THE ANALYSES OF MEASURED NUCLIDE CONCENTRATION IN PROJECT ISTC 2670

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ABSTRACT

In this article are analyzed experiments for VVER-440 fuel and compared with theoretical results by new version of the SCALE 5 code:
nuclide compositions - measurement in Kurchatov institute for 3.6%
- measurement in Dimitrovgrad for 3.6% (project ISTC 2670)
The focus is on modules TRITON and ORIGEN-S.

INTRODUCTION

In russian reactor VVER-440 are used hexagonal assemblies with triangular lattice pitch. In western PWR are used assemblies with square geometry. The change from square geometry to triangular is sometimes big problem. It is necessary to verify code used by calculations of spent fuel (VVER-440) storage. The best way is to compare theoretical results with experiments. Unfortunately, the lack “well documented” measurements remains up to now. Only two measurements are published. In this paper are results of the chemical analyses checked and compared with theoretical calculation. The SCALE 5 code (distributed in 2004) [1] for calculations of nuclide compositions was used. The computing system SCALE 5 includes several modules: KENO V.a, KENO VI, SAS2, SAS4, ORIGEN-S, TRITON etc. The library 44GROUPNDF5 was used.

NUCLIDE COMPOSITIONS

In ORIGEN-S calculations were used libraries prepared by the module SAS2. Basic library was used library 44GROUPNDF5 and 1 library per cycle. Time step by irradiation was maximal 100 days. The new 2D modules (NEWT and TRITON) for inventory calculations were tested. By TRITON calculation was used 1 step per cycle.

The nuclide composition measurement (only some actinides) of spent fuel assembly VVER-440 was made in Kurchatov Institute in Moscow [4-7]. 12 samples (11 actinides) are from one assembly 3.6% from NPP Novovoronezh Unit 4 (In text Novovoronezh 1). In Fig.1 are measured pins shown. New nuclide composition measurement for burnup credit application for VVER-440 reactor was made in RIAR in Dimitrovgrad (ISTC project) [8]. 8 samples (16 actinides and 32 fission products) are from one assembly 3.6% from NPP Novovoronezh Unit 4 (In text Novovoronezh 2). In Fig.2 are measured pins shown. We used module ORIGEN-S and library prepared for fuel VVER-440 (by module SAS2) and the new 2D module TRITON (April 2005 release).

In Attachment 1 are dependence of actinides concentration (measured and calculated) on burnup for both experiments (Novovoronezh 1 and 2) shown. In Attachment 2 are dependence of fission products concentration (measured and calculated) on burnup for experiment Novovoronezh 2 shown. Abbreviation in figures:
E = experimental

O = ORIGEN-S calculation
T = TRITON calculation
1 = fuel pin N^o. 25 (NV1) or N^o. 65 (NV2)
2 = fuel pin N^o. 63 (NV1) or N^o. 67 and 68 (NV2)
3 = fuel pin N^o. 64 (NV1) or N^o. 69 (NV2)
4 = fuel pin N^o. 107 (NV1)

The actinides important for BUC were measured in both cases (together 20 samples), except Np237 and Am241 that were measured only in the project ISTC 2670 (8 samples). The fission products were measured only in the project ISTC 2670 (8 samples).

Pins in assembly VVER-440 have different ratio uranium/water (by central tube, at corner, by side, surrounding by fuel pins) and therefore the concentration depends on pin position. In [12] is detailed analyse of nuclide concentration in pins. In general: the fission products are independent on neutron spectrum (except Cs135 and Sm149, Sm151 depends only according calculation), the actinides slightly depends on neutron spectrum (except strong - Pu239, Am242m and Cm242 or independent U236, Pu242, Am243, Cm245 and Cm246)

According to Attachment 1 and 2 is possible to mean that probably incorrect values are:

- old measurement Novovoronezh 1
  pin N^o.63, sample 21, nuclides U238, Am243, Cm242

- ISTC 2670 (Novovoronezh 2)
  pin N^o.69, sample 79, nuclides U235, Pu241, Am241,Am243, Cm244, Cm245
  pin No.68, sample 162, Am242m
  all samples for Cs134

PROPOSAL FOR NEW SAMPLES

The proposal for a new measurement with 12 samples is: **The samples from 3 pins and 4 samples for each pin for minimal up to maximal burnup**. Positions of pins should be 65, 67 and 69 (see. Fig.2). The typical pin burnup profile is on Fig.3 shown. The proposed positions are marked.

CONCLUSION

The existing measurement of nuclide composition of VVER-440 fuel is possible to use by verification of codes for nuclide composition only for actinides important for BUC. Some nuclide concentration in sample 79 (pin N^o.69, ISTC 2670) may be with high measurement error. The fission products were measured only in the project ISTC 2670, only 8 samples is not enough for verification. The published results for Cs134 are probably incorrect.

The new measurement (12 samples) should be in 4 points in one pin. In this way is possible to check the dependence of nuclide concentration on burnup with respect to different spectrum in the VVER-440 assembly.

REFERENCE

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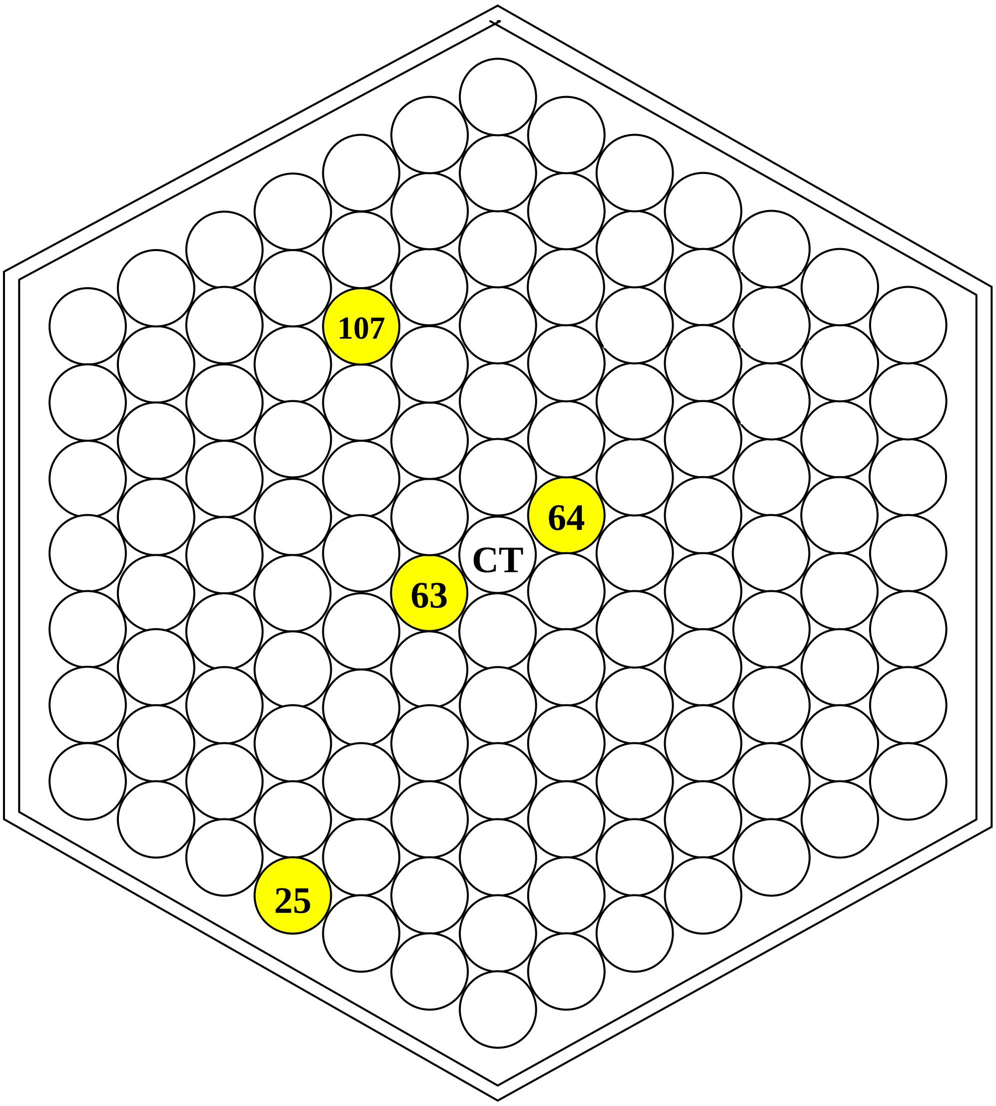


Fig.1 Measured pins in experiment Novovoronezh 1 (CT = central tube)

pin N° 25 - 5 samples
pin N° 63 - 3 samples
pin N° 64 - 3 samples
pin N° 107 - 1 sample
total - 12 samples

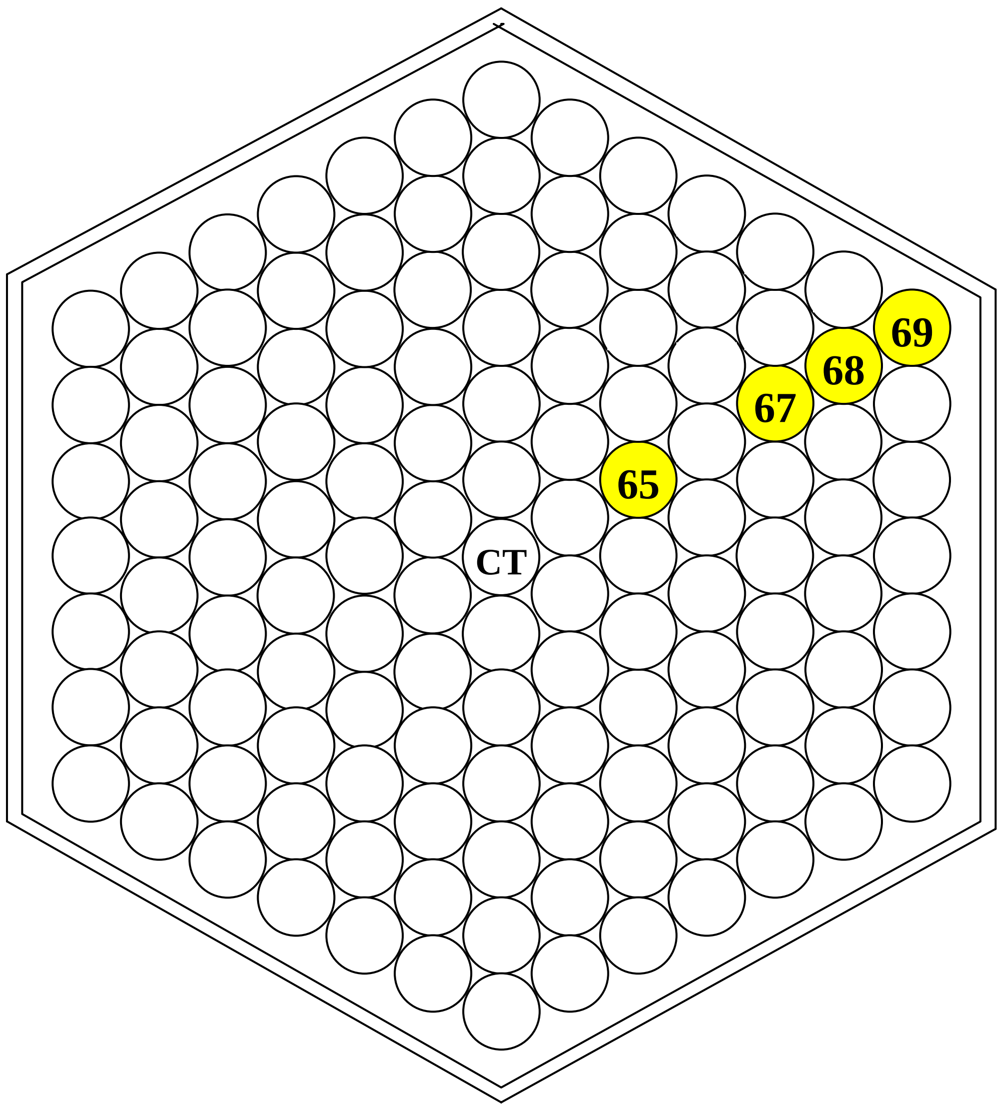
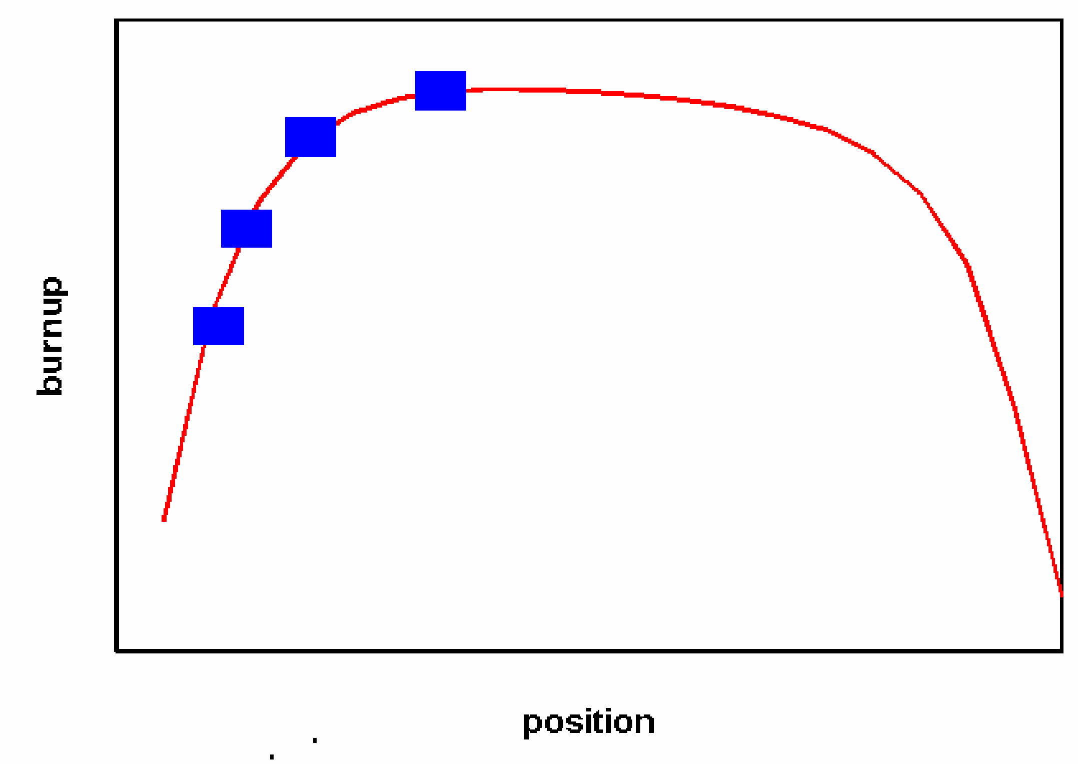


Fig.2 Measured pins in experiment Novovoronezh 2 (CT = central tube)

pin N° 65 - 3 samples
pin N° 67 - 1 sample
pin N° 68 - 1 sample
pin N° 69 - 3 samples
total - 8 samples

