available at the Kurchatov Institute, is a 3-D, finite difference, two group diffusion theory code, which can model each and every assembly in the core and the graphite reflectors, with up to 16 zones in the axial direction. The first and last zones fall in the bottom and top reflectors and the other 14 zones (each 0.5m high) represent the 7 meter high core. The code employs a two group library, generated from the UK neutron cross section data library (UKNDL) with the WIMS-D4 cell code[2]. The boundary between the 2 groups is at 4.0 ev. The cross sections are funtions of channel type, coolant density, graphite and fuel temperatures and Xenon concentration. For fuel and additional absorber channels they are also functions of the fuel burnup and the boron depletion respectively. The STEPAN code is used by the plant personnel at the INPP. The reactor core configuration data files, generated at the plant, are converted to input data files for the STEPAN code with certain processing codes. Thus, the very complicated configuration of the INPP core, with its different types of control rods, additional absorbers etc. is represented completely, and in much detail, in the STEPAN calculation.

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The radial and axial power distributions obtained from a STEPAN calculation are compared to those measured in the core with neutron detectors. In general, the calculated power peakings in both x-y and z directions are different from the counter data. An algorithm, incorporated in the STEPAN code modifies the power distributions to the measured values while keeping the K_{eff} invariant. The code, then calculates the reactivity coefficients with perturbation theory, and the reactivity changes with total voiding of the main loop, and of the control rod loop.

The results obtained from STEPAN calculations are the distributions of fuel channel power, core-average axial distribution of flow density and void fraction. Also available are the reactivity coefficients for changes in fuel and graphite temperature, coolant voiding and core power. A full list of other core characteristics, which are needed for presentation to Russian NRC are also calculated by the STEPAN code.

3 Whole core calculational results

Calculated results of the Ignalina reactor cores, using the STEPAN code are shown in Table 1.

Table 1: *STEPAN calculation results for reactors N1 and N2 of the Ignalina station*

Reactor N	Date	Keff	Kr	Kz	α_φ^w	α_φ^t	α_w	ρ_{cps}	ρ_{ml}
1	940224	1.003	1.63	1.19	0.559	0.729	-0.251E-3	3.43	0.81
1	940318	1.005	1.58	1.20	0.354	0.603	-0.446E-3	3.33	0.85
1	941214	1.003	1.56	1.22	0.547	0.704	-0.256E-3	3.37	0.76
1	941222	1.003	1.54	1.20	0.601	0.752	-0.204E-3	3.54	0.74
1	950120	1.003	1.57	1.24	0.632	0.735	-0.198E-3	3.51	0.67
2	940224	1.004	1.54	1.28	0.338	0.602	-0.449E-3	3.26	0.64
2	940324	1.002	1.72	1.24	0.674	0.753	-0.182E-3	3.37	0.57
2	950625	1.003	1.68	1.16	0.528	0.710	-0.226E-3	3.62	0.68
2	950724	1.003	1.66	1.17	0.469	0.655	-0.253E-3	3.46	0.65
2	950725	1.002	1.67	1.22	0.473	0.640	-0.248E-3	3.41	0.62
2	950807	1.002	1.68	1.17	0.690	0.792	-0.182E-3	3.41	0.62
2	950808	1.002	1.70	1.22	0.705	0.791	-0.180E-3	3.41	0.62

Magnitudes of fuel and graphite temperature coefficient are equal to $-2.5 \cdot 10^{-3}$ and $(7.3 \pm 0.3) \cdot 10^{-3} \beta$/degree.

The results shown in the Table 1 compare well with the available plant experimental data. The local nonuniformity analyses reported in the following paragraphs were performed for the Ignalina unit 2 core configuration of August 8, 1995.

4 Void reactivity spatial variation.

Calculations were performed to determine the axial variation of the void reactivity effect. The voiding reactivity was determined by setting the void of a 50 cm segment along the axial length of the 7 meter high core. The calculational results presented in Fig. 1. It is found that the voiding of the nearest-to-the top and the bottom reflector layers decrease reactivity, due to the increase in the neutron leakage with voiding. The peak of the positive voiding reactivity is slightly shifted to the bottom of core. It follows the shape of axial core power and the flow density distributions, which are presented in Figures 2 and 3, respectively. Voiding of the lower part of core hase a larger effect because coolant density is larger in the lower part of the core, and the power distribution is also shifted slightly to the bottom of core.

5 The Influence of the Control Rod Insertion on the Local Void Reactivity.

The presence of control rods and additional absorbers influences the regional void reactivity effect in the Ignalina core. Calculations were performed to determine the dependence of the voiding reactivity on the insertion of the control rods in a local region. Towards this purpose, 8x8 assembly regions were selected at "center", "north", "south", "east" and "west" regions of the core as shown in Fig. 4. Only the manual control rods (MCR) and automatic control rods (ACR) were moved in each region. The fast scram rods (FSR) and shortened control rods (SCR) stay withdrawn from the core. The calculations were performed for two cases: with and without the additional absorbers (AA) in the investigated regions. In the second case, the AA were replaced by ordinary fuel channels. The fuel burn up in each region was uniform and equal to $8.5MW \cdot days/kg$. In Figs.5 and 6 the variations of δ on the region cumulative control rod depth for cases with AA and without AA are presented. The region cumulative control rod depth X was calculated with the folowing formula:
$X = \sum_{i=1}^{n} l_i/700.0$,
where l_i = the MCR and ACR depth in the region,
n = number of the MCR and ACR in the region.

With increase of the dimensionless cumulative control rod depth in the region with AA, from 0.0 to 3.0, the void reactivity rapidly decreases. With further insertion of control rods, void reactivity does not change greatly. Considerable differences are seen, between the selected regions, for the void reactivity with zero cumulative control rod depth, (all control rods out of region). These differences may result from the differences in the cumulative control rod depth in the surrounding layers. Diffusion length of neutrons in graphite is approximately equal to the two graphite brick sizes, thus the influence of control rods or additional absorbers, extends over a considerable number of assemblies in their surroundings. In Table 2 cumulative control rod depth in the first and second surrounding layers is presented for the five regions investigated.

