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OECD/NEA Burnup Credit Criticality Benchmarks Phase IIIB:

Burnup Calculations of BWR Fuel Assemblies for Storage and Transport

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OECD/NEA Burnup Credit Criticality Benchmarks Phase IIIB: Burnup Calculations of BWR Fuel Assemblies for Storage and Transport

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The report describes the final results of the Phase IIIB Benchmark conducted by the Expert Group on Burnup Credit Criticality Safety under the auspices of the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD). The Benchmark was intended to compare the predictability of current computer code and data library combinations for the atomic number densities of an irradiated BWR fuel assembly model. The fuel assembly was irradiated under specific power of 25.6 MW/tHM up to 40 GWd/tHM and cooled for five years. The void fraction was assumed to be uniform throughout the channel box and constant, at 0, 40 and 70%, during burnup. In total, 16 results were submitted from 13 institutes of 7 countries. The calculated atomic number densities of 12 actinides and 20 fission product nuclides were found to be for the most part within a range of ± 10% relative to the average, although some results, esp. ^{155}Eu and gadolinium isotopes, exceeded the band, which will require further investigation. Pin-wise burnup results agreed well among the participants. The results in the infinite neutron multiplication factor k_∞ also accorded well with each other for void fractions of 0 and 40%; however some results deviated from the averaged value noticeably for the void fraction of 70%.

Keywords: Burnup Credit, BWR, Fuel Assembly, Nuclide Concentration, Void, Benchmark, OECD/NEA, Burnup, Criticality

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1. Introduction

The reactivity of thermal reactor fuels typically decreases as the fuel burnup proceeds. Essentially, the decrease in reactivity comes from a reduction in concentration of fissile nuclides and an increase in concentration of fission products (FPs) that absorb neutrons. "Burnup credit," which is currently of wide interest in the field of nuclear criticality safety research, generally involves taking into account this reactivity decrease for criticality safety assessments and control of spent fuel by crediting burnup of fuel.

The difference between the reactivity of fresh fuel and that of irradiated fuel becomes large for high burnups. Typically, 5 wt %-enriched uranium fuel will be irradiated up to 50 GWd/tHM, and may represent significant economic benefit when burnup credit is used to yield a better estimate of fuel reactivity. Safety benefit by introducing burnup credit is also recognized for transportation of irradiated fuel with a larger capacity cask to result in fewer shipments, therefore decreased risk to the public than by assuming the fuel to be fresh.[1)] The fresh fuel assumption is, however, still used in criticality safety assessment of spent fuel storage and transport in many countries. Difficulties that may exist in introducing burnup credit into criticality safety evaluation are:

(1) Burnup confirmation procedure is not well established, and

(2) Lack of validation of computer codes and data library combinations which predict changes in atomic number densities and k_{eff} of the system as a function of fuel burnup.

Although a few methods were proposed,[2,3)] the direct measurement of reactivity at fuel handling facilities is not yet practical; reliable computational tools are therefore crucial for nuclear criticality safety evaluation of irradiated fuels in storage and transportation.[4,5)]

An Expert Group on Burnup Credit Criticality Safety (EGBUC) was formed in 1991 under the auspices of the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA).[1,6)] This group has developed and analysed a series of related benchmark calculations. From 1991 to 1995, the main activity of the Expert Group was concentrated on benchmarking calculational tools for evaluating criticality safety of PWR irradiated fuels. In Phase I, separate criticality and burnup calculations were made for an infinite array of PWR fuel rods of axially infinite length. The criticality calculations were carried out to study the differences of k_{eff} results among participants in changing treatment of actinides and fission product (FP) nuclides (Phase IA);[7)] the burnup calculations were made to compare different computer code systems in capability to predict spent fuel isotopic concentrations (Phase IB).[8)] Phase II benchmarks studied the end effect by considering an axial burnup profile for PWR fuel rods. Phase IIA[9)] dealt with an infinite array of fuel rods with an axial burnup symmetry about the mid-plane. Phase IIB[10)] was involved in a finite number of fuel assemblies (21) in a fuel cask. The configuration was slightly axially asymmetric about the mid-plane due to axial boundary conditions. Recently initiated and on-going Phase IIC Benchmark are intended to study the effect of an axial burnup profile of fuel assemblies in a transportation cask considering a measured burnup range for each axial zone of fuel rods.[11)]

Benchmark calculations for irradiated BWR fuels started from 1996 as Phase III of the burnup credit study. The existence of voids during burnup was an important difference from the irradiated PWR fuels studied in earlier Phases. Phase IIIA Benchmark dealt with criticality calculations of irradiated BWR fuels.[12)] Its main conclusions follow: The dispersion from the average k_{eff} calculated by the participants was generally within a band of ±1%Δk/k except for the case involving fresh fuel. The deviations from the average of the calculated fission rate profiles were found to be within ±5% for most cases. The end effect had a similar tendency as the PWR cases, however, it appeared less pronounced, up to 1%Δk. In addition to consideration of void profiles, constant uniform void fractions of 40% and 70% were also studied. The 70% case overestimated k_{eff} relative to the cases considering void profiles when the burnup profile was disregarded. However, a further calculation suggested the last conclusion might change if the burnup profile is considered.