Fig.3 Typical pin burnup profile and proposed position for samples



Attachment 1

Dependence of actinides concentration on burnup

Fig.1a Dependence of U235 on burnup, experiment Novovoronezh 1

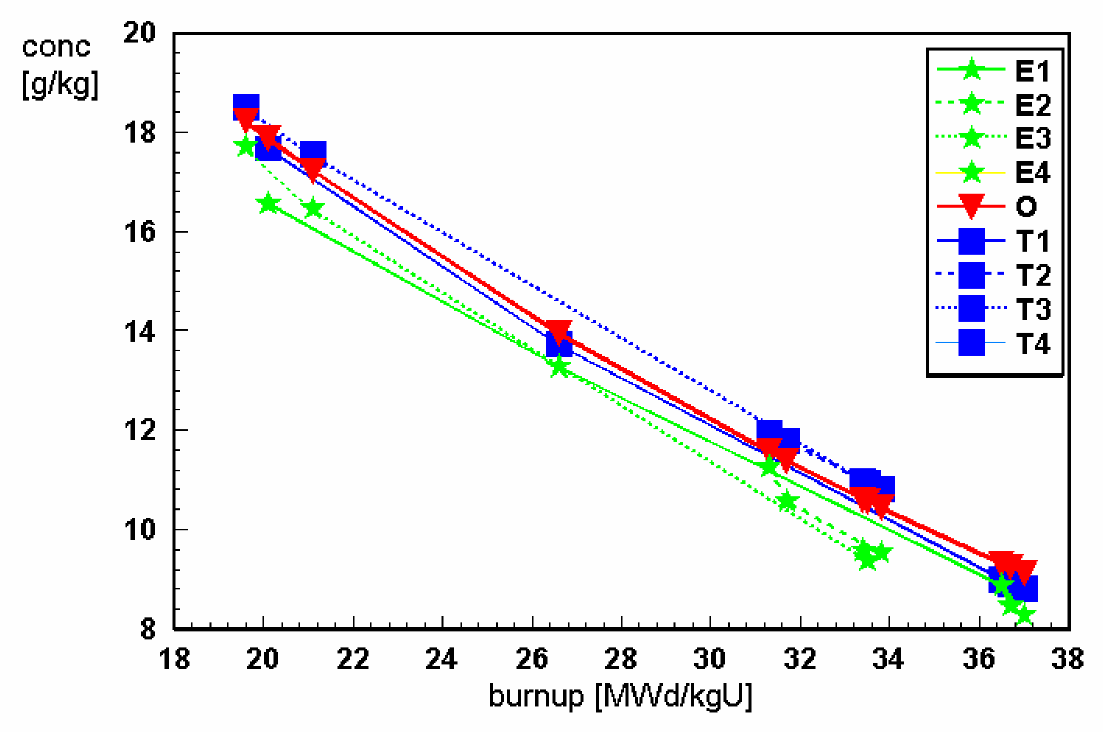


Fig.1b Dependence of U235 on burnup, experiment Novovoronezh 2

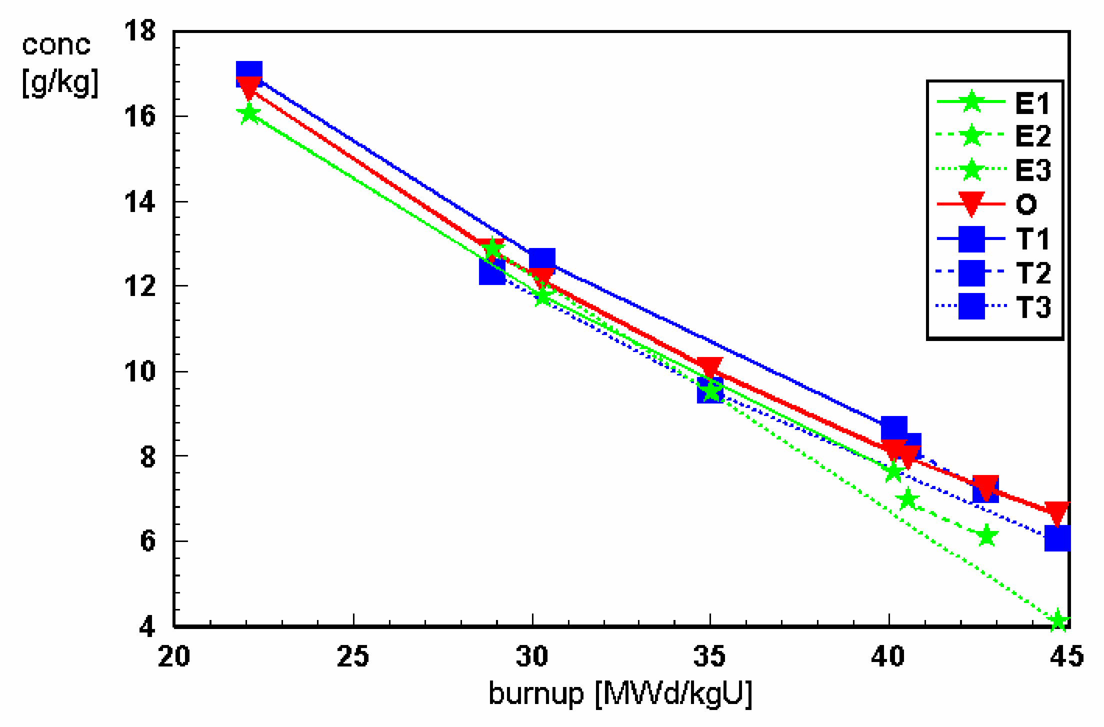


Fig.2a Dependence of U236 on burnup, experiment Novovoronezh 1

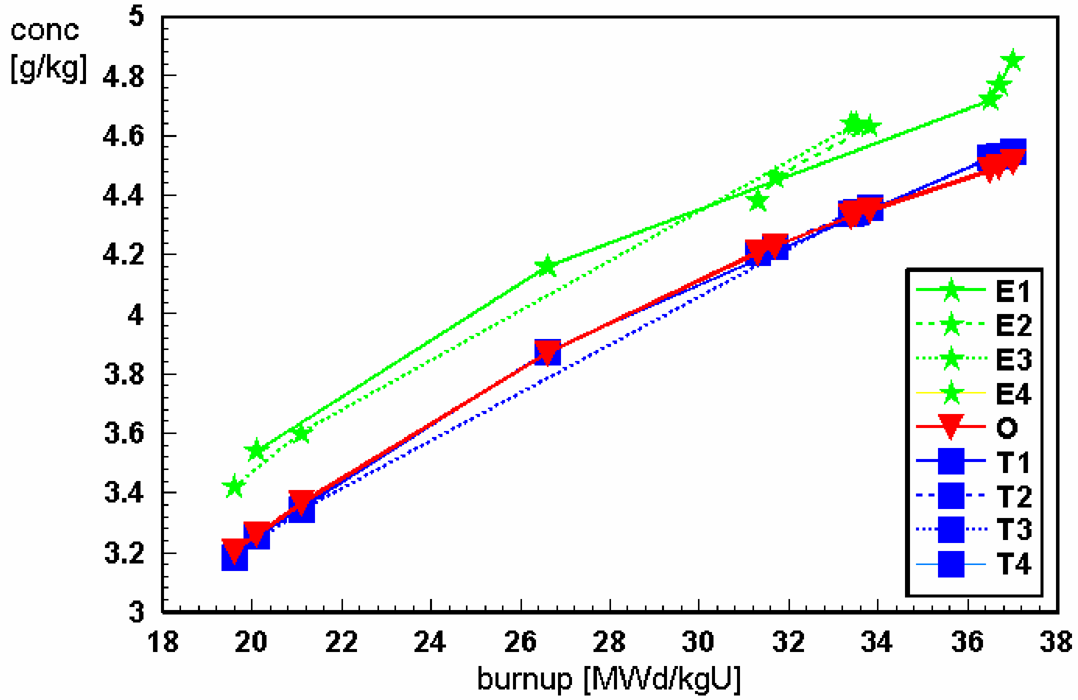


Fig.2b Dependence of U236 on burnup, experiment Novovoronezh 2

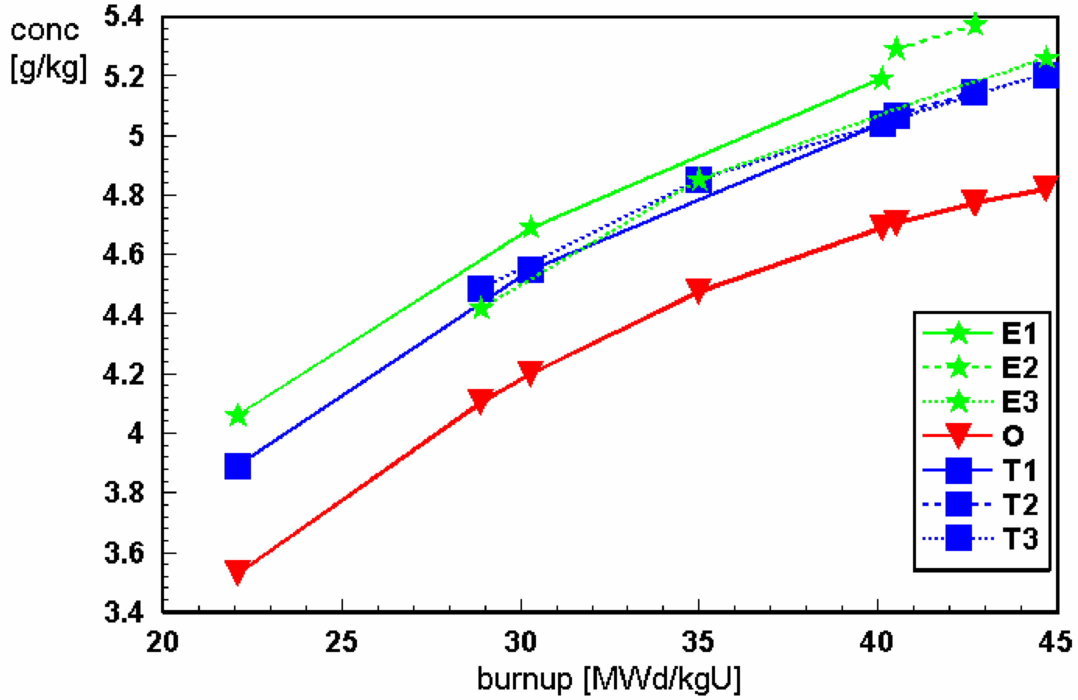


Fig.3a Dependence of U238 on burnup, experiment Novovoronezh 1

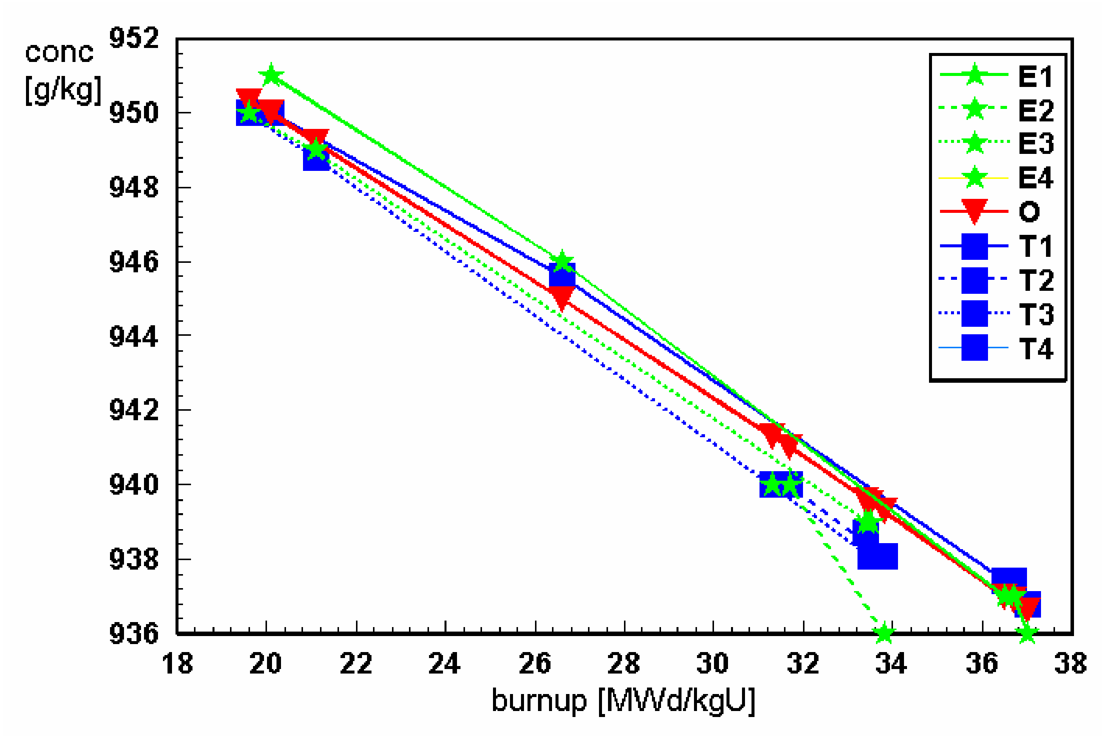


Fig.3b Dependence of U238 on burnup, experiment Novovoronezh 2

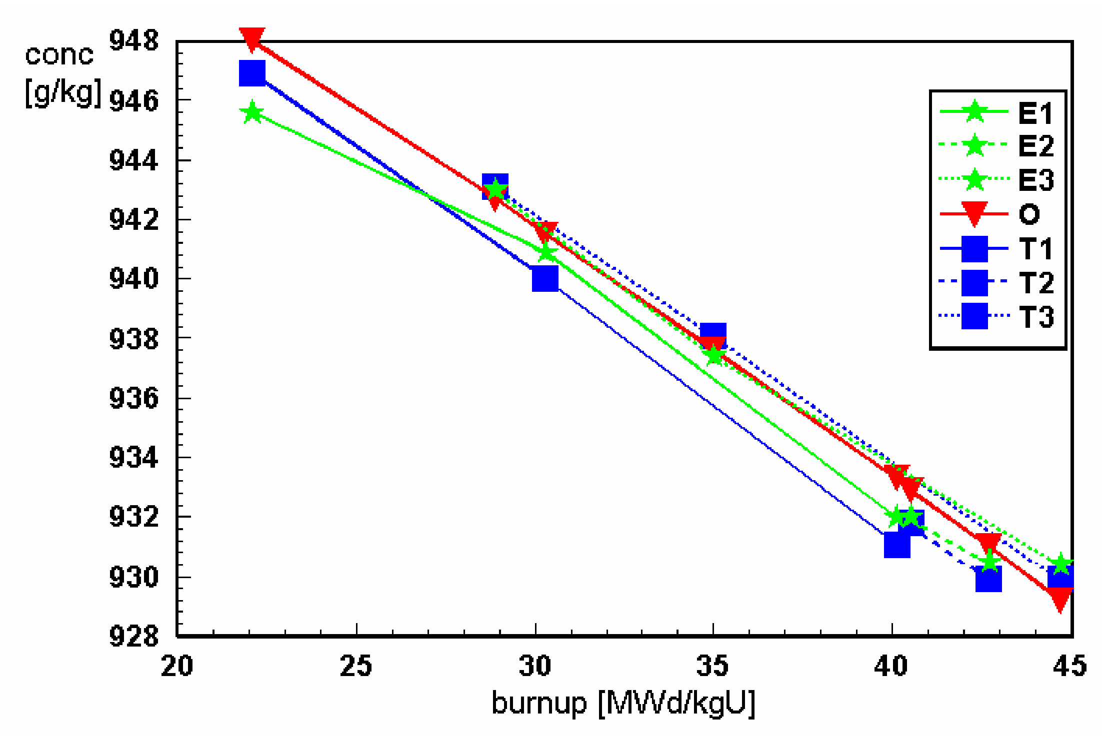


Fig.4a Dependence of Pu238 on burnup, experiment Novovoronezh 1

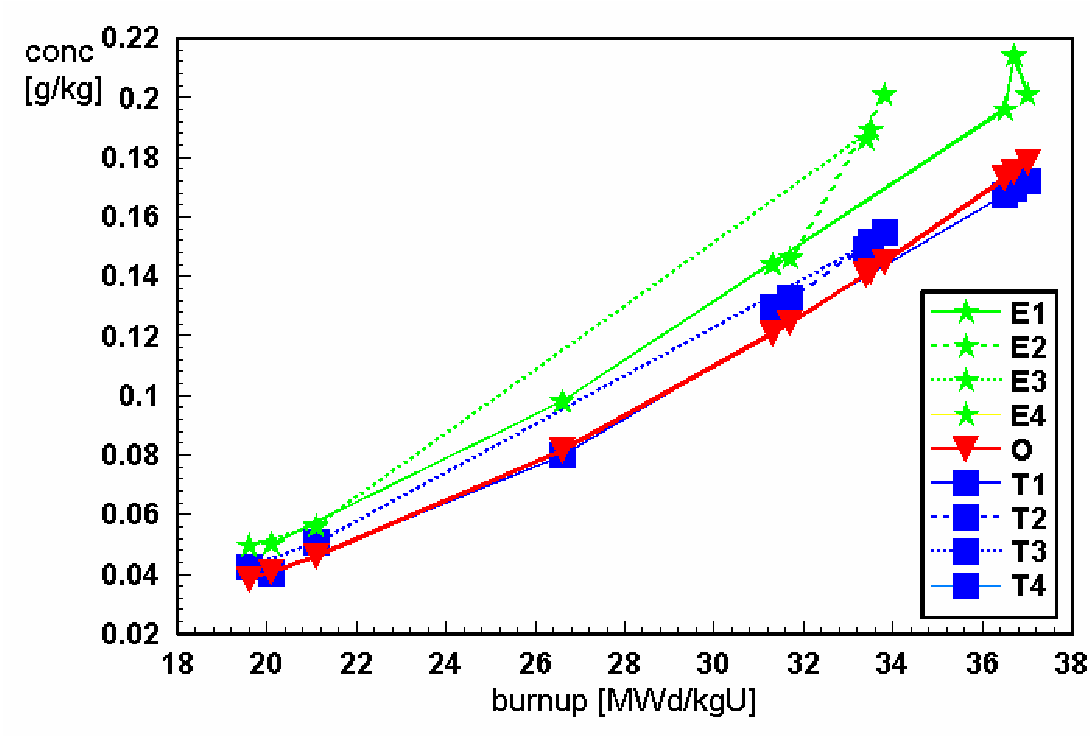


Fig.4b Dependence of Pu238 on burnup, experiment Novovoronezh 2