Table 2: *The effect of cumulative control rod depth on void reactivity.*

Region	Depth 1	Depth 2	V
"NORTH"	219	564	8.0E-4
"EAST"	619	719	7.2E-4
"SOUTH"	813	948	5.4E-4
"CENTER"	762	1461	4.4E-4
"WEST"	832	1004	3.2E-4

In this table: "Depth 1" and "Depth 2" are cumulative control rod depths in the first and second surrounding layers, respectively, and "V" is the region voiding reactivity with zero cumulative control rod depth, with AA present in the region. It is seen that the magnitude of the void reactivity depends, to some extent, on the cumulative control rod depth in the layers surrounding the 8x8 region. In general, the larger the cumulative control rod depth in the two surrounding layers, the less the void reactivity in the region investigated. There are differences between the void reactivity for the "center" and the peripheral regions, which may be due to the leakage experienced at the core boundaries by the peripheral regions. It is seen that the regional void ΔK, without the additional absorbers, is about 5 times of that with the additional absorbers. Additionally, for the case without additional absorbers, the insertion of the control rods affects the magnitude of the void reactivity, only after the control rods have been inserted to $\simeq 20\%$ of their total depth.

6 Fresh fuel assembly reloading.

Fresh fuel is continously loaded in the INPP. The fuel machine periodically removes a burned-up fuel assembly and in its place installs a fresh fuel assembly. The neighbouring control rods are moved to limit the local power increase due to the addition of fresh fuel. An investigation of the influence of the fresh fuel assembly reloading on the multiplication factor and core power redistribution was performed. Toward this purpose, the effect of replacing the most-burned up assembly with fresh fuel assembly, in one of the five regions, mentioned above, was calculated. Calculations were performed for the standard core condition without the normalization to the counter spatial data correction. The calculated results are presented in Table 3

Table 3: *Fresh fuel assembly reloading effect.*

	"before reloading"	"North"	"South"	"West"	"East"	"Center
K_{eff}	1.00239	1.00242	1.00271	1.00247	1.00266	1.00250
δK	0.0	0.3E-4	3.2E-4	0.8E-4	2.7E-4	1.1E-4
K_r	2.23	2.21	2.10	2.08	2.54	2.21
Q_{reg}	-	105.31	159.02	89.72	239.05	110.58

In this table $\delta K = K_{eff} - K^{st}_{eff}$ - reloading effect
K^{st}_{eff} - multiplication factor before fuel assembly reloading
Q_{reg} - region power production.

It seen that with greater power in a region, the reloading δK is larger; and so is K_r after reloading. Channel power changes due to fresh fuel loading, and those after fuel reloading, in terms of ratios of powers after fuel reloading to the powers before reloading, are presented in Tables 4 - 8 for all five regions.

Table 4: *Power ratio after/before fuel reloading in north region.*

IK	*JK*							
	28	27	26	25	24	23	22	21
1	1.06	1.07	1.08	1.09	1.11	1.13	1.17	*1.50
2	1.06	-	1.08	1.09	1.10	-	1.13	1.15
3	-	1.06	1.07	1.08	1.09	1.09	1.10	1.09
4	1.05	1.06	1.06	-	1.07	1.08	1.08	-
5	1.05	1.06	1.06	1.06	1.09	1.07	1.07	1.06
6	1.05	-	1.05	1.06	1.06	-	1.05	1.05
7	1.04	1.04	1.04	1.04	-	1.04	1.05	1.04
8	1.03	1.03	1.04	-	1.04	1.03	1.04	-

Table 5: *Power ratio after/before fuel reloading in south region.*

IK	*JK*							
	28	27	26	25	24	23	22	21
41	1.43	1.34	-	1.30	1.28	1.26	1.24	1.22
42	1.39	-	1.38	1.34	1.31	-	1.25	1.23
43	1.44	1.46	1.43	1.38	1.33	1.30	1.26	1.24
44	1.49	*2.00	1.47	-	1.36	1.32	1.28	-
45	1.47	1.49	1.45	1.41	1.37	1.33	-	1.25
46	1.44	-	1.43	1.40	1.36	-	1.30	1.27
47	1.42	1.42	1.41	1.39	1.36	1.33	1.30	1.27
48	1.41	1.41	1.40	1.38	1.36	1.33	1.30	1.27

Table 6: *Power ratio after/before fuel reloading in west region.*

IK	*JK*							
	48	47	46	45	44	43	42	41
21	1.34	1.33	-	1.29	1.28	1.26	1.25	1.22
22	1.37	-	1.36	1.33	1.31	-	1.26	1.24
23	1.41	1.40	1.38	1.36	1.34	1.31	1.27	1.24
24	1.44	1.44	1.43	-	1.36	1.33	1.29	-
25	1.47	1.49	1.49	1.44	1.38	1.35	-	1.26
26	1.50	-	*2.03	1.47	1.40	-	1.31	1.26
27	1.48	1.50	1.50	1.43	1.38	1.34	1.29	1.26
28	1.44	1.45	1.43	-	1.35	1.31	1.28	-

Table 7: *Power ratio after/before fuel reloading in east region.*

IK	*JK*							
	8	7	6	5	4	3	2	1
21	1.09	1.09	1.10	1.11	1.12	1.12	1.13	1.13
22	1.09	-	1.11	1.12	1.12	-	1.14	1.14
23	-	1.41	1.12	1.13	1.13	1.14	1.15	1.16
24	1.11	1.12	1.12	-	1.14	1.15	1.17	1.18
25	1.11	1.12	1.13	1.14	1.15	1.17	1.19	1.20
26	1.12	-	1.13	1.15	1.17	-	1.22	1.24
27	1.12	1.13	1.14	1.16	-	1.22	1.26	1.30
28	1.12	1.13	1.41	-	1.20	1.24	1.29	*1.75