This report presents the results of the Phase IIIB benchmark, which was designed to compare the prediction capability of depletion codes for BWR fuels, similar to the Phase IB Benchmark for PWR fuels. Chapter 2 of this report gives an overview of the benchmark problems. Chapter 3 summarizes information on participants to the Benchmark and their analysis methods, followed by Chapter 4, which presents the results of participant calculations with some discussion of these results. Some general conclusions are drawn in the final Chapter. Appendix I gives the problem specifications in its original form as provided to the members of OECD/NEA/EGBUC. The final results submitted by the participants are collected in Appendix II. Appendix III collects the documents presented at 1997 Meeting in Paris (EGBUC6). Appendix IV reproduces the document presented at 1999 Meeting in Albuquerque (EGBUC8). Appendix V lists information about participants.

2. Overview of Benchmark Problems

The basic model for the benchmark problem is an infinite two-dimensional array of BWR fuel assemblies that consist of an eight-by-eight fuel rod array with a thick (3.2-cm-diameter) water rod in the center (See **Figure 2.1**). The model is very similar to that of Phase IIIA Benchmark, although the following two differences should be noted:

1) The array of fuel rods is assumed axially infinite and uniform, whereas it was finite (about 370 cm) in length for Phase IIIA Benchmark.
2) Five types of fuel rods having different initial uranium enrichments are assumed, while only one type of fuel rod with varying axial composition was adopted for Phase IIIA Benchmark.

The initial uranium enrichments of fuel rods without gadolinium are 4.9, 3.6, 3.0 and 2.3 wt %, and that with gadolinium is 3.0 wt %. The channel box is surrounded by 8.5-mm-thick water, and the reflective boundary condition is imposed outside the 15.24-cm-square fuel assembly cell.

The burnup condition is the following: the infinite array of fuel assemblies is irradiated under the specific power of 25.6 MW/tHM to a final burnup of 40 GWd/tHM, and it is cooled for five years. A constant void fraction during burnup is assumed, and its value is set parametrically to 0, 40 or 70%. The case name and the irradiation conditions are summarized in **Table 2.1**.

Participants in the Benchmark were requested to submit four kinds of information:

1) Atomic number densities of 12 actinides and 20 FP nuclides, as listed in **Table 2.2**. The requested nuclides are the same as the previous benchmarks for actinides, however five nuclides (Eu-155, Gd-156, -157, 158 and Xe-131) more for FPs;
2) The infinite neutron multiplication factor k_∞ for 0, 2, 10, 20, 30 and 40 GWd/tHM. The peak value of k_∞ and the corresponding burnup value were also requested;
3) Burnup values of fuel rods in nine different positions (See **Figure 2.2**);
4) Analysis environment that includes information on the computer code, nuclear data libraries, and modelling used for analysis.

Precise problem specifications are given in Appendix I, as originally distributed. Atomic number densities for the fresh fuel were also supplied as a part of the specifications.

Table 2.1. Irradiation conditions and cooling time for the Benchmark

Case Name	Void Fraction [%]	Burnup* [GWd/tHM]	Specific Power [MW/tHM]	Cooling Time [y]
1a	0	40	25.6	0
1b	0	40	25.6	5
2a	40	40	25.6	0
2b	40	40	25.6	5
3a	70	40	25.6	0
3b	70	40	25.6	5

* Assembly-averaged value.

Table 2.2. Actinides and fission product (FP) nuclides for which calculated number densities were requested

Actinides or Fission Products	Nuclides	Number of Nuclides
Actinides	U-234, -235, -236, -238, Pu-238, -239, -240, -241, -242, Am-241, -243, Np-237	12
Fission Products	Mo-95, Tc-99, Ru-101, Rh-103, Ag-109, Cs-133, Sm-147, -149, -150, -151, -152, Nd-143, -145, Eu-153, -155, Gd-155, -156, -157, -158, Xe-131	20
Total		32