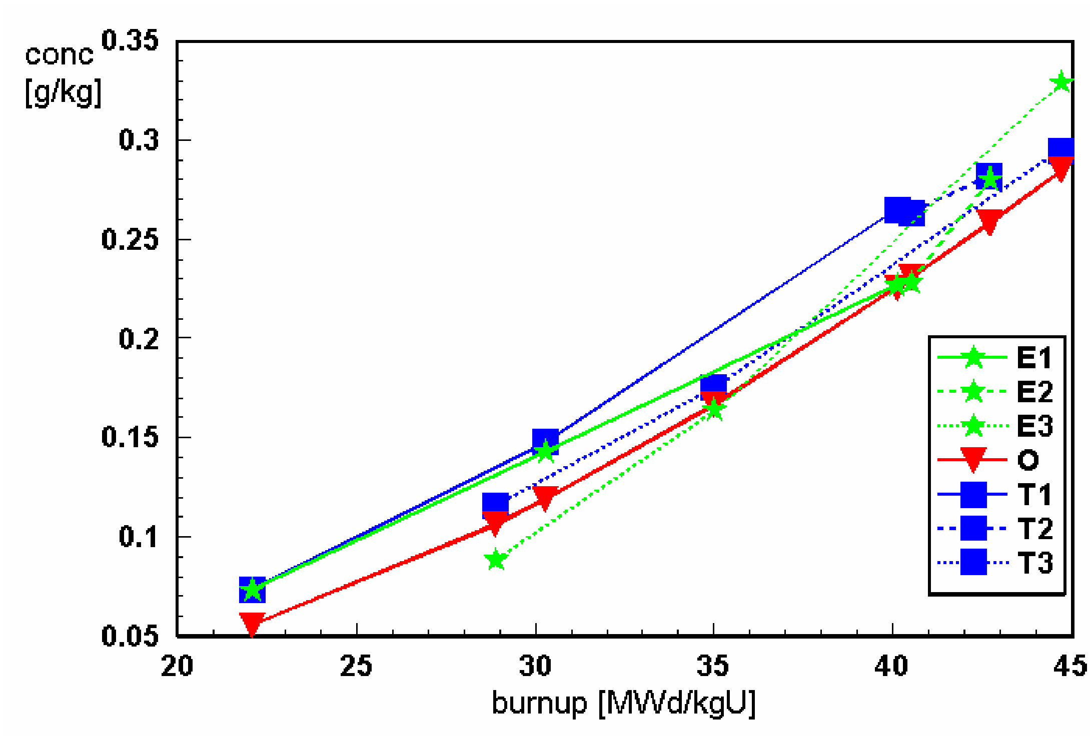


Fig.5a Dependence of Pu239 on burnup, experiment Novovoronezh 1

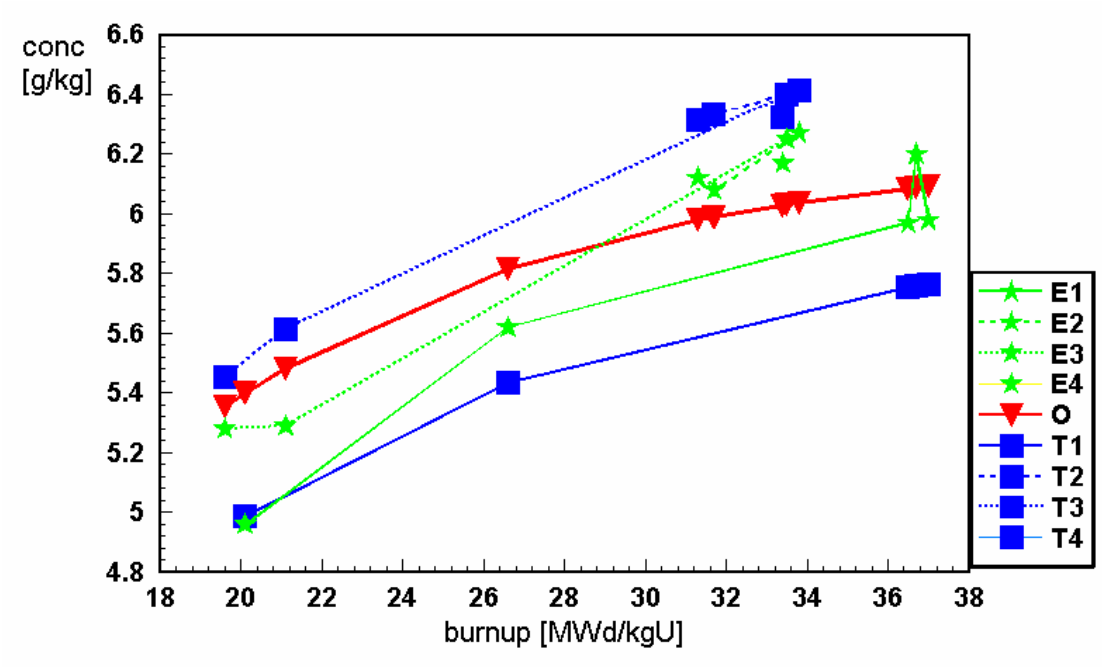


Fig.5b Dependence of Pu239 on burnup, experiment Novovoronezh 2

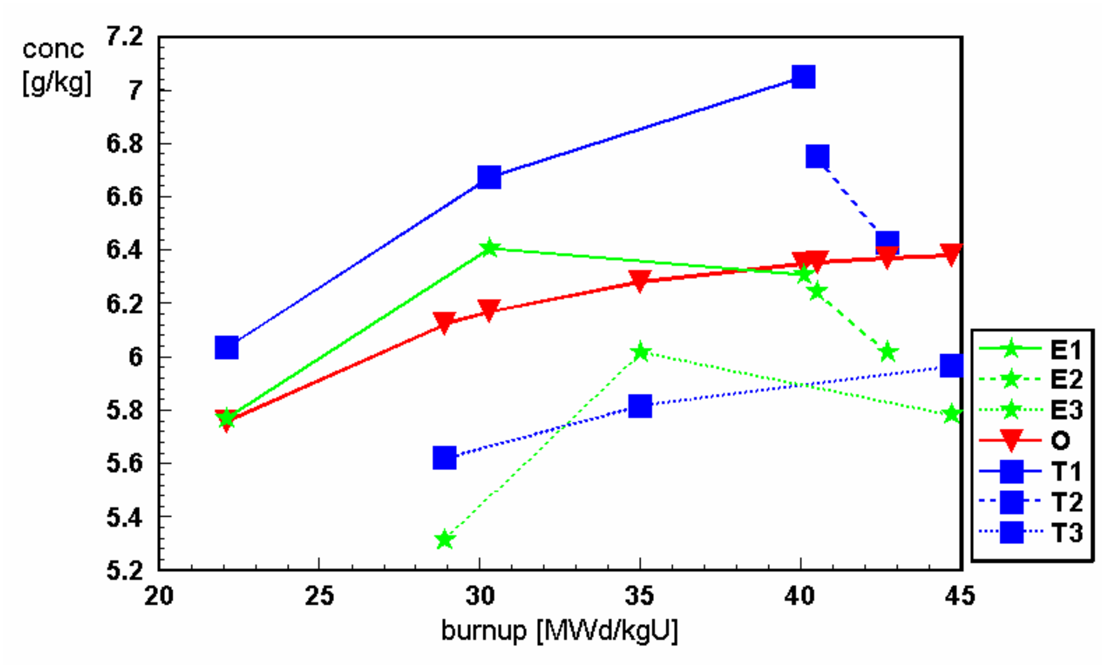


Fig.6a Dependence of Pu240 on burnup, experiment Novovoronezh 1

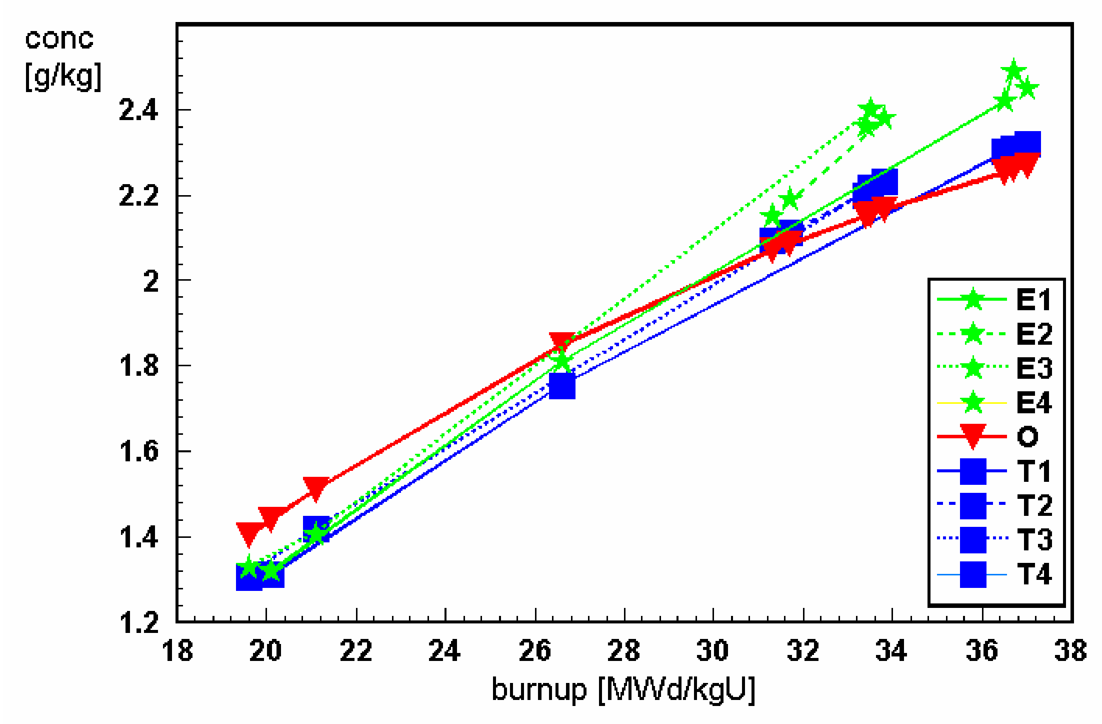


Fig.6b Dependence of Pu240 on burnup, experiment Novovoronezh 2

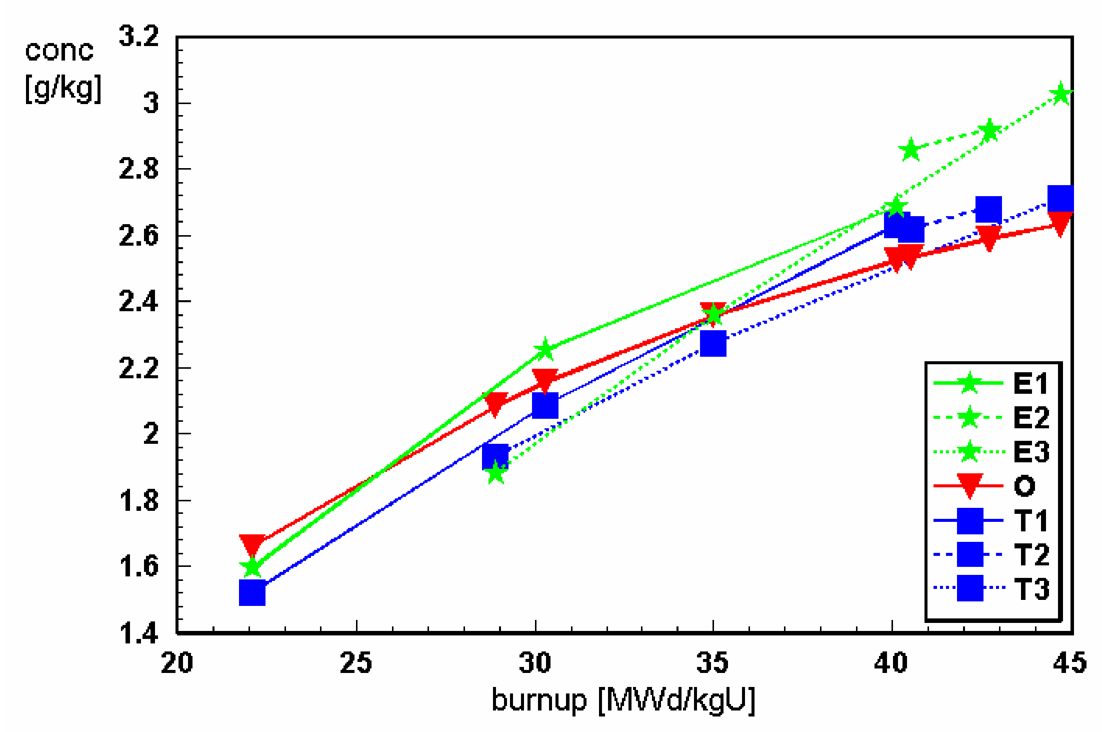


Fig.7a Dependence of Pu241 on burnup, experiment Novovoronezh 1

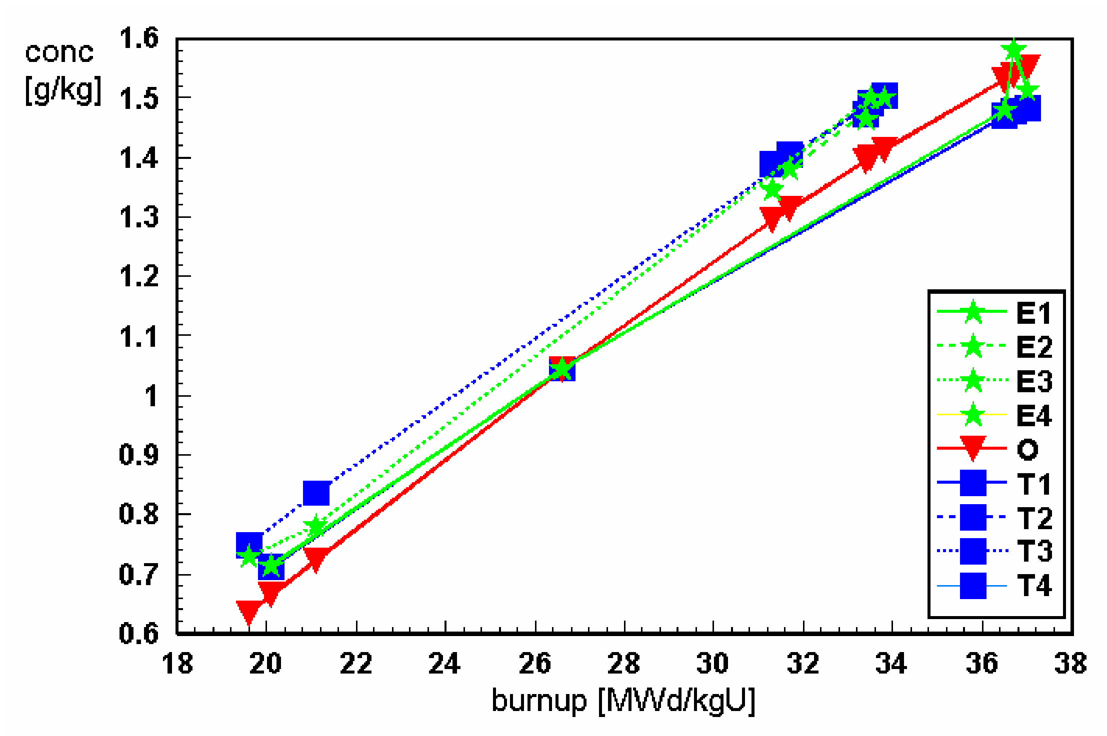


Fig.7b Dependence of Pu241 on burnup, experiment Novovoronezh 2

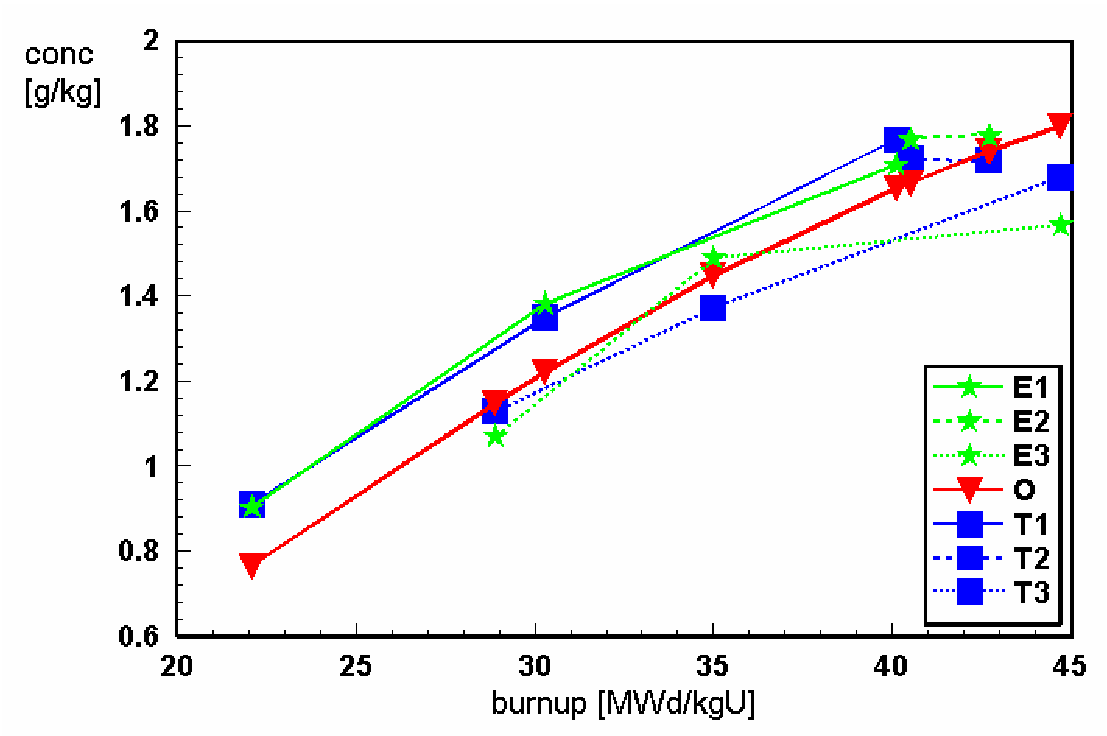


Fig.8a Dependence of Pu242 on burnup, experiment Novovoronezh 1

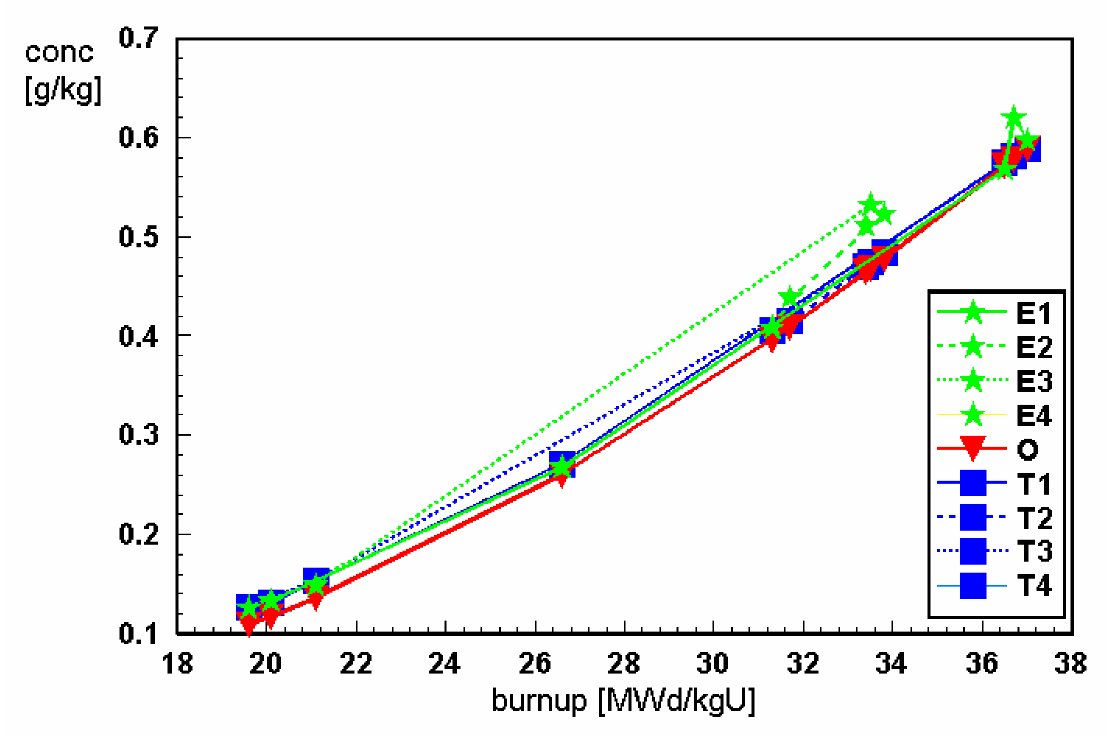


Fig.8b Dependence of Pu242 on burnup, experiment Novovoronezh 2

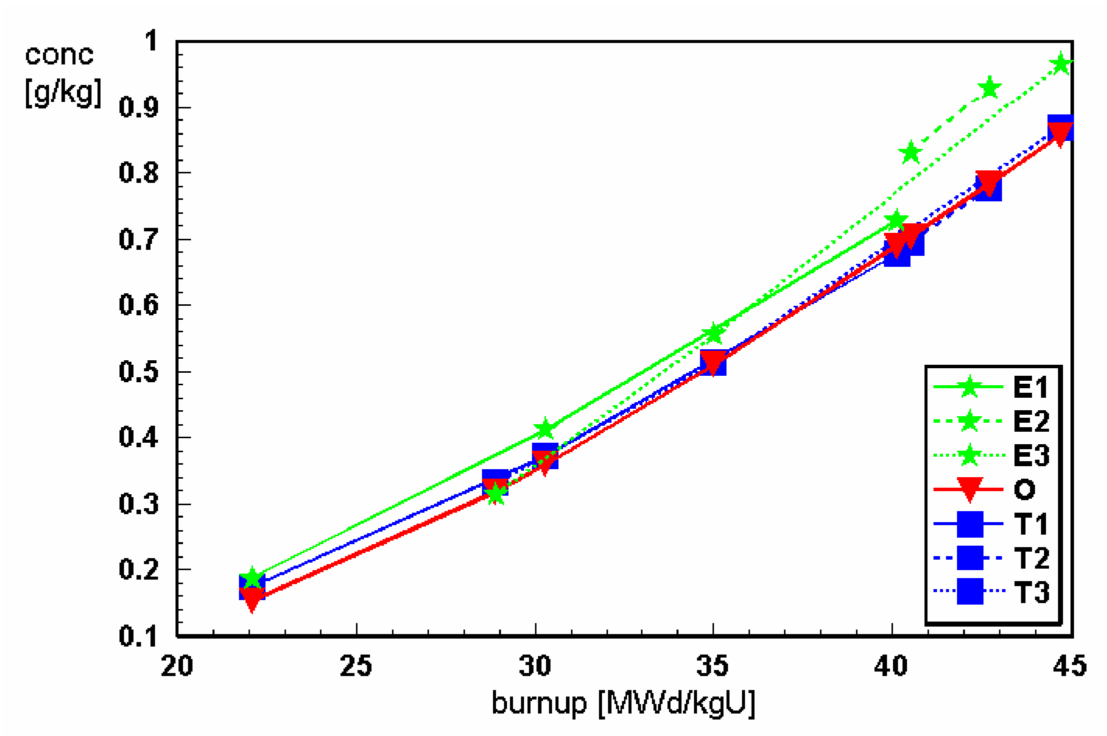


Fig.9b Dependence of Np237 on burnup, experiment Novovoronezh 2