Table 8: *Power ratio after/before fuel reloading in center region.*

IK	*JK*							
	28	27	26	25	24	23	22	21
21	1.02	1.02	1.03	1.03	-	1.04	1.04	1.04
22	1.03	-	1.04	1.04	1.05	-	1.06	1.06
23	1.03	1.03	1.04	1.05	1.06	1.07	1.07	1.07
24	1.03	1.04	1.04	-	1.07	1.08	1.09	-
25	1.03	1.04	-	1.06	1.07	1.09	1.12	1.12
26	1.03	-	1.05	1.06	1.07	-	1.14	*1.52
27	1.03	1.04	1.05	1.05	1.07	1.09	1.11	1.13
28	1.03	1.04	1.04	-	1.06	1.07	1.08	-

In these Tables IK and JK are the assembly coordinates. Reloaded assembly is marked with an asterisk. The burn-up of the assemblies replaced, are :
/begincenter for north region - 1387 MWt days
for south region - 1618MWt days
for west region - 1591MWt days
for east region - 1591MWt days
for center region - 1585MWt days
/endcenter It is seen that power in the fresh fuel reloaded is from 50 to 100% larger than the average power in the surrounding assemblies. The power increase in the channels surrounding the fresh fuel is of approximately 10 to 30% of the average power.

7 Effects of control rods.

The effects of control rods on the Ignalina core local behaviour were investigated. For this purpose, calculations were performed for unit 2 of the Ignalina power station for the core configuration on 950808. The multiplication factor was calculated for different insertion depths of a single control rod in the "center" and "north" regions (core channel locations 22;23 and 6;23 respectively). The calculated results are presented in Fig 7.

The power in the channels, around the moving control rod, increases to $\simeq 1.3$ times if CR is

withdrawn to the half of its total height in the core and to $\simeq$ 1.8 times. if CR is withdrawn to its full length from the core.
The peak power channel location in case 1 is (39.13). $P_{max} = 4.20 MWt$
The peak power channel location in cases 2 and 3 is (18,24), close to moving control rod.
$P_{max} = 4.09 MWt$ and $P_{max} = 4.50 MWt$ for cases 2 and 3, respectively.
Cases 1 2 and 3 corresponds to the moving CR insertion depth 700cm, 350cm and 0cm respectively.

Calculations of the worth distribution of a control rod in "north" region 8x8 sqare, versus depth, without additional absorbers, and/or with MCR and ACR withdrawn from the core, except the moving CR, were also performed. The calculated results are presented in Fig 8.

It is seen that the worth of a single control rod in the "north" region is affected strongly by the presence of AAs and CRs. The worth of a control rod decreases by $\simeq 0.006 (\simeq 1\beta)$ when AA are installed in the region and by $\simeq 0.0025 (\simeq 0.4\beta)$ when control rods in the region are fully inserted. These results imply that the total control rod worth was substantially reduced when the Ignalina core was modified after the Chernobyl accident to include additional absorbers. To investigate control rods interference, calculations of core multiplication factor with withdrawl of successive control rods from the "center" and the "north" regions was performed. The calculated results are presented in Table 9.

Table 9: *Successive CRs withdrawing effect.*

Number of CRs in region	*north*				*center*			
	location	K_{eff}	K_r	δK	location	K_{eff}	K_r	δK
5	-	1.00336	2.02	0.0	-	1.00334	2.00	0.0
4	2,23	1.00341	2.00	0.5e-4	22,27	1.00364	1.91	3.0e-4
3	6,23	1.00358	1.94	1.7e-4	24,25	1.00393	1.85	5.9e-4
2	8.21	1.00416	1.83	5.8e-4	26,27	1.00448	1.72	11.4e-4
1	2,27	1.00450	1.76	3.4e-4	22,23	1.00531	2.00	8.3e-4
0	6,27	1.00651	3.40	20.1e-4	26,23	1.00712	3.03	18.1e-4

In this table:
location - location of control rod removed
δK - reactivity change due to removal of each control rod.
It is seen that the worth of a control rod is affected strongly by the presence of other control rods in the vicinity. There is substantial flux depression in the region as the control rods are inserted. Thus there is a large difference in the "worth" of the first control rod inserted in a region versus the last control rod. Removing of CRs and AAs just in such a small core region as 8x8, gives a very skewed power distribution. Fig.9 and 10 present the standard core power distribution and that without AAs and CRs in the "north" 8x8 core region. Thus, there is a large shift in the spatial power distribution when a control rod or an additional absorber is removed from any region of the Ignalina core. Such a power shift must be controlled by movement of additional control rods.

8 Ignalina NPP core characteristics with Erbium-poisoned fuel.

As mentioned earlier, additional absorbers were added to the Ignalina core to reduce the positive void reactivity coefficient. These absorbers, however, worsen the fuel economy and more frequent fuel reloading had to be instituted since that time. More recently, it has been suggested that higher enrichment fuel, along with a burnable poison should be used, in order to reduce the number of additional absorbers in the core. Since June 1995, the Ignalina plant unit 2 is progressively loading 0.41w% Erbium poisoned 2.4w% U^{235} enriched fuel assemblies in the core to replace the burned-up 2.0w% U^{235} enriched fuel assemblies. On January 29 1996 a total of 150 assemblies with Erbium had been loaded. More assemblies with Er are scheduled to be loaded in the core of unit 2, along with progressive removal of a part of the 54 additional absorbers currently resident in the core of unit 2.

The objective of our work is to determine the core characteristics with the partial loading of the core with Erbium poisoned assemblies. In particular, to ascertain whether a reduction in the core positive void coefficient can be achieved and the additional absorbers removed.

The calculations are performed for 5 core configurations incorporating 0, 5, 26, 50 and 150 Erbium assemblies. The number of additional absorbers remains at 54, since none have been removed so far. Again the STEPAN code is used for those calculations; its cross section library was enhanced to include 2 group cross sections for an Erbium poisoned fuel assembly.