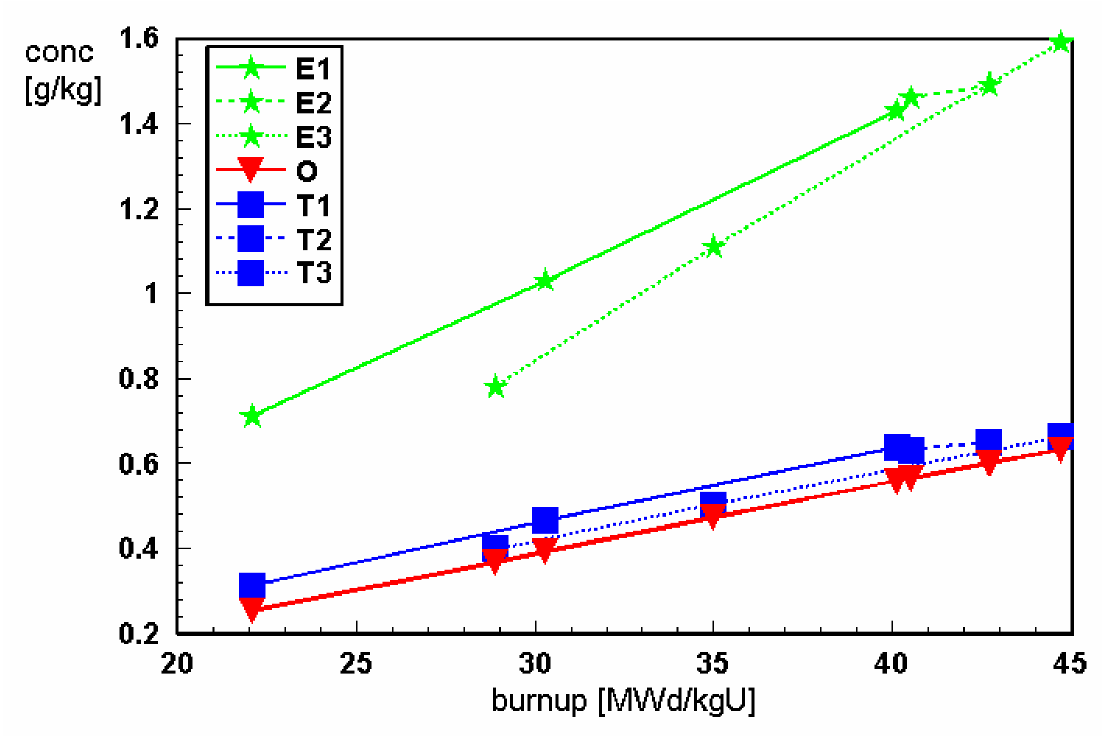


Fig.10b Dependence of Am241 on burnup, experiment Novovoronezh 2

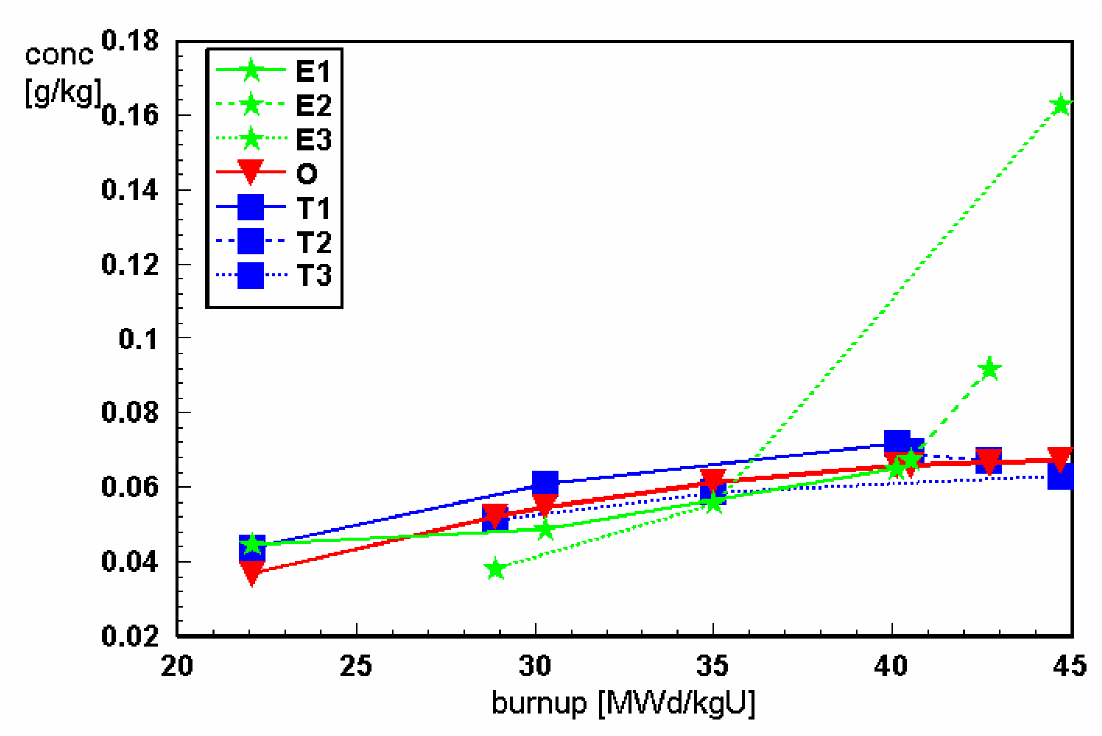


Fig.11b Dependence of Am242m on burnup, experiment Novovoronezh 2

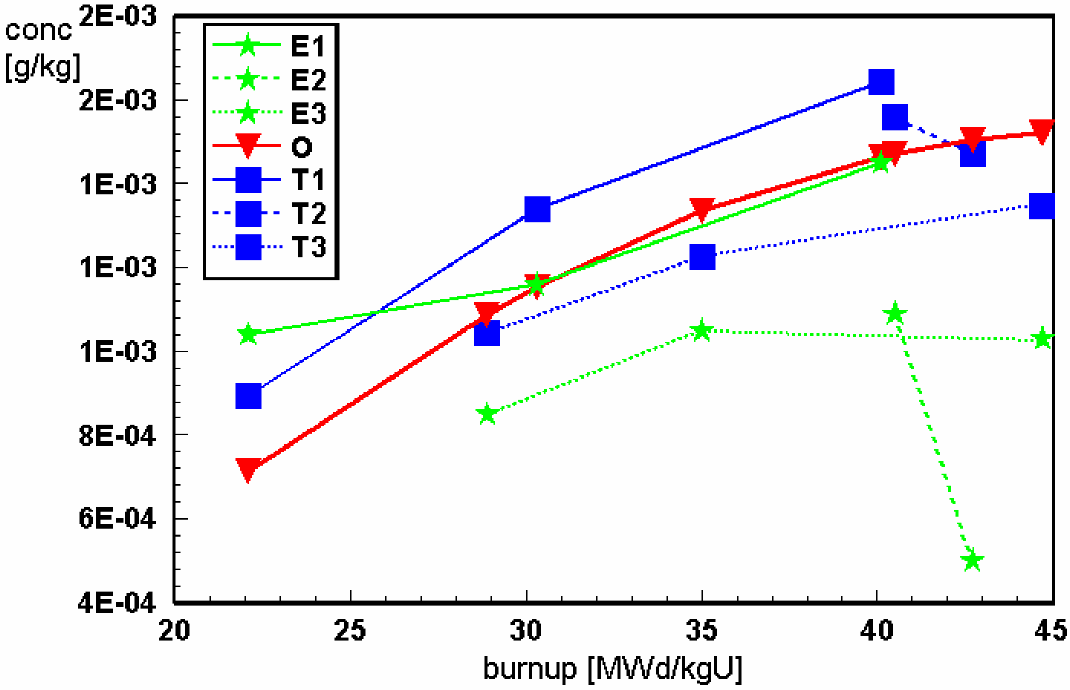


Fig.13a Dependence of Cm242 on burnup, experiment Novovoronezh 1

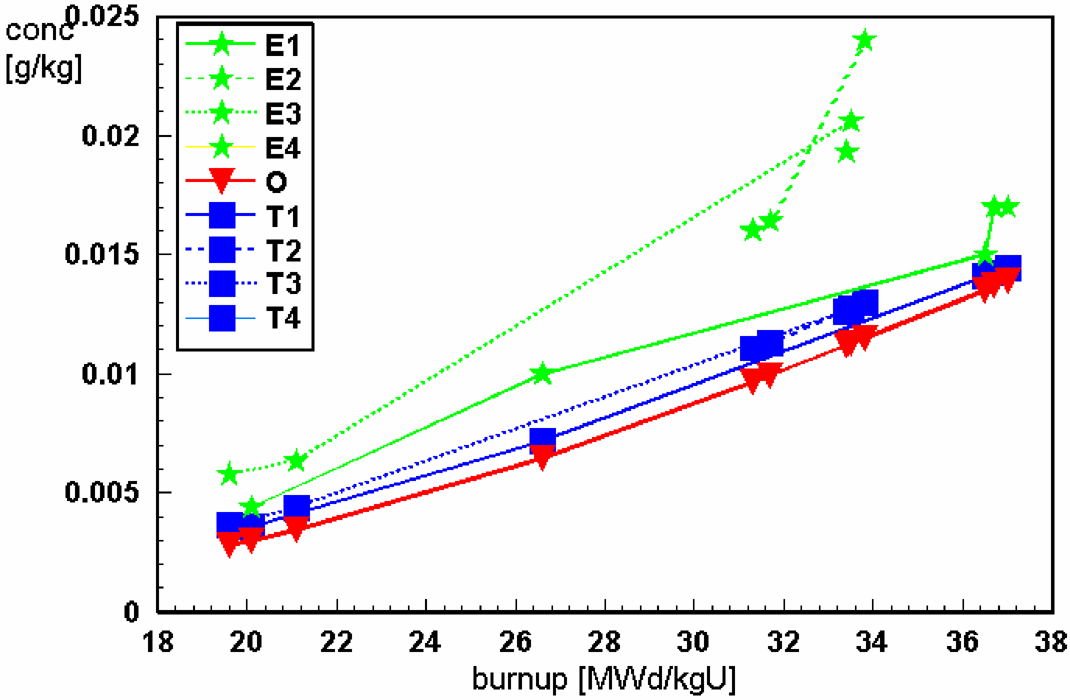


Fig.12a Dependence of Am243 on burnup, experiment Novovoronezh 1

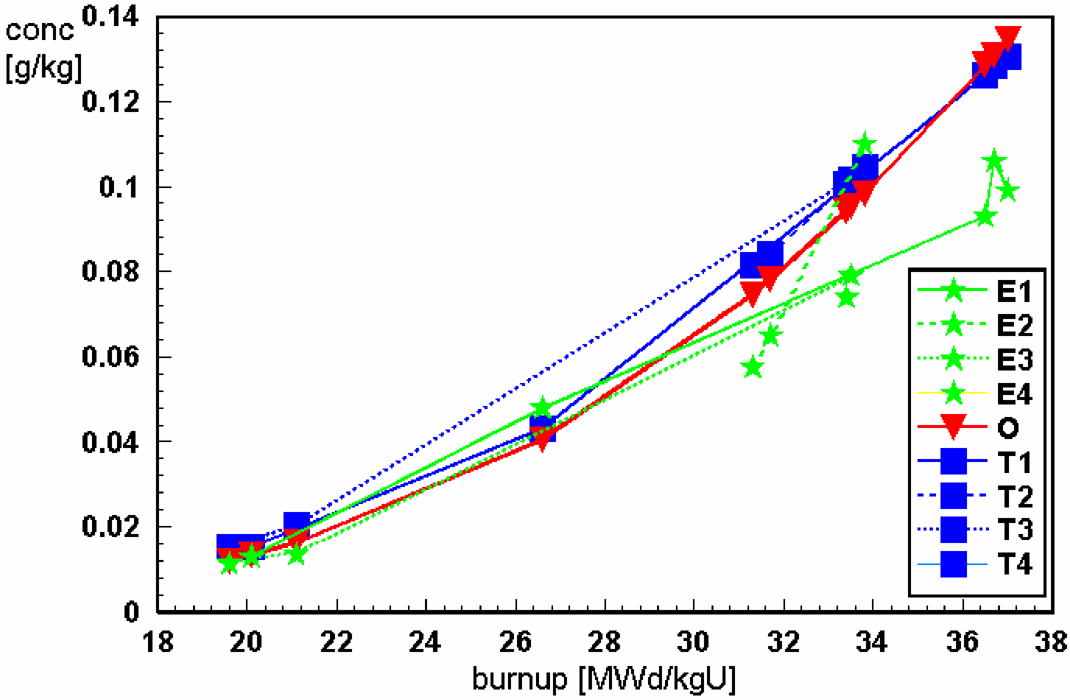


Fig.12b Dependence of Am243 on burnup, experiment Novovoronezh 2

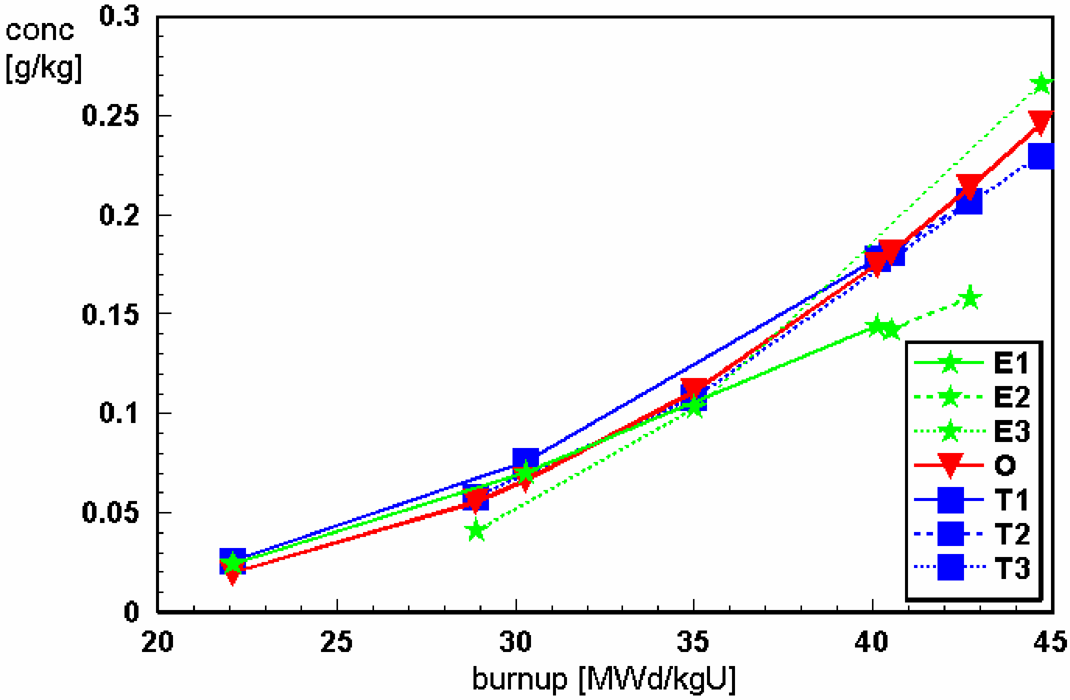


Fig.14a Dependence of Cm244 on burnup, experiment Novovoronezh 1

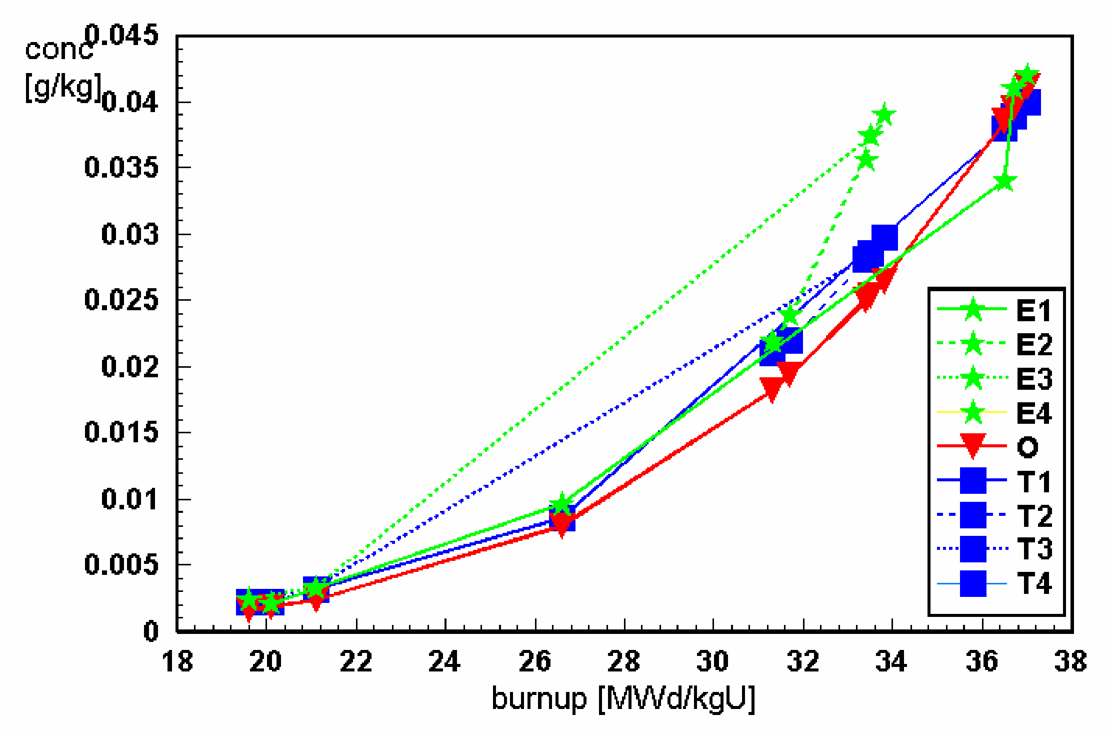


Fig.14b Dependence of Cm244 on burnup, experiment Novovoronezh 2

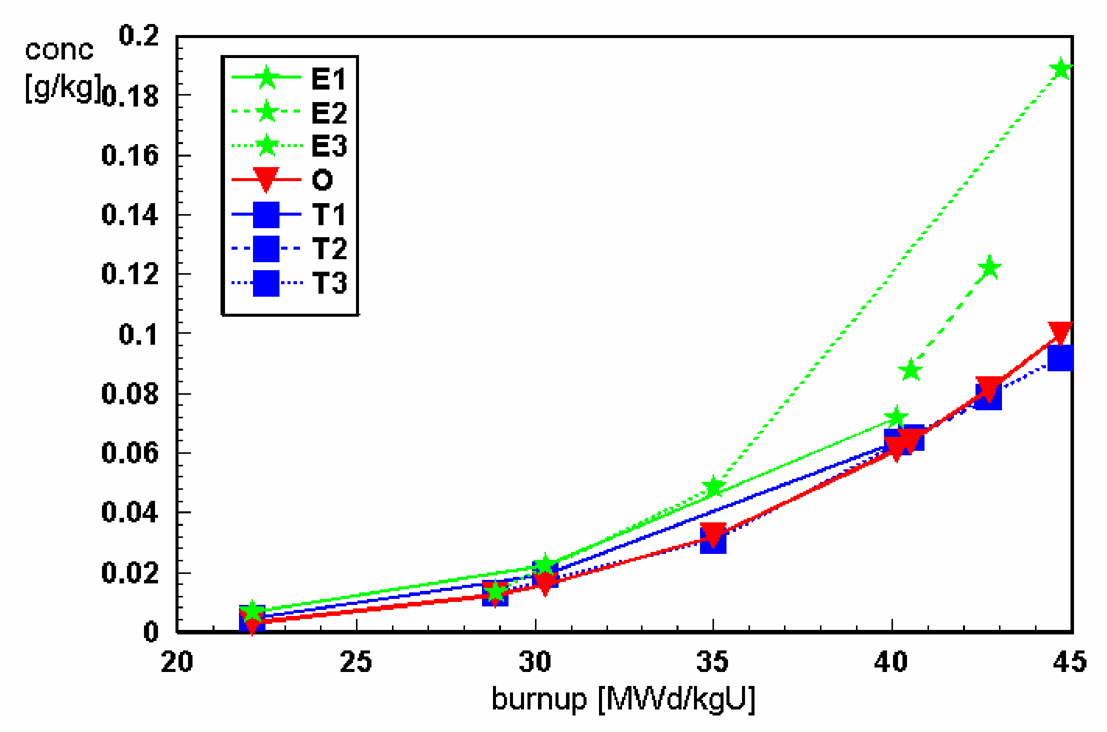


Fig.15b Dependence of Cm245 on burnup, experiment Novovoronezh 2

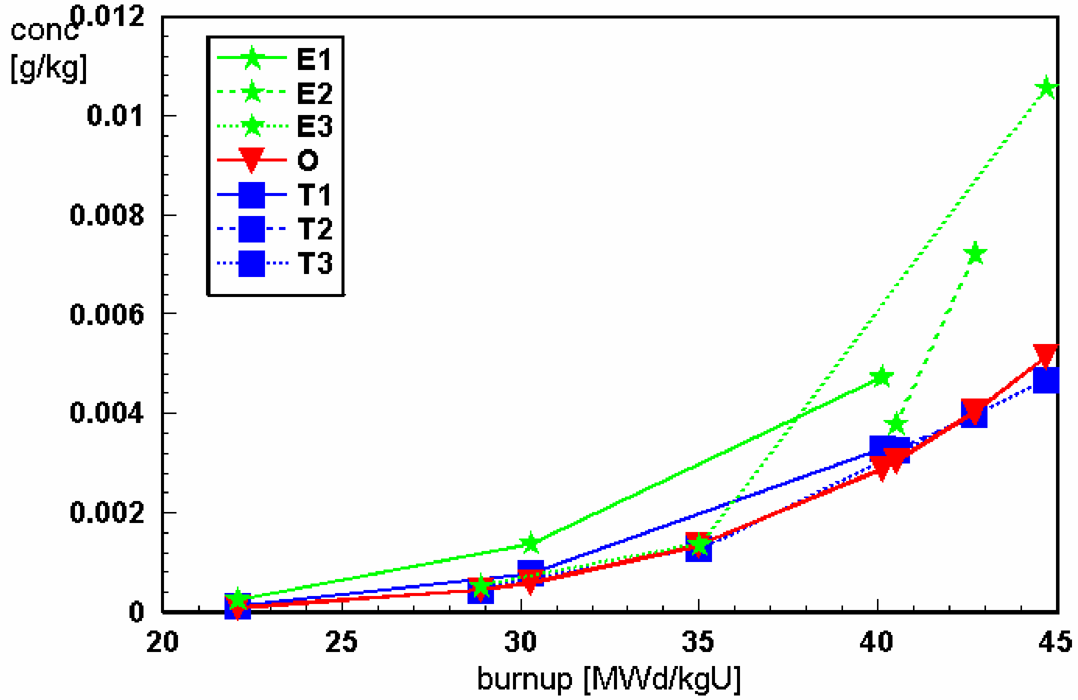
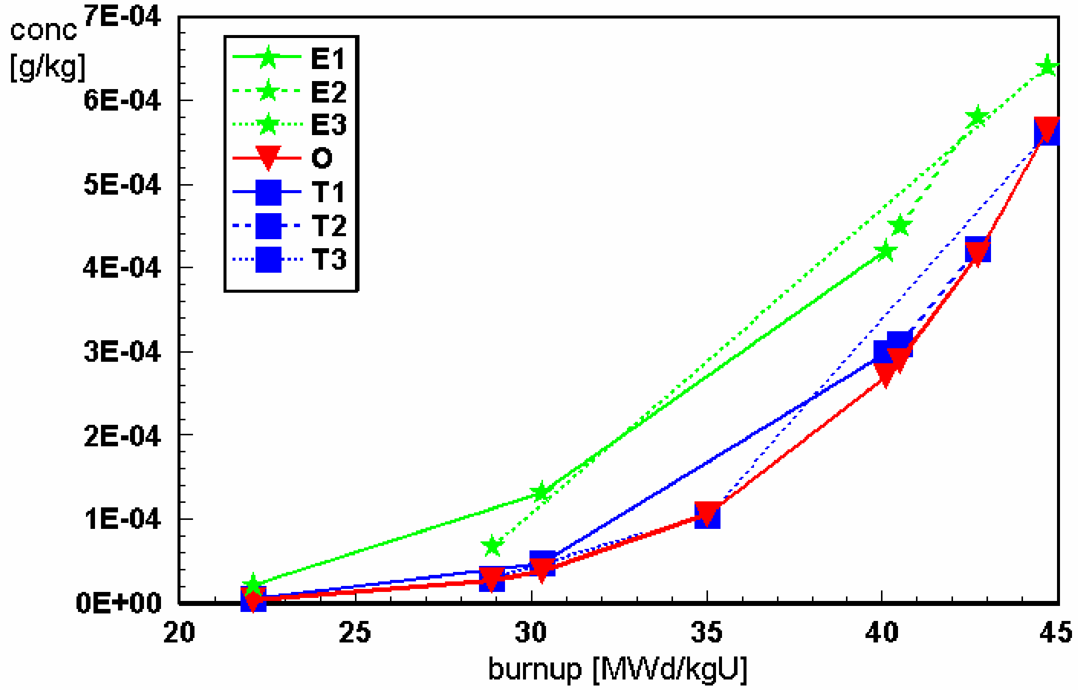