The calculated results are shown in Table 10, where the important reactivity coefficients and the power-peaking factors are shown for these five core configurations. It is seen that with the increase in the number of the Erbium poisoned fuel assemblies, the positive void reactivity coefficient α_φ and the power peaking factors K_r and K_z decrease. It appears that with the loading of 2.4 U^{235} w% enriched, Erbium poisoned fuel it may be possible to progressively withdraw the additional absorbers, thereby improving the neutron economy, consistent with obtaining the desired value of the void coefficient. It may also be possible to obtain less peaking power distribution in the core.

Calculated results for the core characteristics are shown in Table 10.

Table 10: *Ignalina NPP unit 2 core behaviour as a function of the number of Er assemblies.*

Date	24.03.94	29.06.95	25.07.95	08.08.95	29.01.96
No of Er Assemb.	0	5	26	50	150
No of AA	54	54	54	54	54
No of WC	0	2	2	2	0
K_{eff}	1.00251	1.00265	1.00233	1.00244	1.00032
K_r	1.72	1.68	1.67	1.70	1.53
K_z	1.24	1.16	1.22	1.22	1.18
α_c	7.616e-3	7.248e-3	6.987e-3	7.001e-3	6.004e-3
α_t	-2.481e-3	-2.458e-3	-2.463e-3	-2.460e-3	-2.443e-3
α_φ	0.753	0.672	0.534	0.591	0.263
α_w	-0.182e-3	-0.235e-3	-0.272e-3	-0.217e-3	-0.305e-3

It is seen that with the increase in the number of Er assemblies the values of α_φ and the K_r decrease. The decrease of K_r may be explained by the fact that the power in a fresh fuel bundle is lowered substantially by the Erbium, it contains. The decrease in α_φ may be caused by the absorption, in the near thermal energy region, by the 0.3 ev resonance of Erbium.

Summary and conclusions.

Analyses of several Ignalina nuclear power plant cores were performed with the three-dimensional neutronics code STEPAN developed in the "Kurchatov Institute" Moscow. The objective was to investigate the local non-uniformities in the core characteristics. It was found that:

(a) the void reactivity varies substantially along the core height. It has a large positive peak about 2.3 meters from the core bottom and slightly negative near the lower and upper core boundary, due to the predominance of neutron leakage at the boundaries. The distribution is bottom peaked. We believe, such an axial variation will affect the local power increase, in case of core voiding, without control rod action.

(b) The insertion of control rods in a region affects the void region effect (ΔK) strongly: the larger the control rod incertion depth, the smaller the void ΔK.

(c) The additional absorbers, present in a region, greatly decrease regional void reactivity. Removal of additional absorbers would increase the positive void reactivity by factors of 5 to 7. The core power also shifts sharply to the lower absorption regions, as control rods, or additional absorbers, are withdrawn.

(d) An acsident in which the fueling machine drops a fresh assembly, after removing a high burnup assembly, was analysed. It was found that, in the absence of local control action, power in the neighboring assemblies may jump by $\approx 50\%$ in regions of relatively larger power. Similarly, the control rod movements also vary the local power distributions, whose magnitude changes from region to region, in a similar fashion. Thus, it appears that continous monitoring, to maintain a relatively flat power distribution, is an essential prerequisite for normal power operation of the INPP, or of other RBMK plants.

(e) The worth of a control rod varies as the other control rods in a region are withdrawn. There is a substantial difference in the worth of the "first" control rod, versus that of the last control rod, in successive withdrawals from a region in the core.

(f) Analyses of the core characteristics with progressive loading of Erbium poisoned 2.4w% U^{235} enriched fuel assemblies was performed. It was found that loading of such assemblies reduces the positive void coefficient and the voided peaking factor. It may be possible to remove the additional absorbers, currently in the core, progressively, while obtaining the desired void coefficient; thereby improving the fuel economy of the INPP units substantially. In conclusion, the analyses performed showed that there are large local, and regional, effects due to the movement of control rods, of additional absorbers, of fuel assemblies or of coolant void. We believe, that understanding and prediction of local non-uniformities are important for assessing the safety margins in the Ignalina core for abnormal operational situations. Additionally, it appears that loading of Erbium poisoned fuel may improve the fuel economy of the Ignalina Nuclear Power plant; consistent with maintaining a typical positive void coefficient.

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Nomenclature.

Arabic letters

AA	- additional absorber;
ACR	- automatical control rod;
CR	- control rod;
FFB	- fresh fuel bundle;
$INPP$	- Ignalina nuclear power plant;
MCR	- manual control rod;
NPP	- nuclear power plant;
NRC	- Nuclear Regulatory Comission;
$RBMK$	- acronym of "Channelised Large Power Reactor";
WC	- water column;
$Keff$	- multiplication factor;
Kr	- radial power nonuniformity coefficient after adjustment to in-core detector data;
Kz	- axial power nonuniformity coefficient after adjustment to in-core detector data;

Greek letters

α_{φ}^{w}	power voiding reactivity coefficient;
α_{φ}^{t}	temperature voiding reactivity coefficient;
α_{w}	power reactivity coefficient;
α_{c}	graphite temperature coefficient;
α_{f}	fuel temperature coefficient;
ρ_{cps}	control protection system voiding reactivity effect;
ρ_{ml}	main loop voiding reactivity effect; All values are given in units of $\beta(\beta = 0.595 \cdot 10^{-3})$.

α_w is measured in units of β/MWt.

Fig. 1. Height region core voiding reactivity effect.