Fig.16b Dependence of Cm246 on burnup, experiment Novovoronezh 2



Attachment 2

Dependence of fission products concentration on burnup

Fig.1 Dependence of Nd142 on burnup, experiment Novovoronezh 2

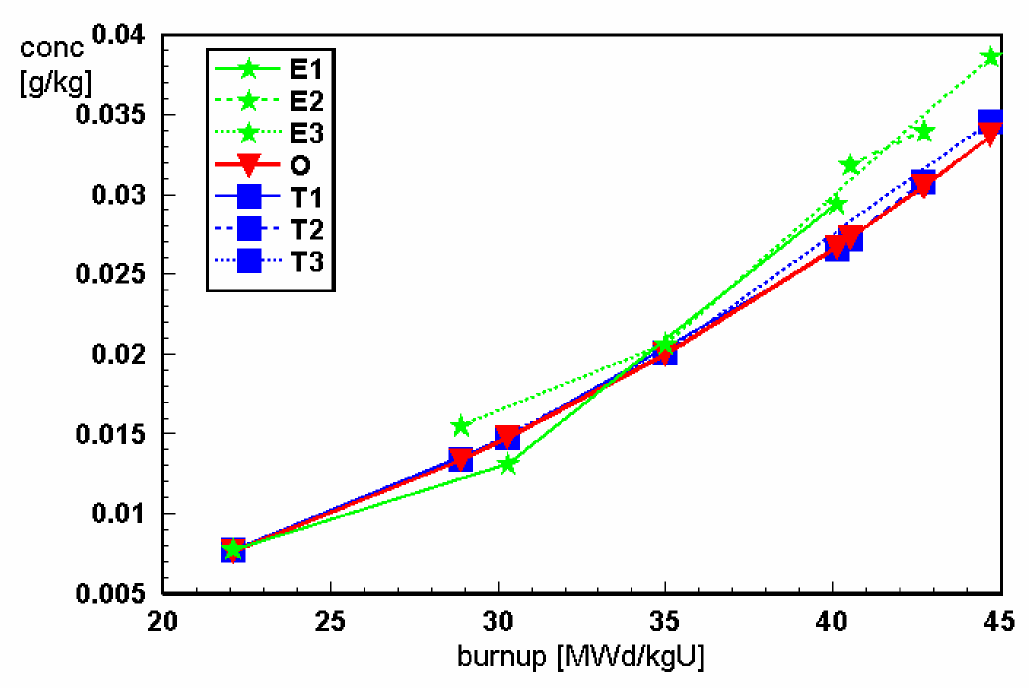


Fig.2 Dependence of Nd143 on burnup, experiment Novovoronezh 2

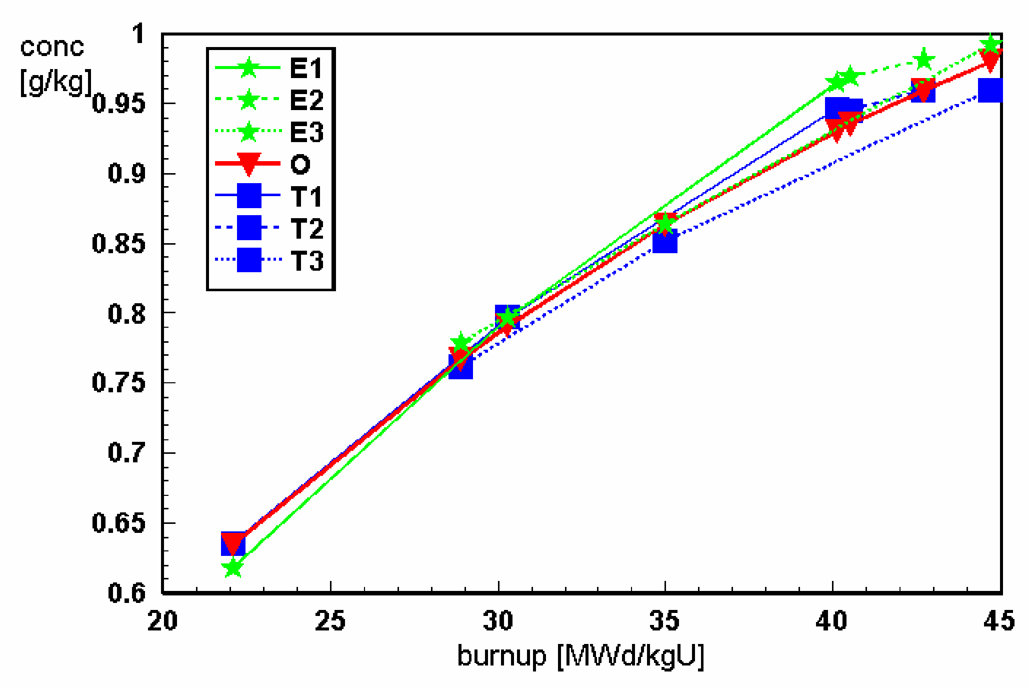


Fig.3 Dependence of Nd144 on burnup, experiment Novovoronezh 2

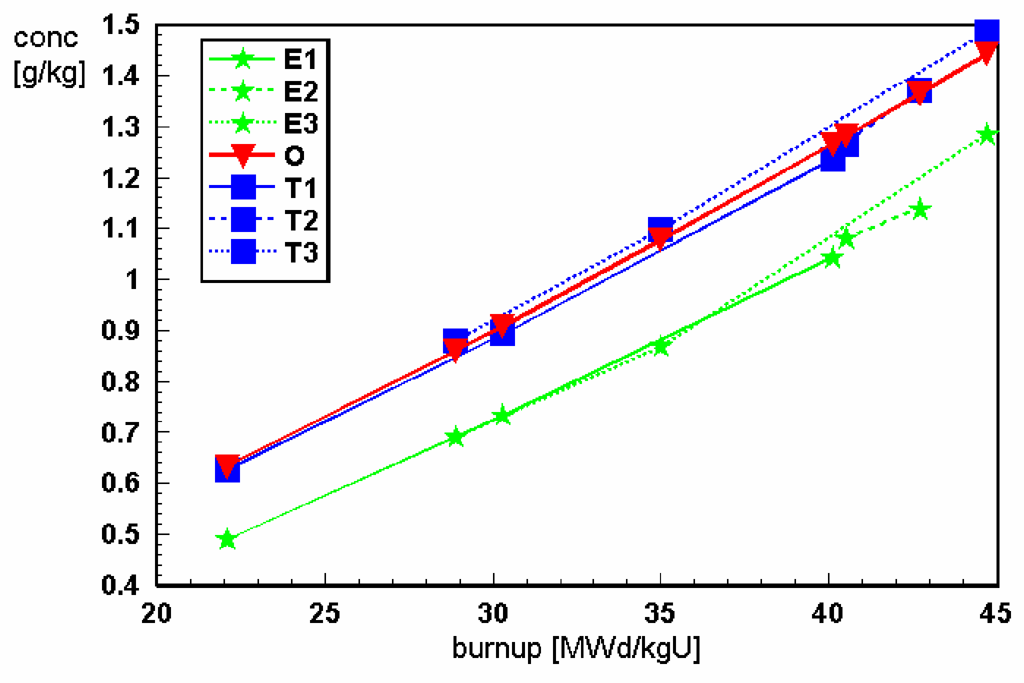


Fig.4 Dependence of Nd145 on burnup, experiment Novovoronezh 2

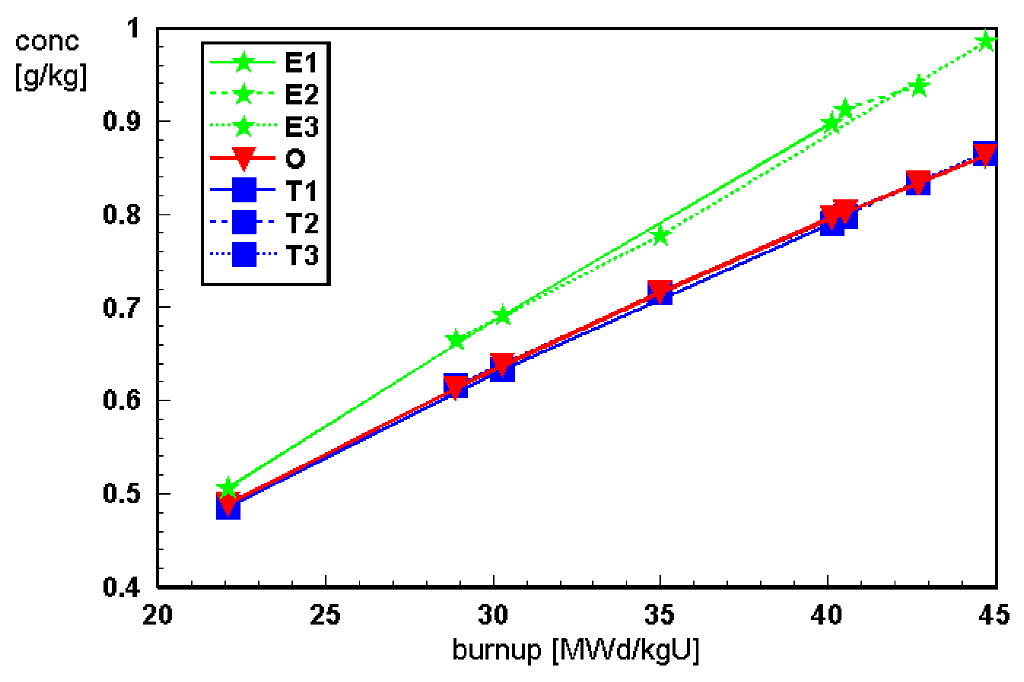


Fig.5 Dependence of Nd146 on burnup, experiment Novovoronezh 2

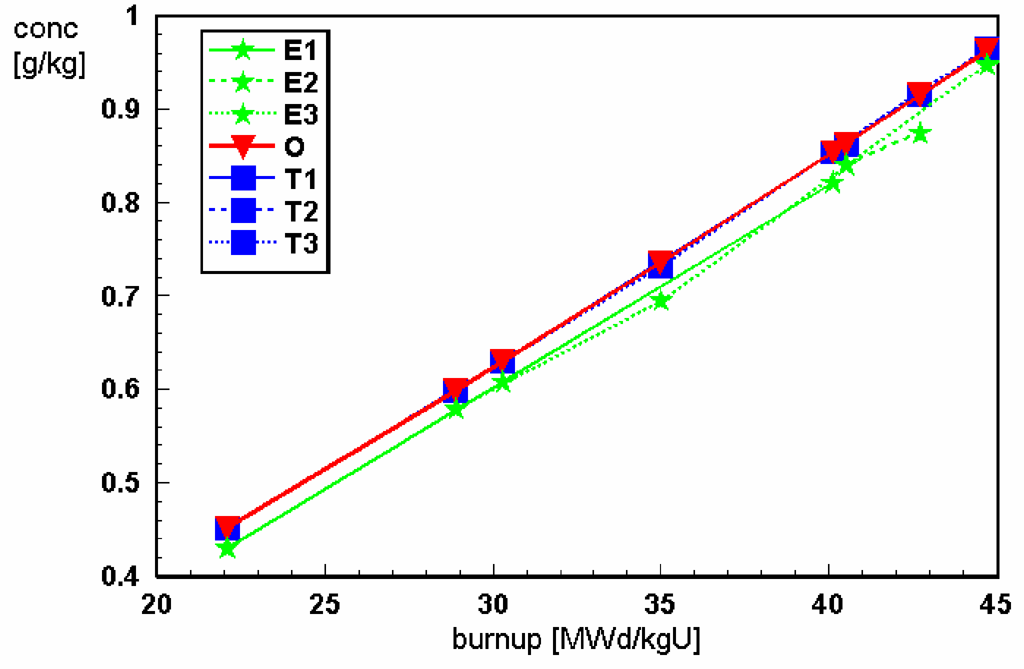


Fig.6 Dependence of Nd148 on burnup, experiment Novovoronezh 2

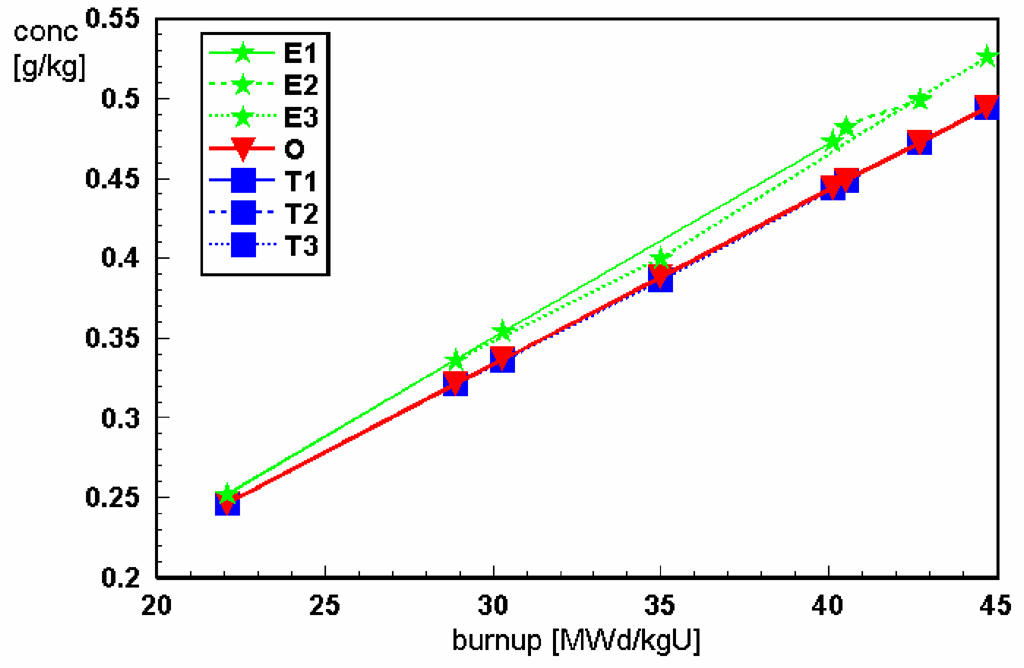


Fig.7 Dependence of Nd150 on burnup, experiment Novovoronezh 2

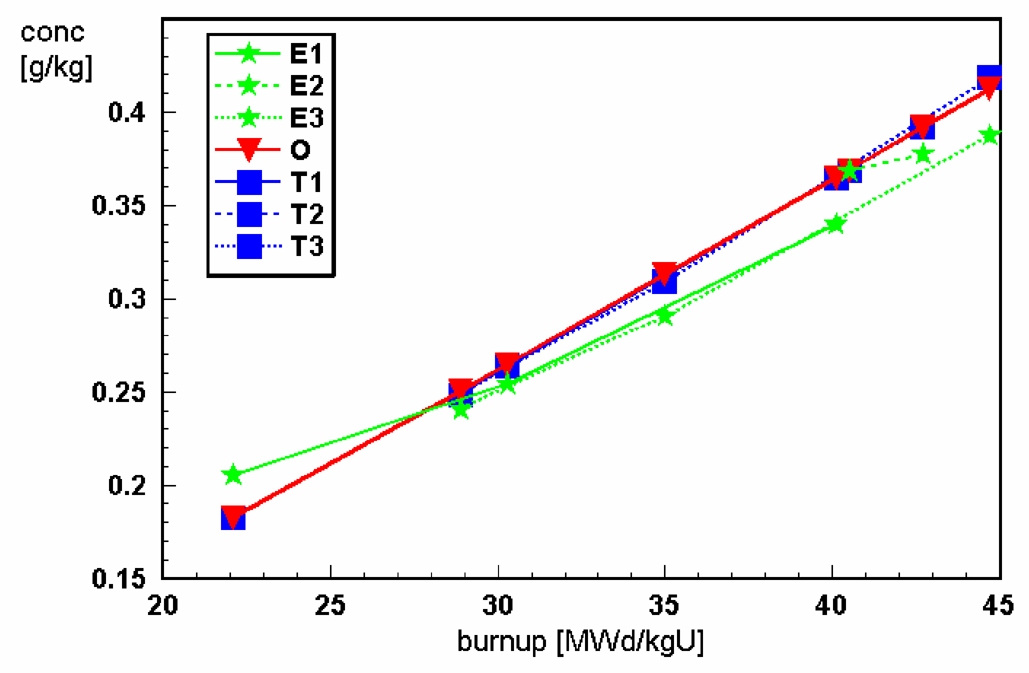