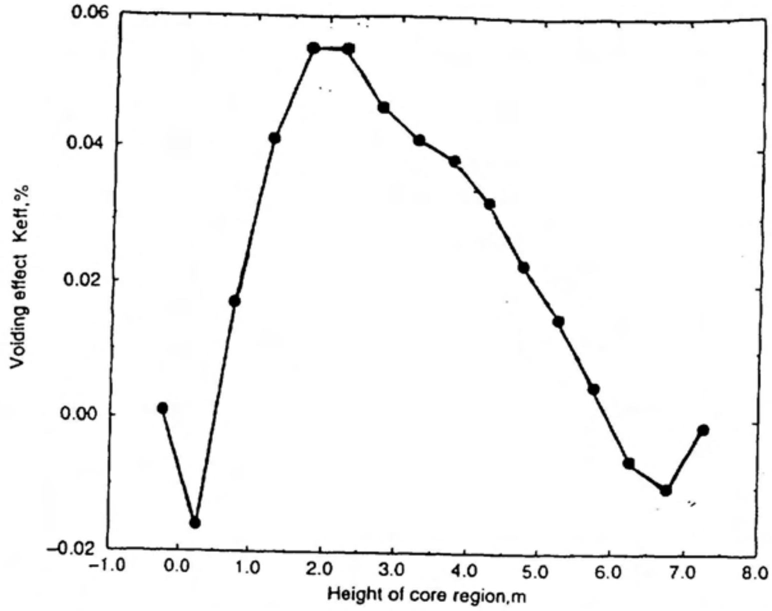


Fig. 2 Axial core power distribution.

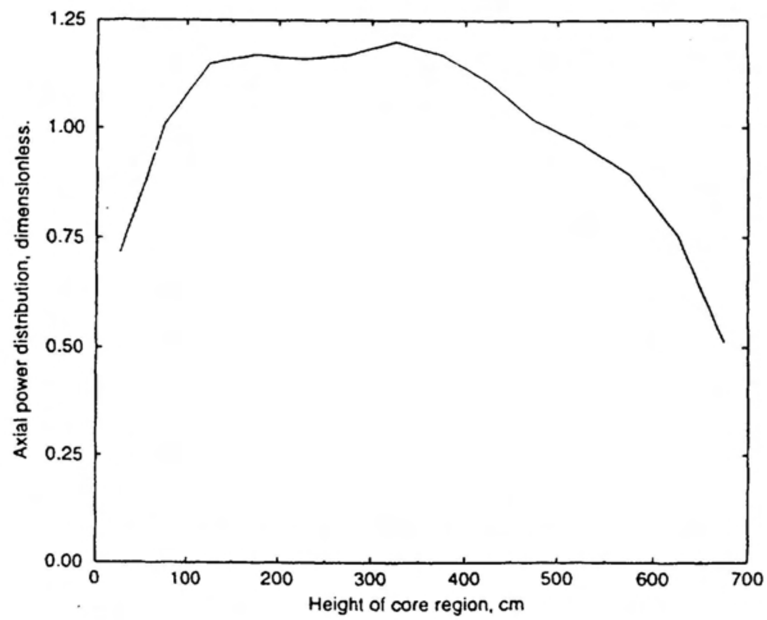


Fig. 3. Flow density distribution on the core axial direction.

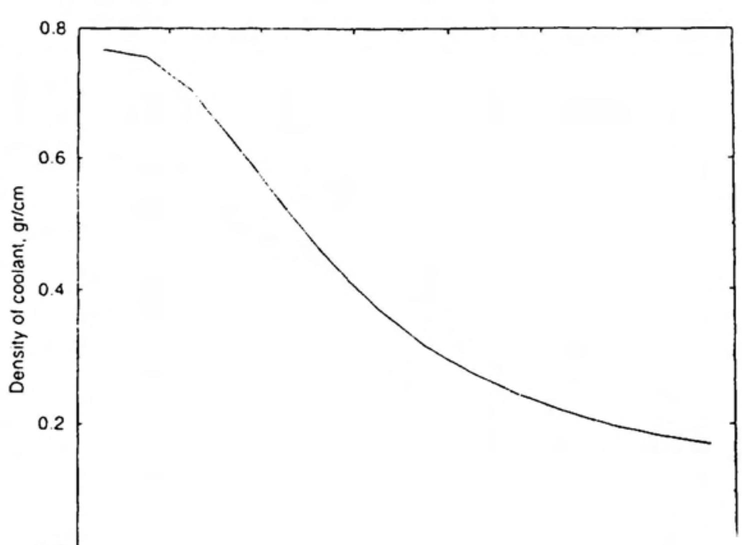
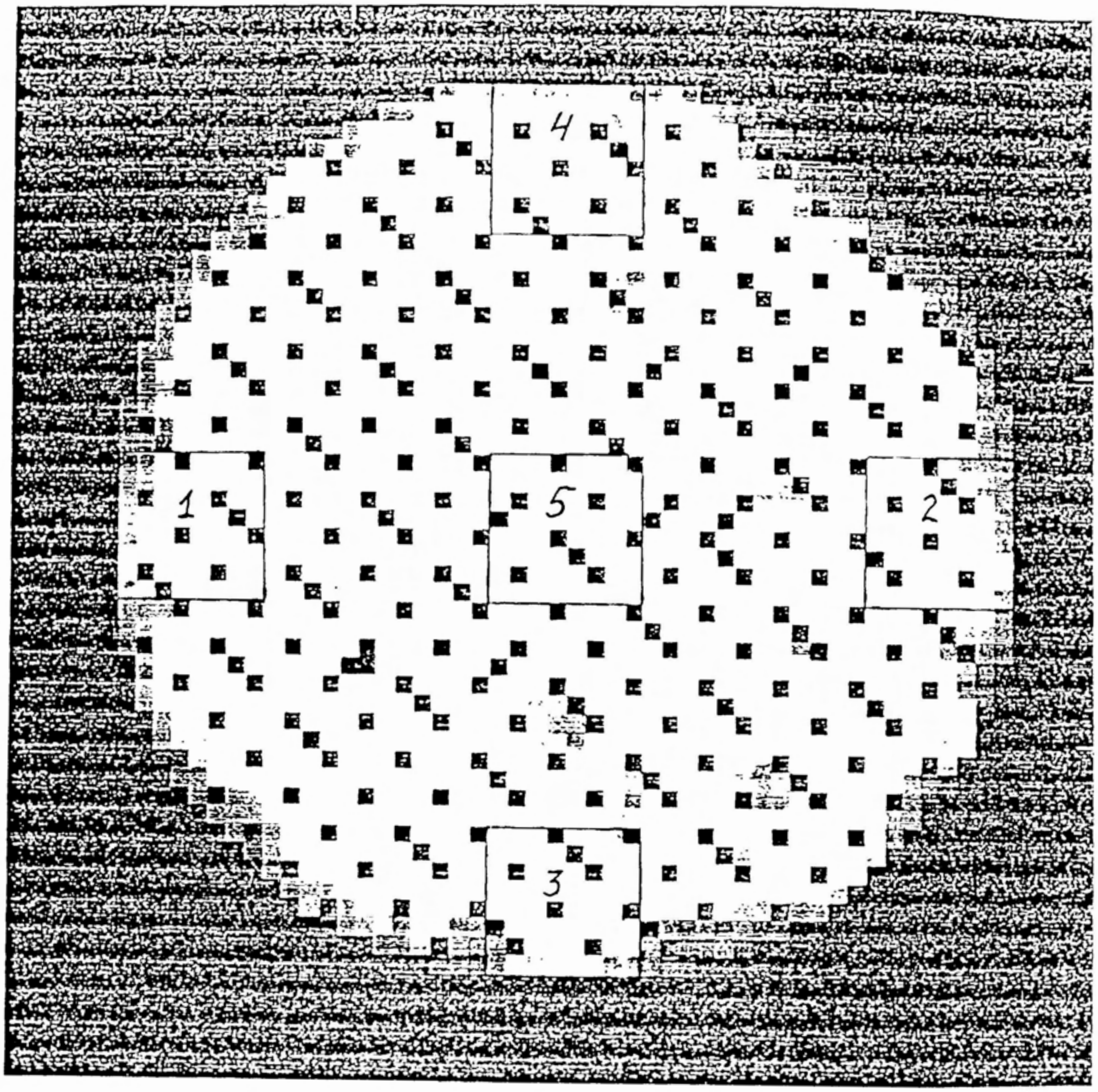


Fig. 4 Core region locations



1 - "North" region
2 - "South" region
3 - "West" region
4 - "East" region
5 - "Center" region

Fig.5 Region voiding effect dependence on cumulative control rod depth.
With AA in region.

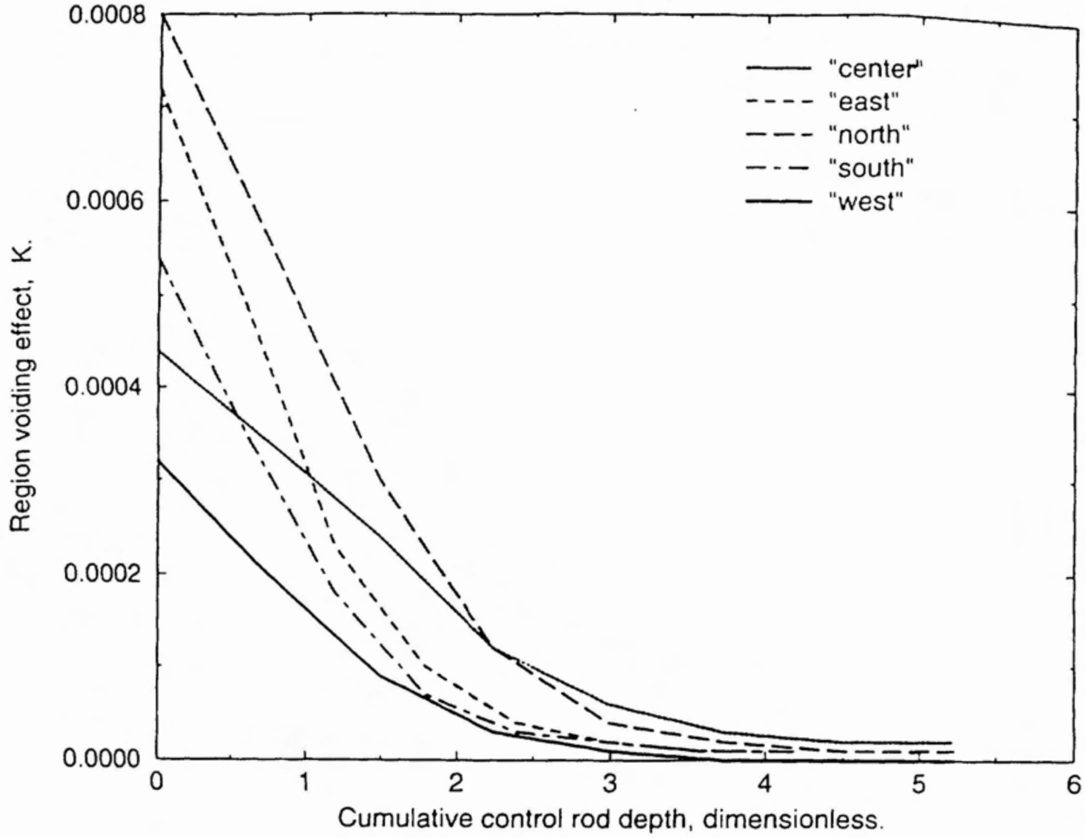


Fig.6 Region voiding effect dependence on comulative control rod depth.
With AA in region.