Fig.8 Dependence of Cs133 on burnup, experiment Novovoronezh 2

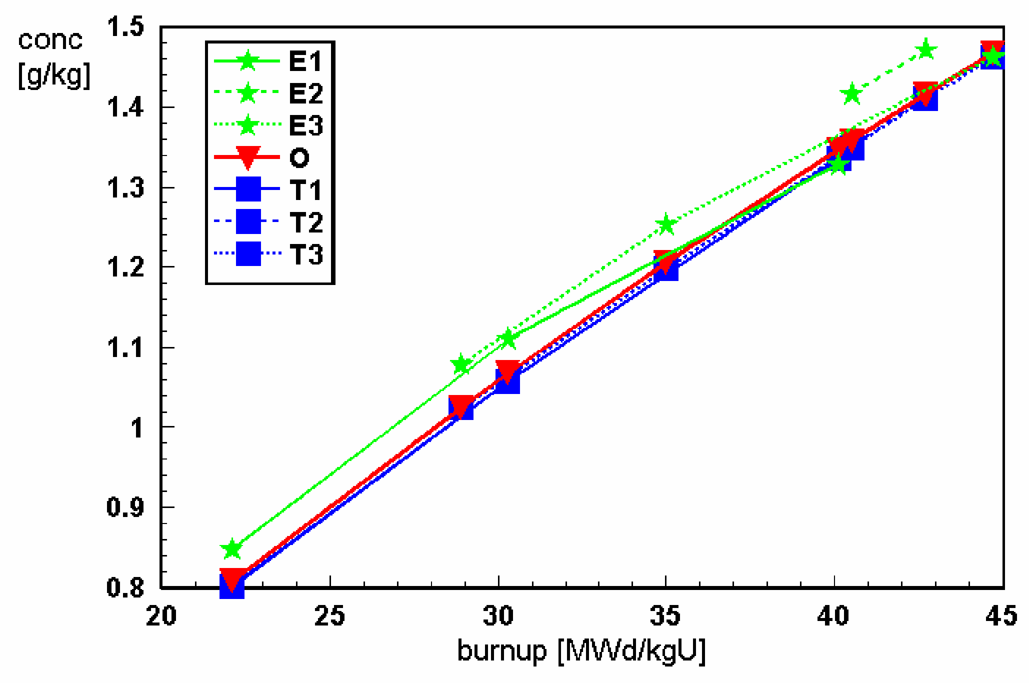


Fig.9 Dependence of Cs134 on burnup, experiment Novovoronezh 2

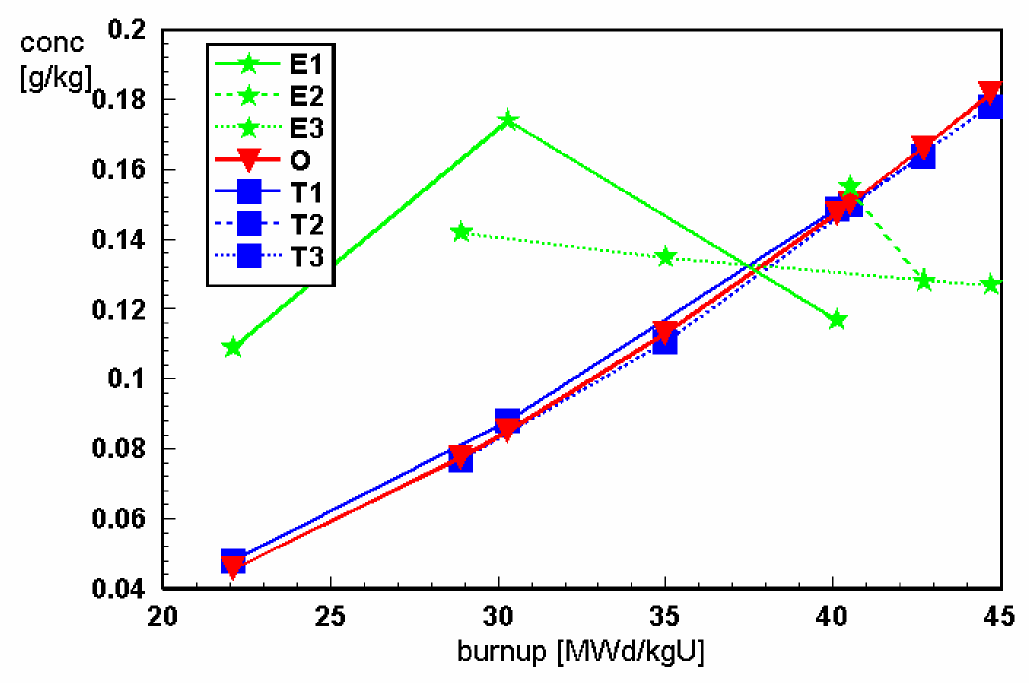


Fig.10 Dependence of Cs135 on burnup, experiment Novovoronezh 2

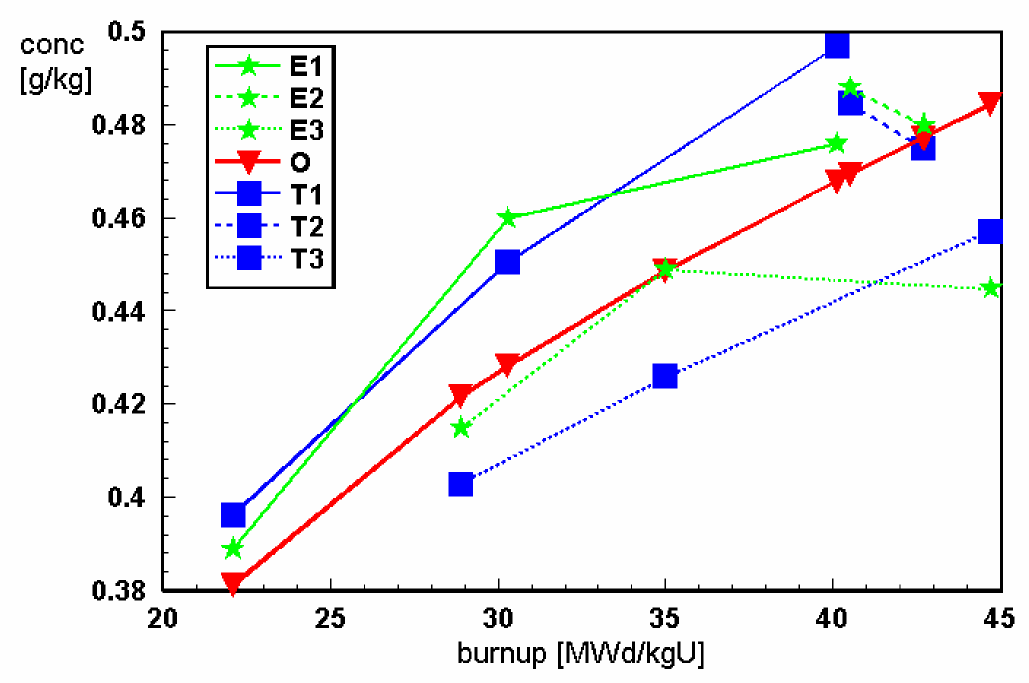


Fig.11 Dependence of Cs137 on burnup, experiment Novovoronezh 2

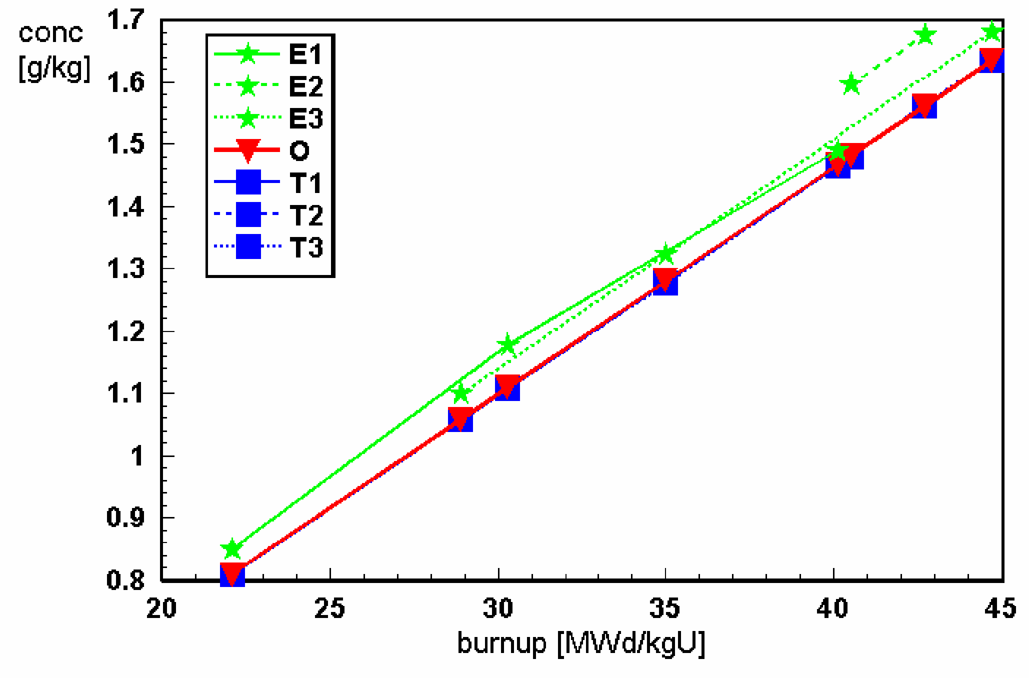


Fig.12 Dependence of Ce140 on burnup, experiment Novovoronezh 2

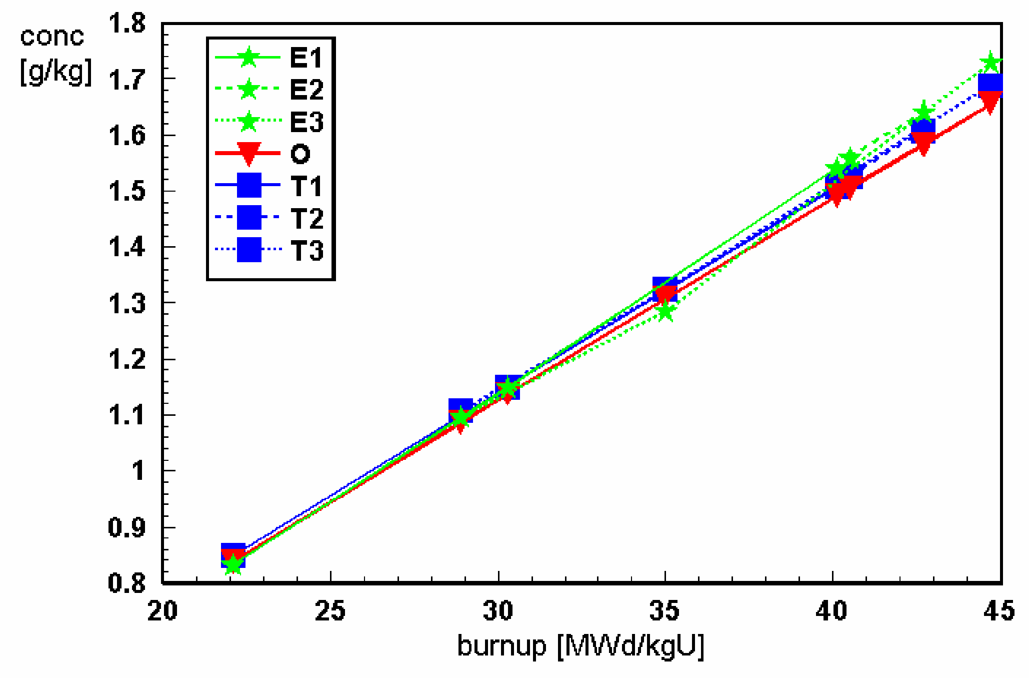


Fig.13 Dependence of Ce142 on burnup, experiment Novovoronezh 2

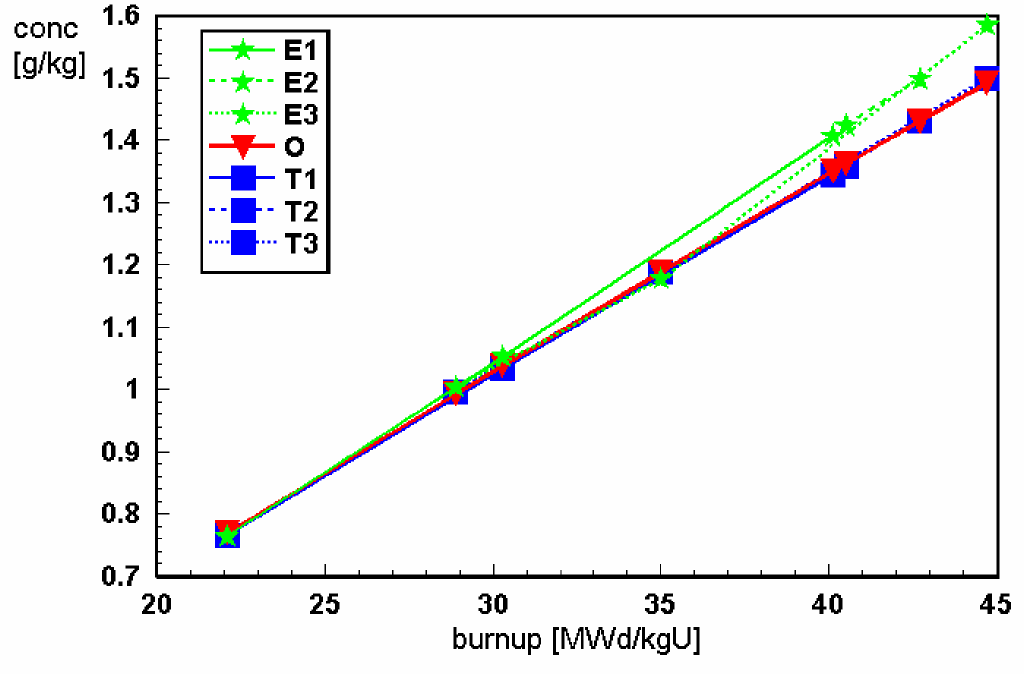


Fig.14 Dependence of Ce144 on burnup, experiment Novovoronezh 2

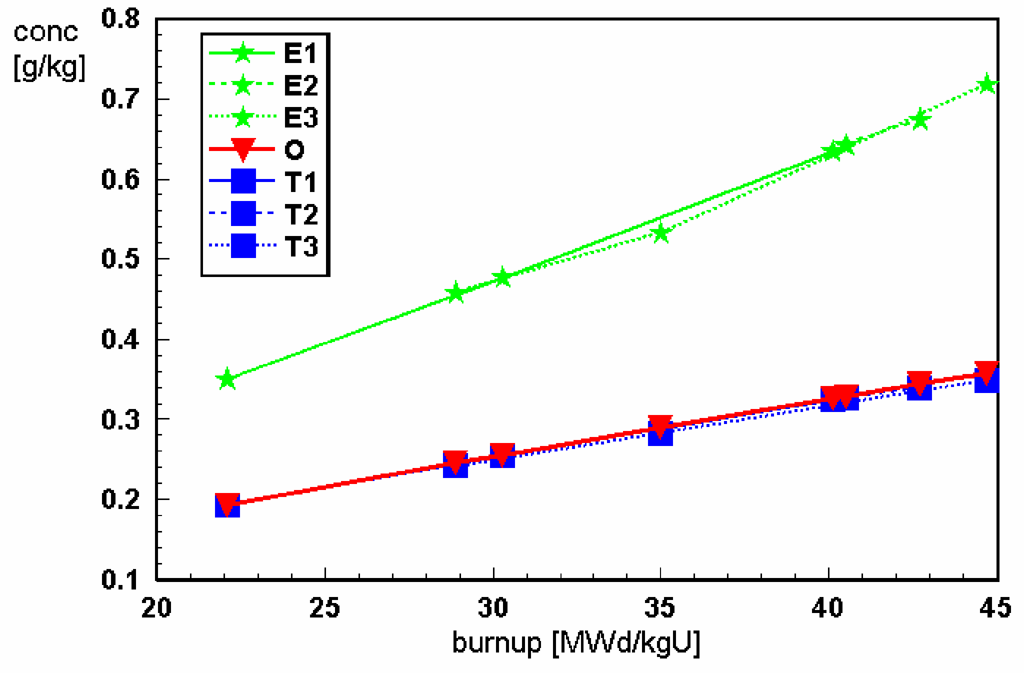


Fig.15 Dependence of Sm147 on burnup, experiment Novovoronezh 2

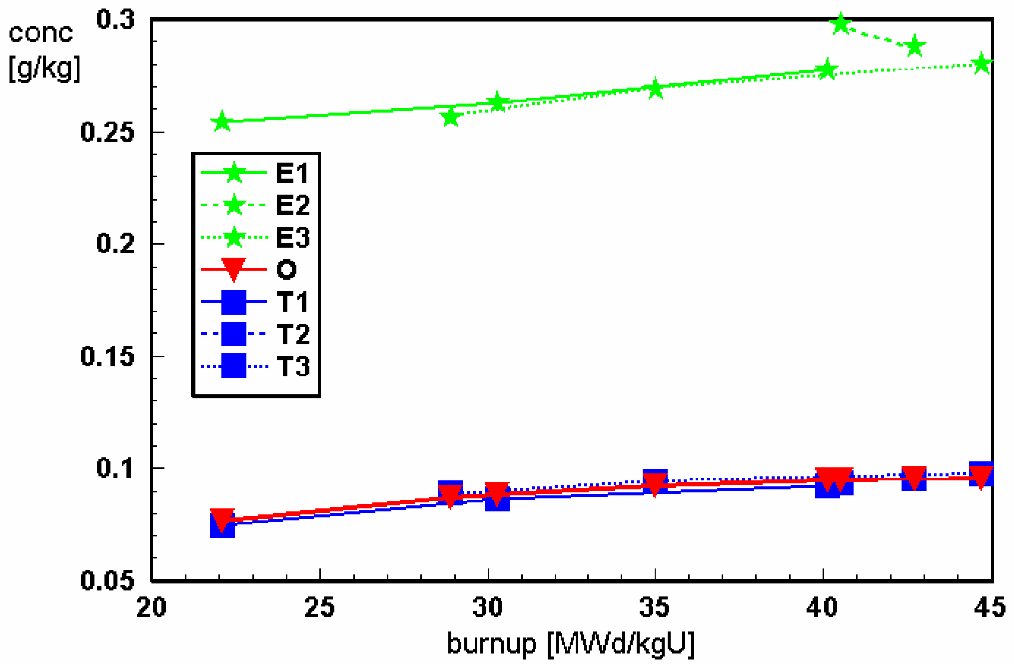