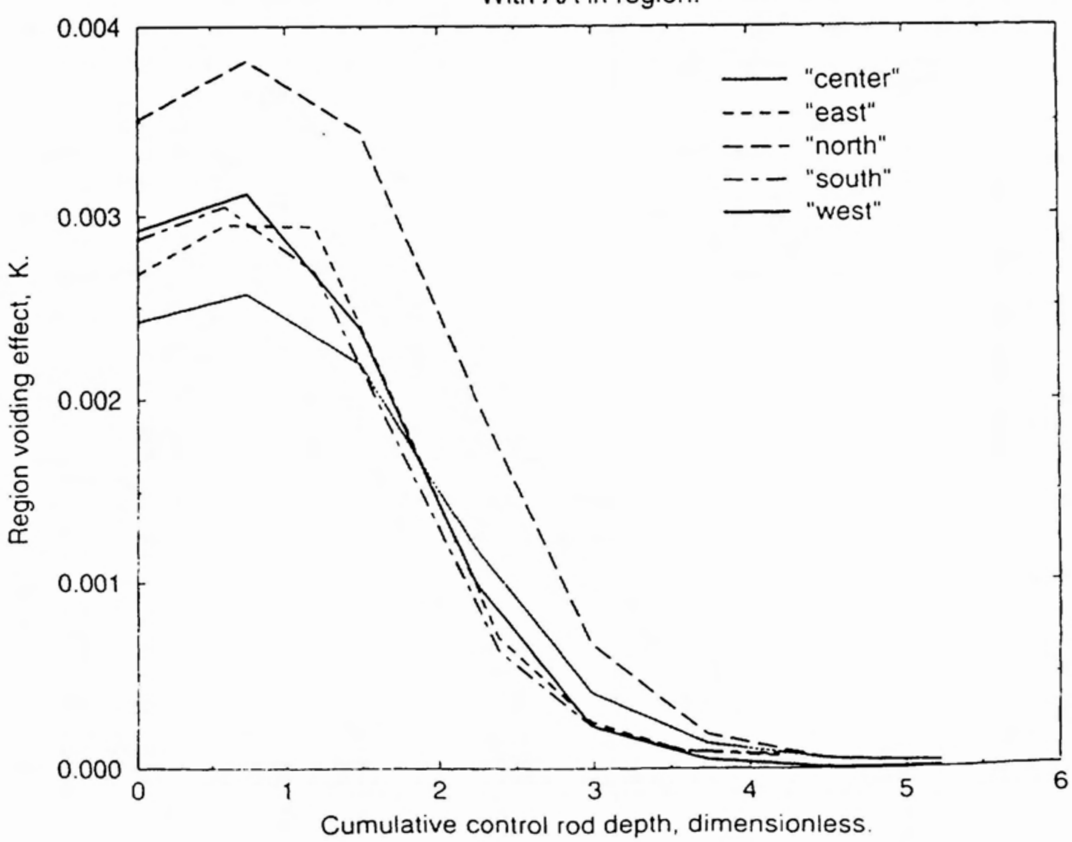


Fig. 7 Single control rod worth in "center" and "north" regions versus the insertion depth.

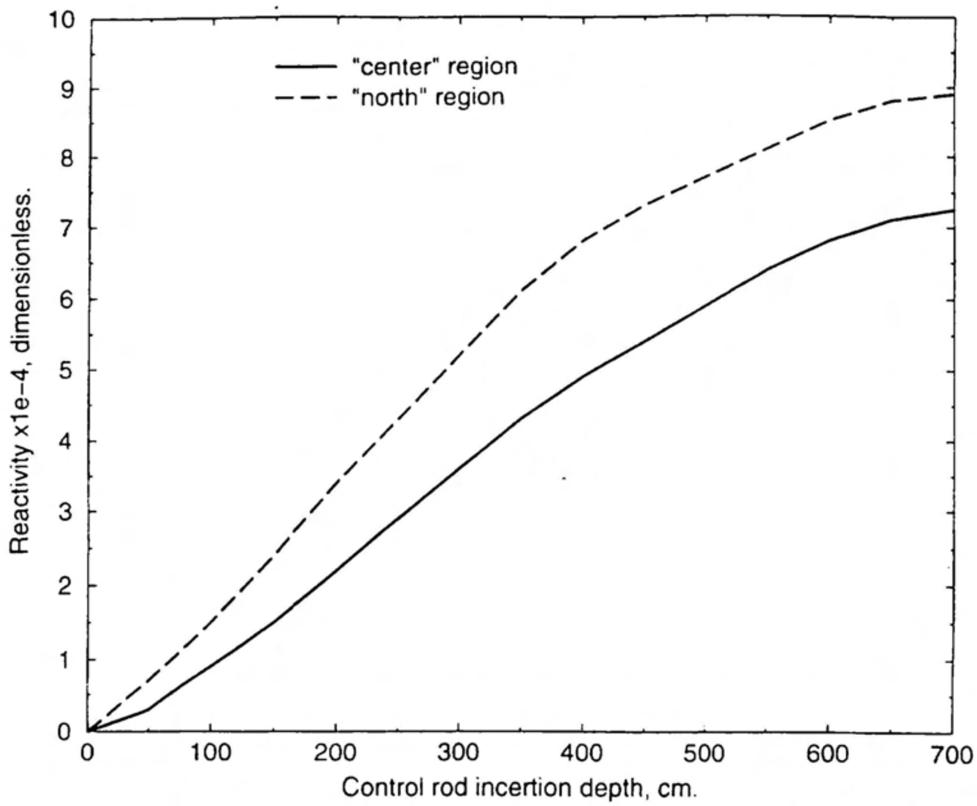


Fig. 8 Single control rod worth in north region versus insertion depth.

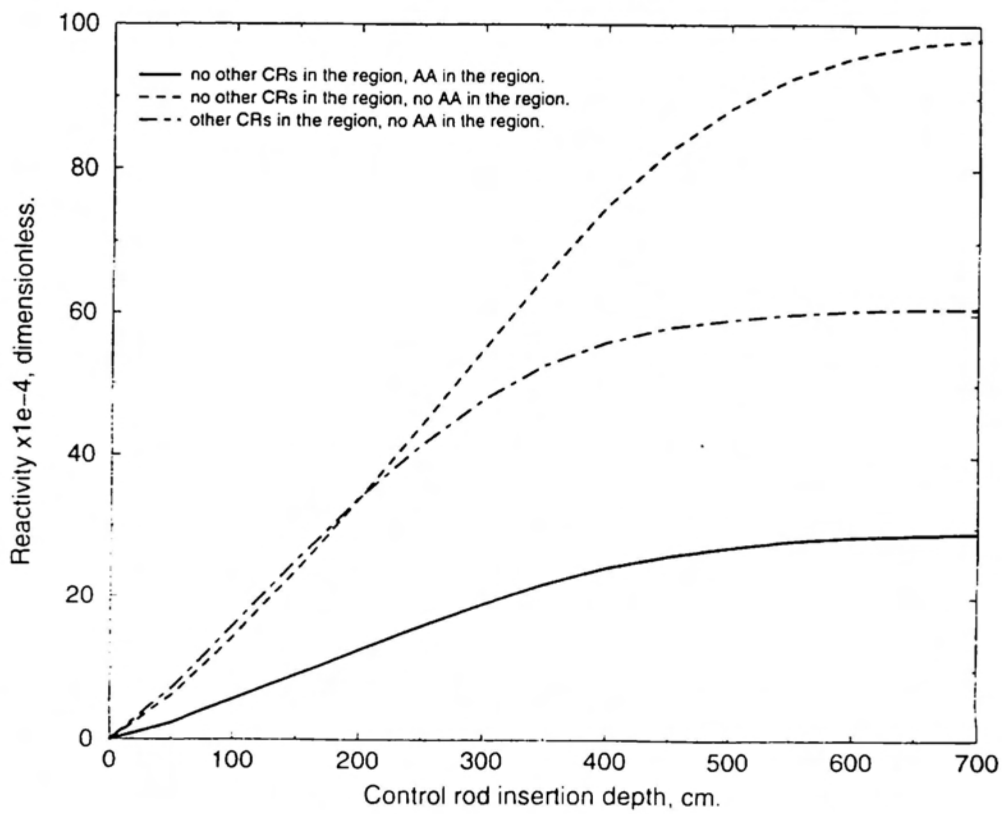


Fig. 9 Power density distribution. Ignalina NPP unit 2 core on 950808.

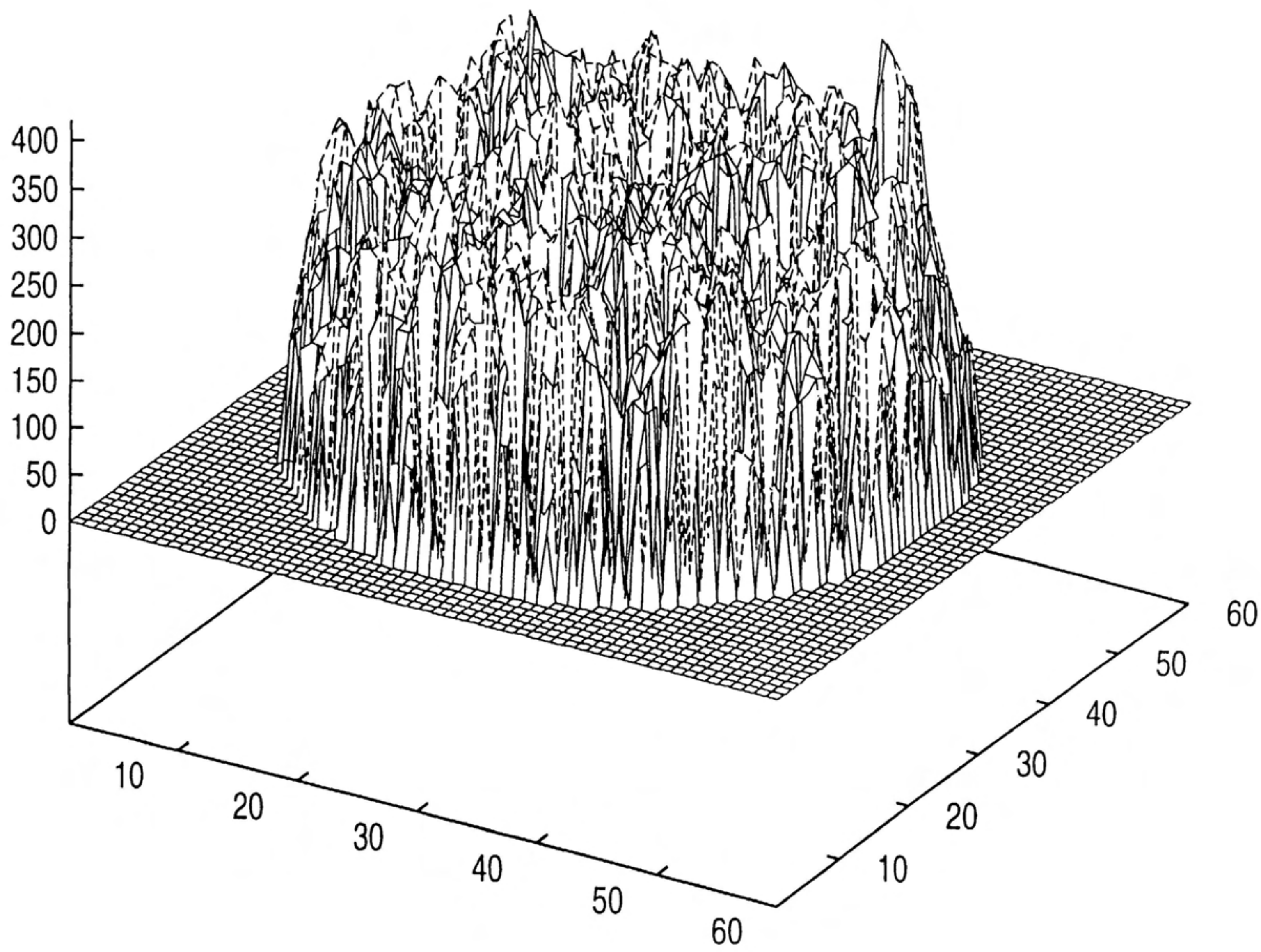


Fig. 10 Power density distribution. Ignalina NPP unit 2 core on 950808 without AA and CR in the north region.