Fig.16 Dependence of Sm148 on burnup, experiment Novovoronezh 2

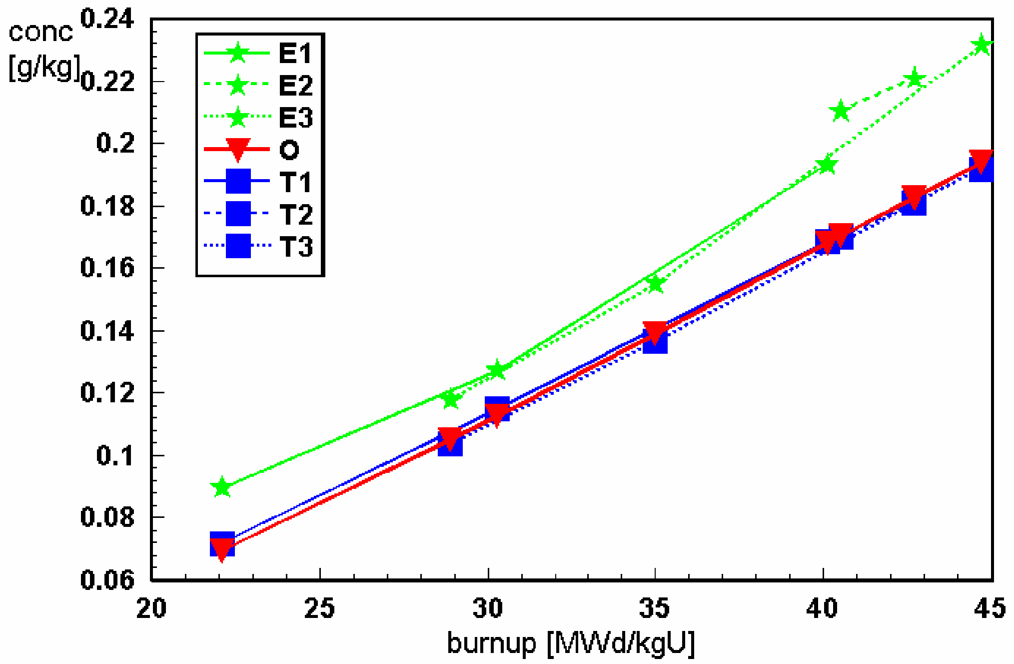


Fig.17 Dependence of Sm149 on burnup, experiment Novovoronezh 2

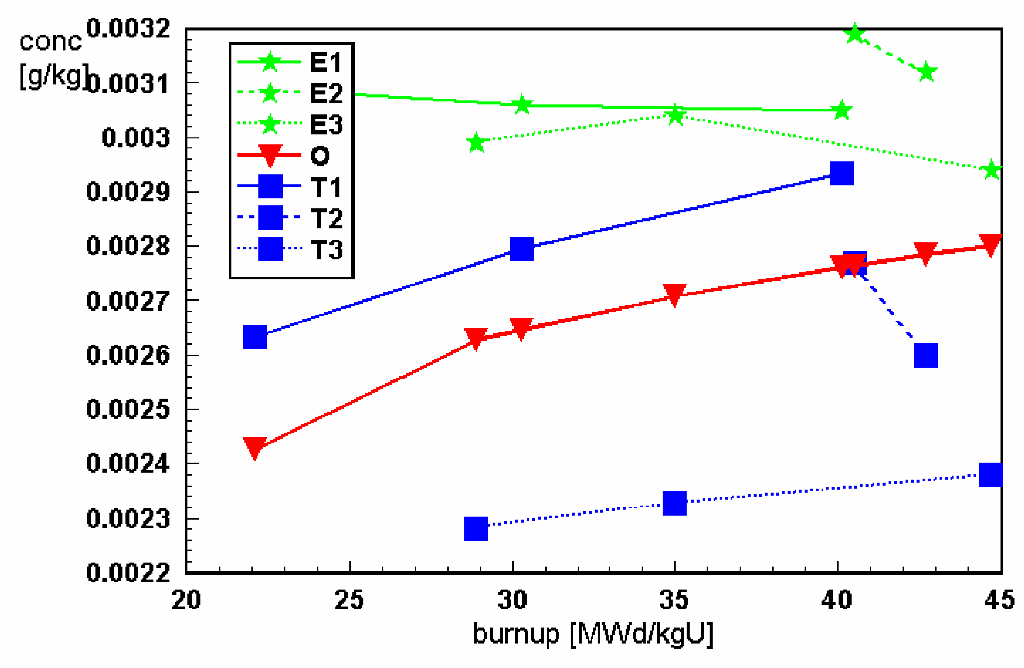


Fig.18 Dependence of Sm150 on burnup, experiment Novovoronezh 2

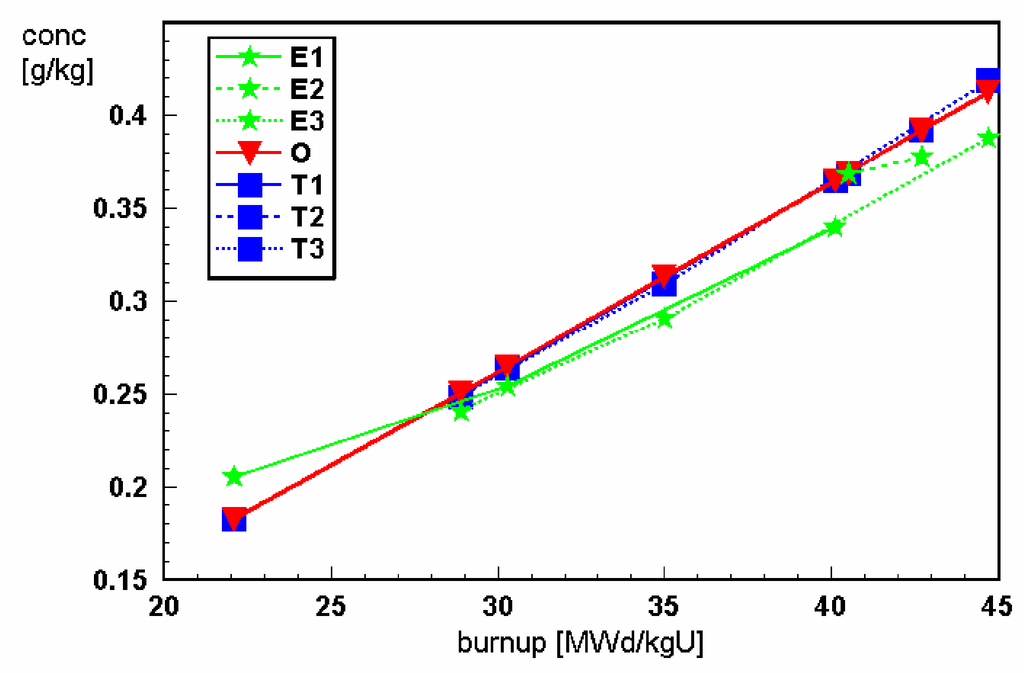


Fig.19 Dependence of Sm151 on burnup, experiment Novovoronezh 2

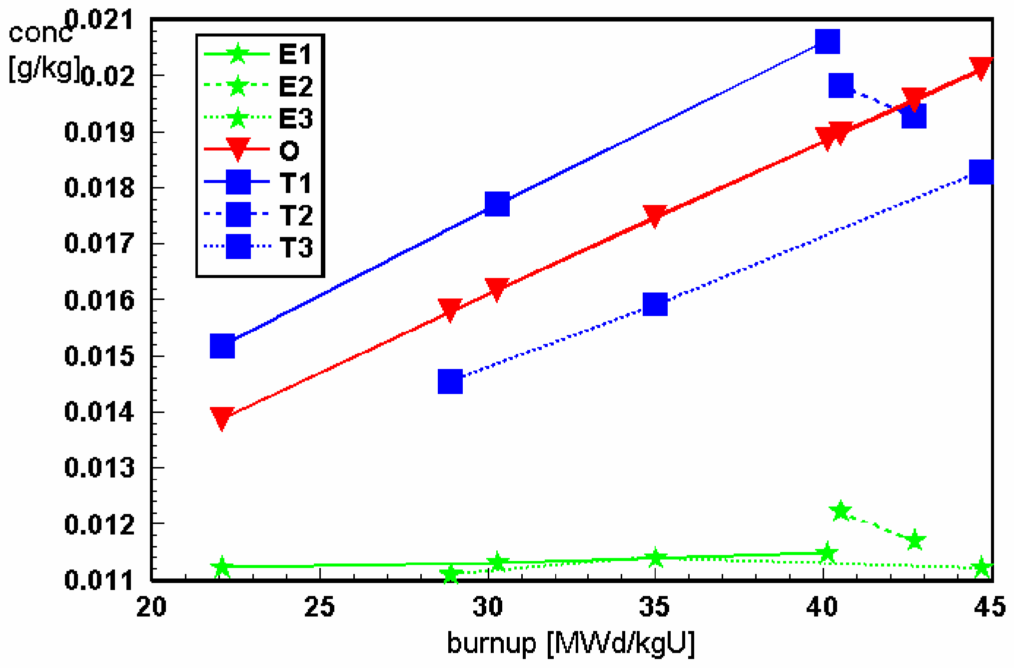


Fig.20 Dependence of Sm152 on burnup, experiment Novovoronezh 2

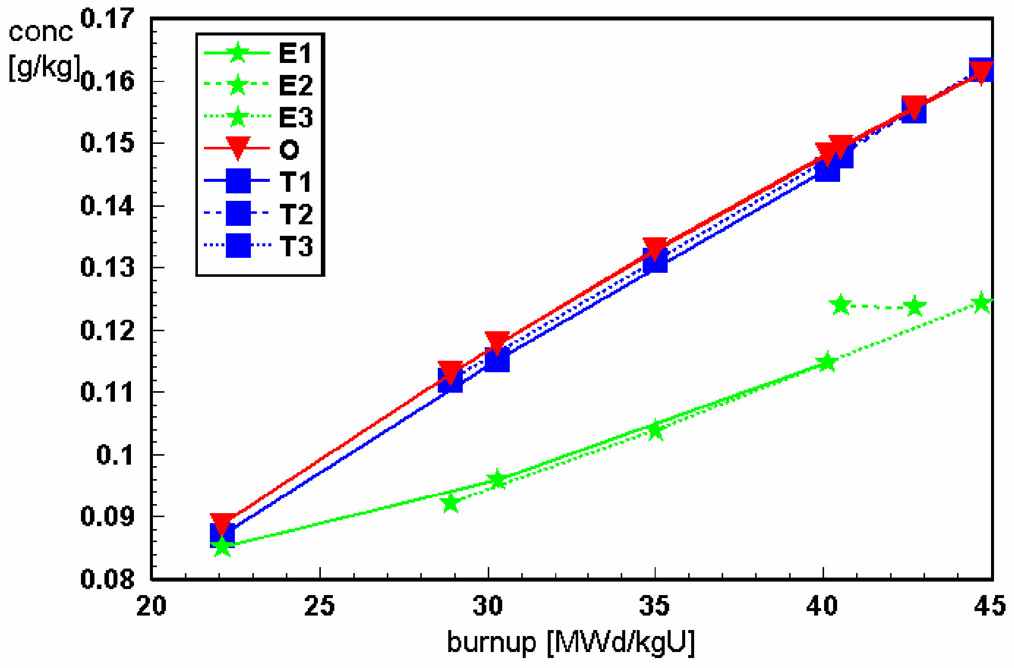


Fig.21 Dependence of Sm154 on burnup, experiment Novovoronezh 2

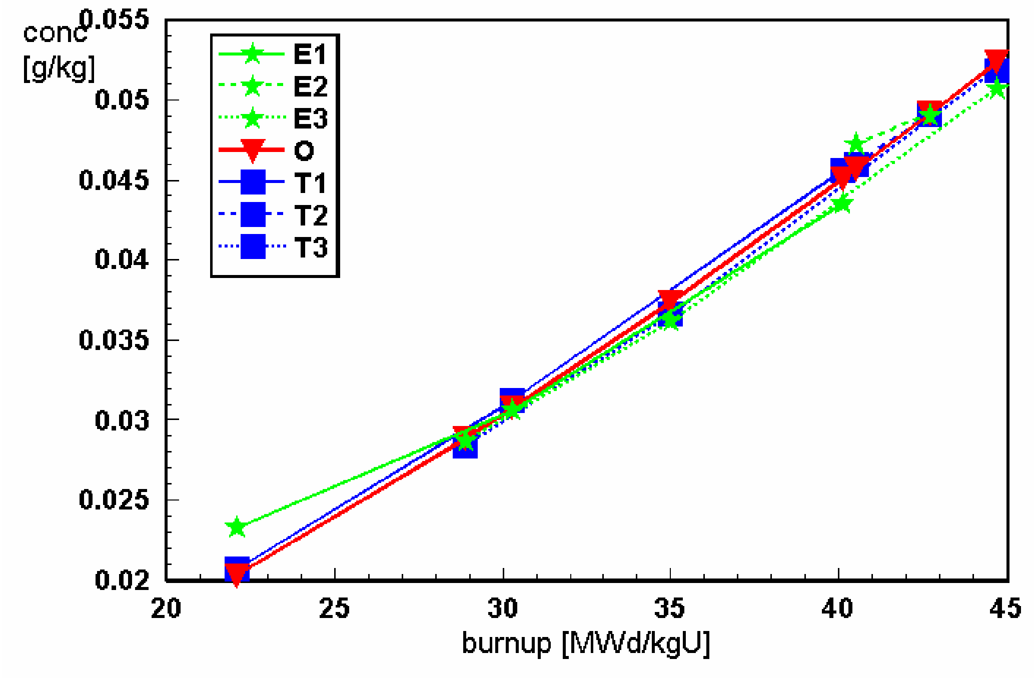


Fig.22 Dependence of Eu151 on burnup, experiment Novovoronezh 2

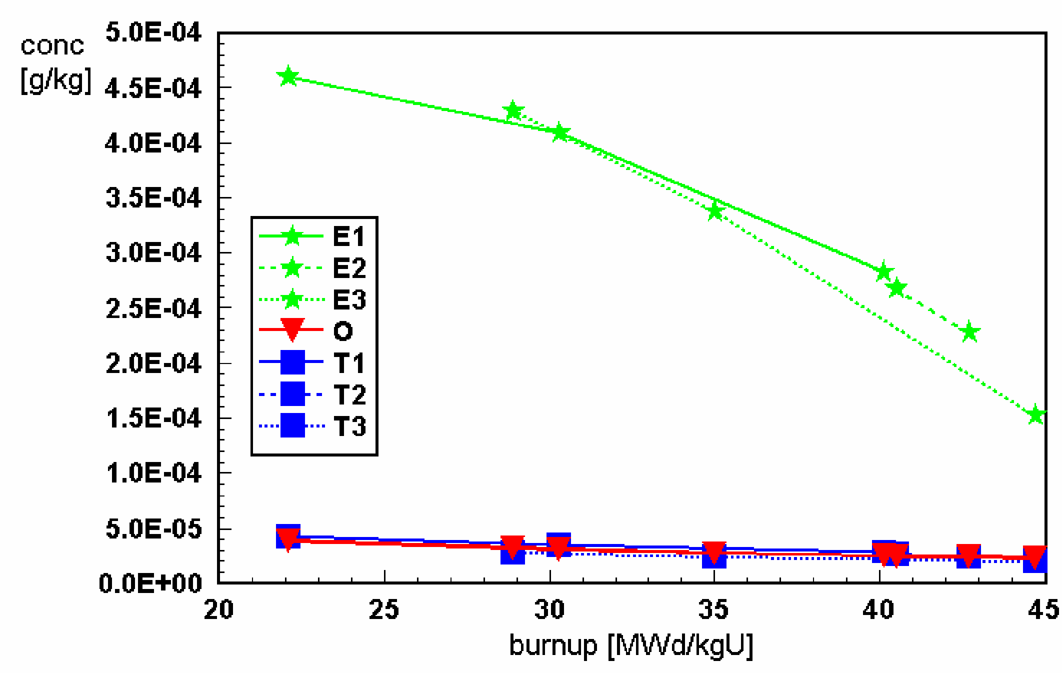


Fig.23 Dependence of Eu153 on burnup, experiment Novovoronezh 2

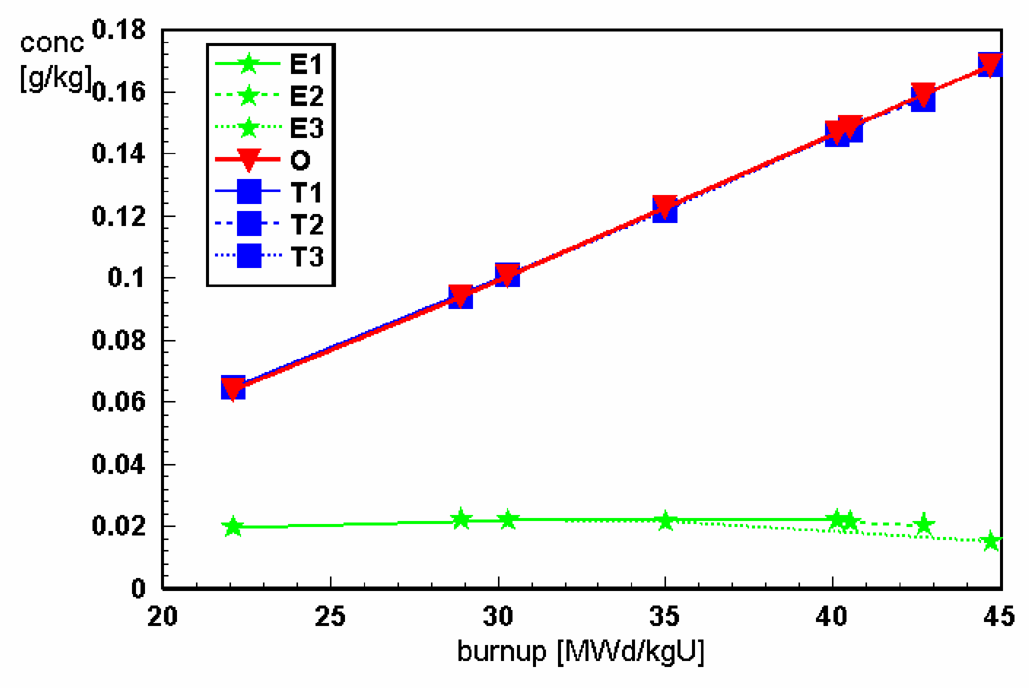


Fig.24 Dependence of Eu154 on burnup, experiment Novovoronezh 2

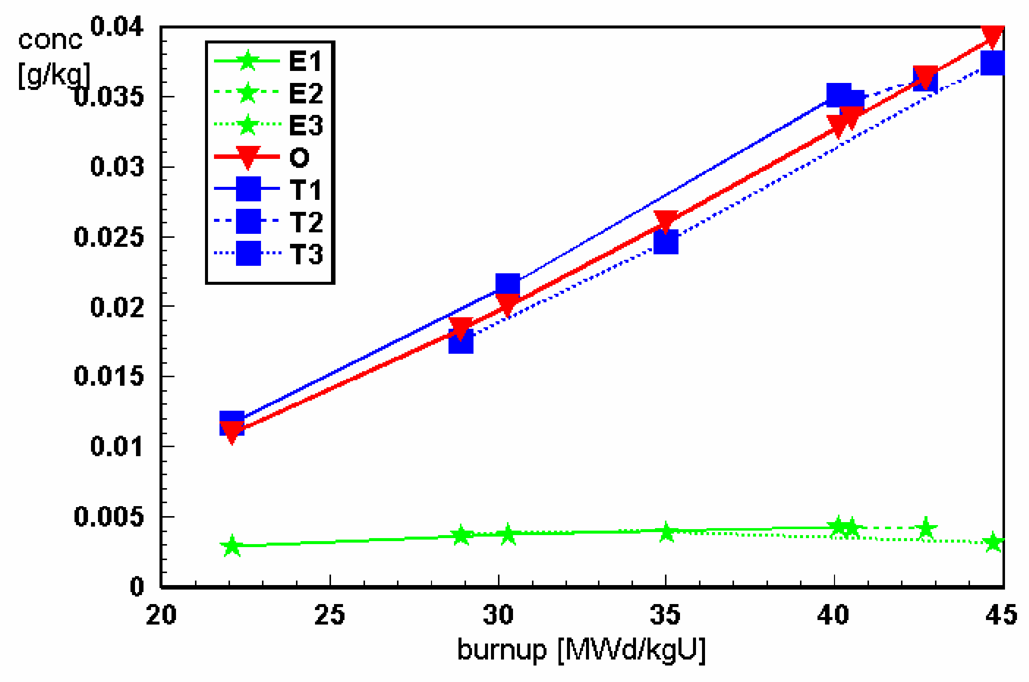


Fig.25 Dependence of Eu155 on burnup, experiment Novovoronezh 2

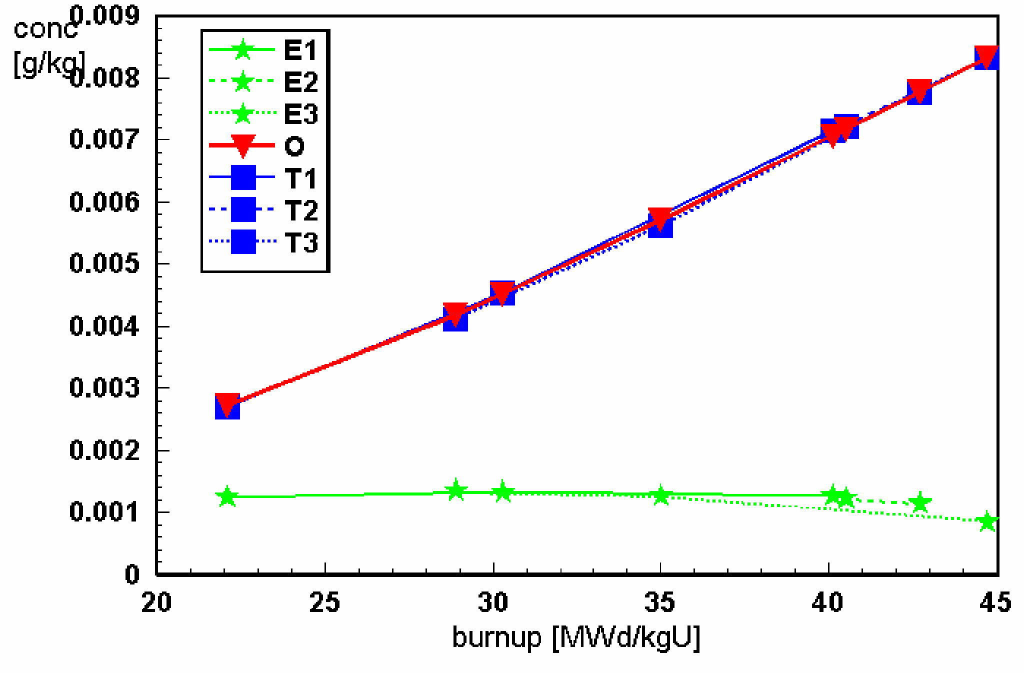


Fig.26 Dependence of Mo95 on burnup, experiment Novovoronezh 2

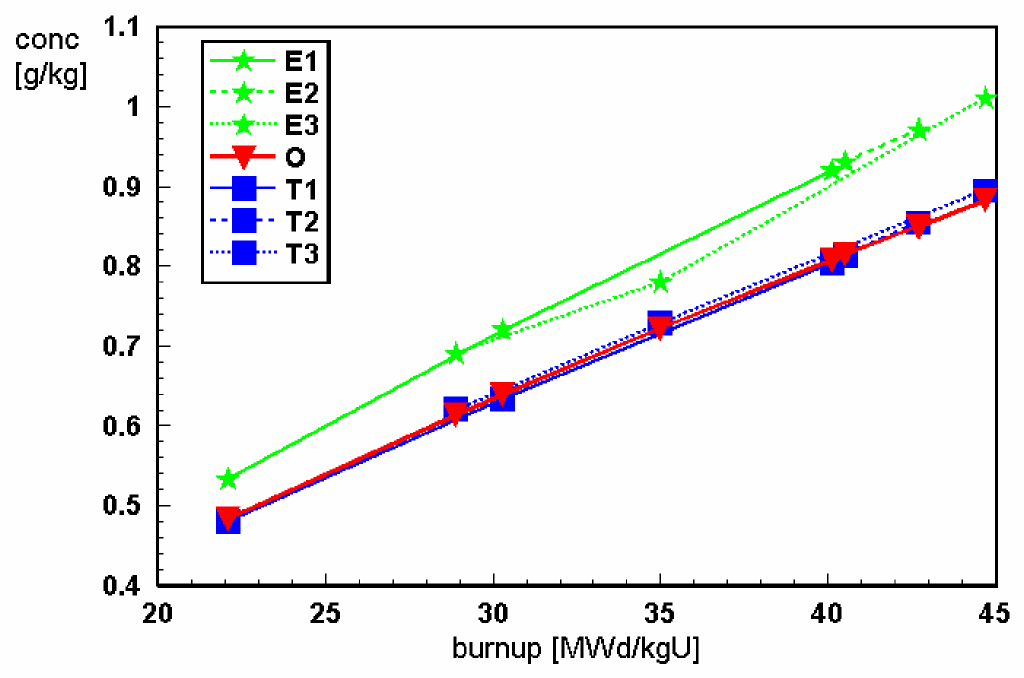


Fig.27 Dependence of Tc99 on burnup, experiment Novovoronezh 2

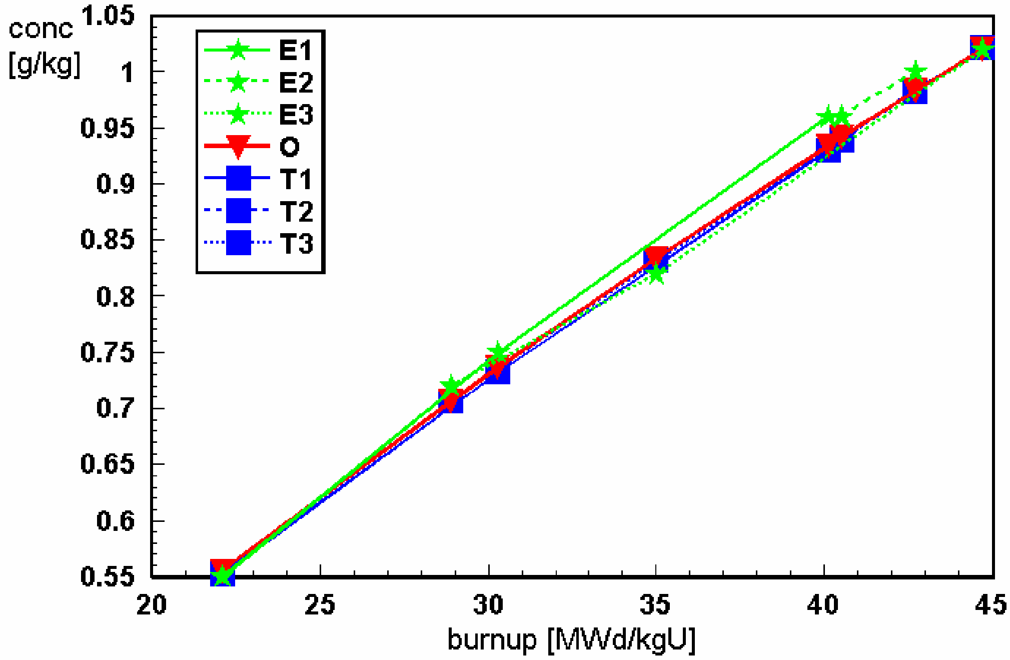


Fig.28 Dependence of Ru101 on burnup, experiment Novovoronezh 2

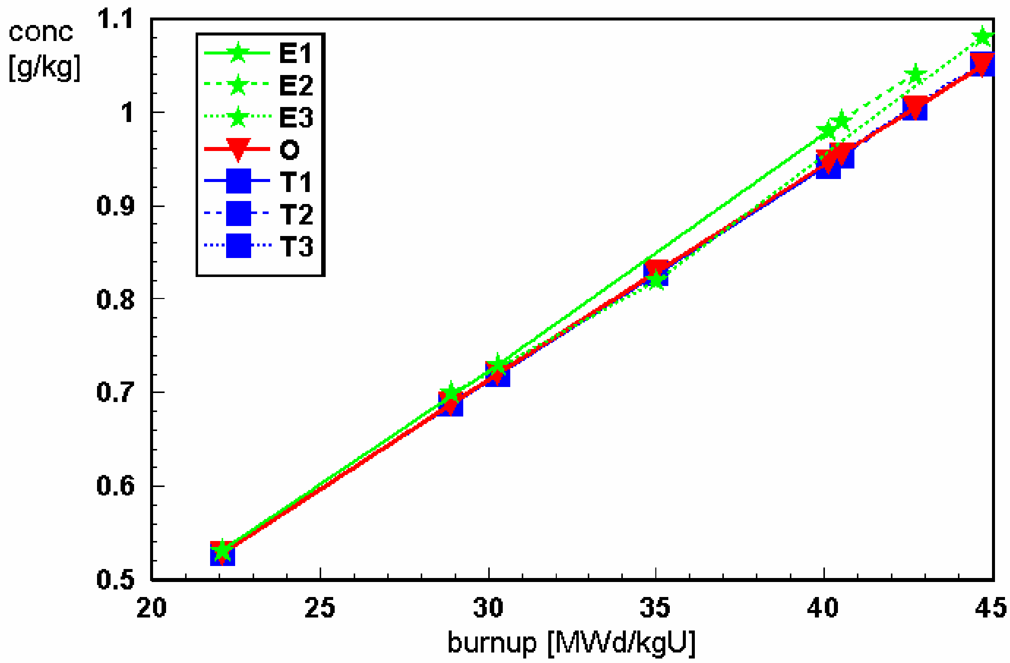


Fig.29 Dependence of Pd105 on burnup, experiment Novovoronezh 2

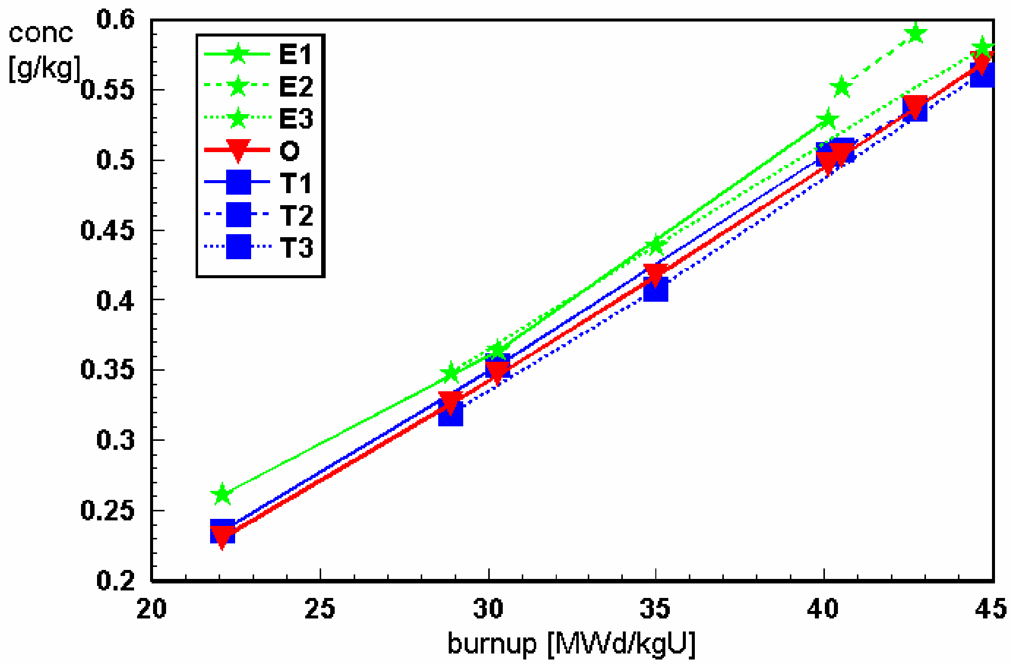


Fig.30 Dependence of Pd108 on burnup, experiment Novovoronezh 2

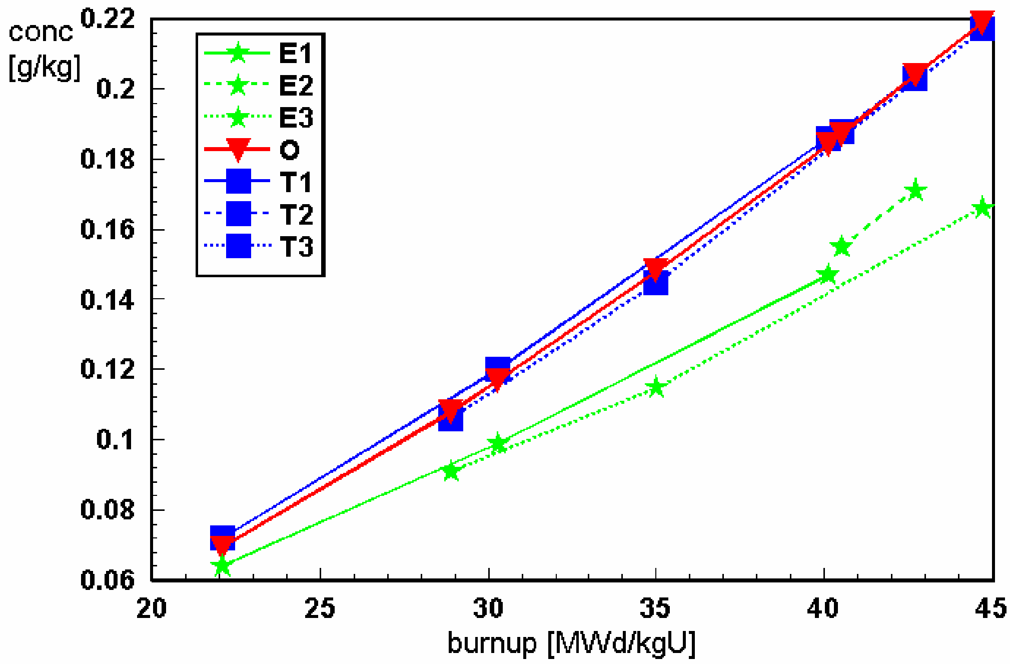


Fig.31 Dependence of Ag109 on burnup, experiment Novovoronezh 2

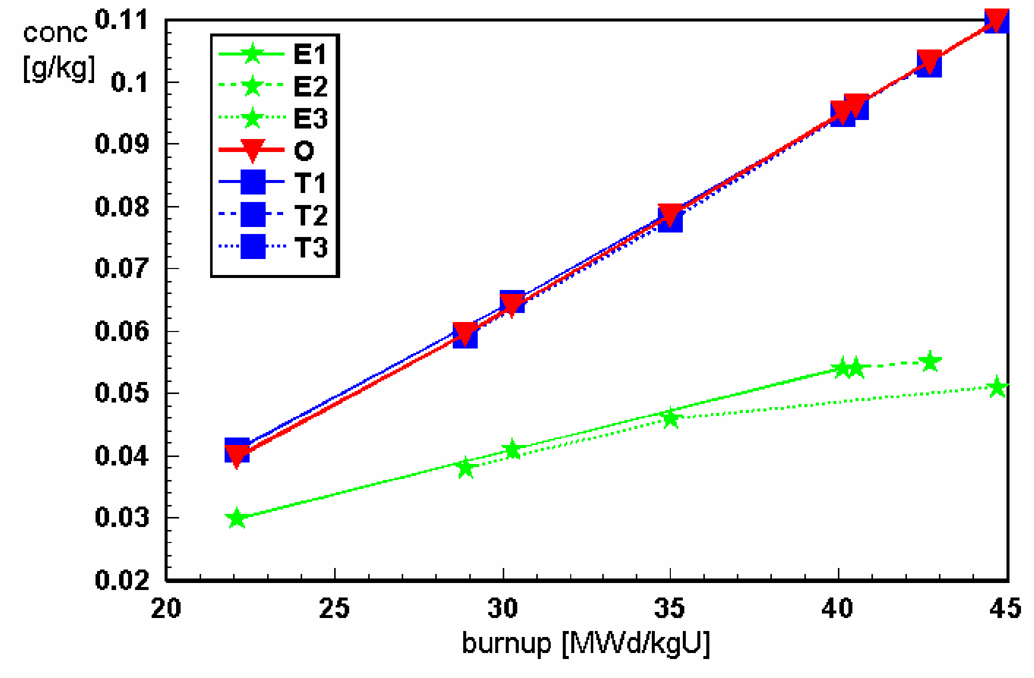


Fig.32 Dependence of Gd155 on burnup, experiment Novovoronezh 2