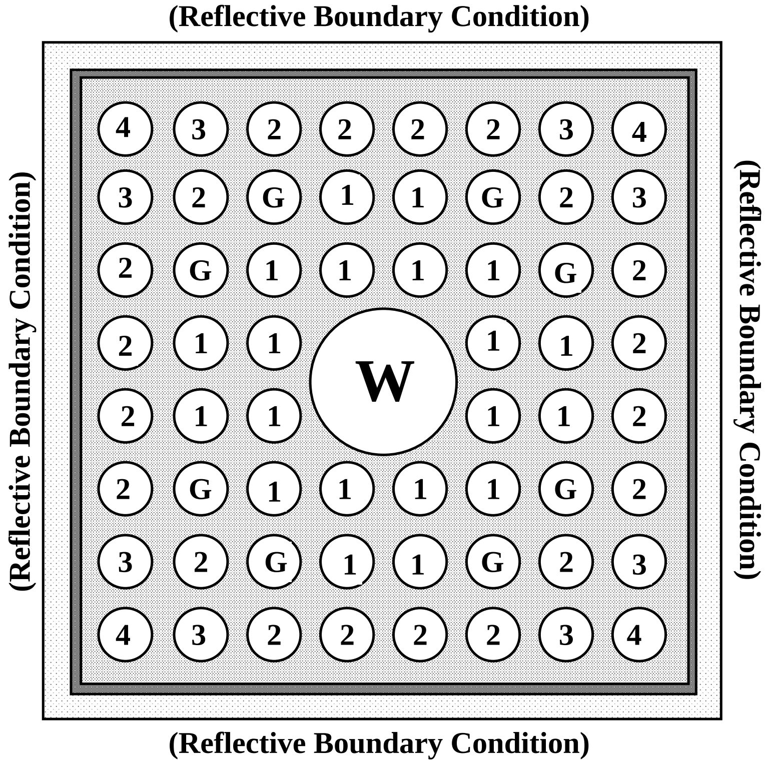

Figure 2.1. Modelled BWR assembly for Phase IIIB Benchmark.

W: water rod; **G**: gadolinium rod; others are fuel rods with the initial enrichment of 4.9 wt % (**1**), 3.6 wt % (**2**), 3.0 wt % (**3**) and 2.3 wt % (**4**).

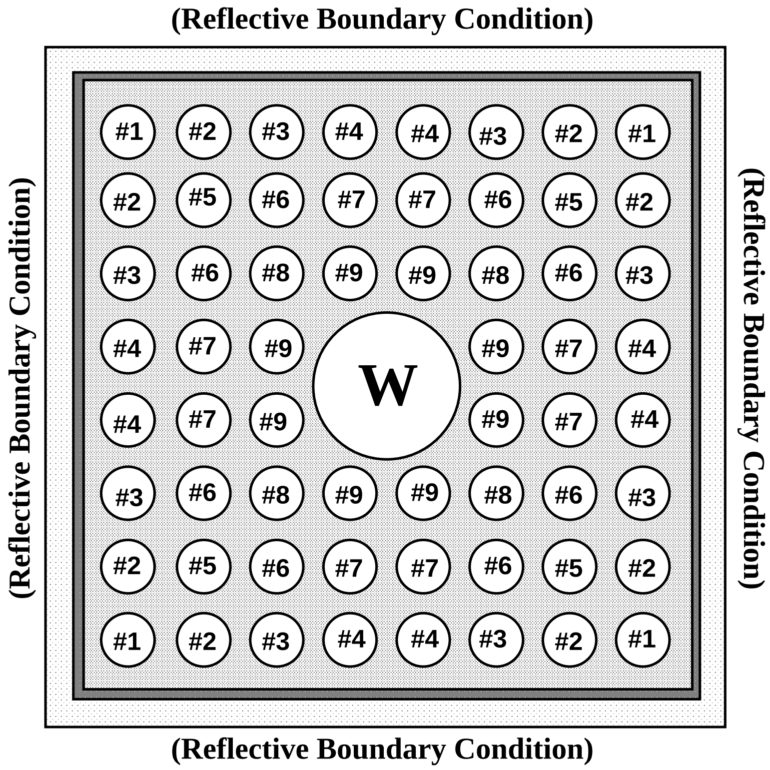

Figure 2.2. Position number of fuel rods for the modelled BWR fuel assembly.

3. Participants and Analysis Methods

A copy of the problem specification as given in Appendix I was distributed to the members of OECD/NEA Burnup Credit Expert Group in November 1996. The deadline for submission of results was set as the end of March 1997. Some of the results were submitted or revised after the deadline; the final results are provided in this report.

Table 3.1 lists the final participation in the Phase IIIB series of benchmark. It includes names of the contact person(s), their affiliation, the computer code used and the evaluated nuclear data files upon which the calculations were based. More precise information on the computer code and library used by each participant may be found in Appendix II, which collects the final results and related information submitted from the participants. Note that the column labeled **ID** in **Table 3.1** identifies each participant throughout this report. **ID**s **I** and **O** were assigned to participants who have withdrawn their results, therefore these **ID**s and their results are not included in this report.

Table 3.2 arranges all the participating institutes according to their countries. It shows that 16 results in total were submitted from 13 institutes of 7 countries. Note that a half of the total number of participants came from Japan, reflecting their interests in this series of benchmark.

The participants in the Benchmark are categorized according to the evaluated nuclear data files for the main actinides upon which the calculations were based. **Table 3.3** indicates that 6 were based on ENDF (ENDF-B4, -B5 and -B6), 6 on JEF (JEF-1 and -2.2), and 4 on JENDL (JENDL-3.2). It is clear from this table and **Table 3.1** that Americans use ENDF, Europeans use JEF and Japanese use JENDL or ENDF. **Table 3.4** summarizes the burnup codes applied to the calculation. Bateman, matrix exponential and Runge-Kutta-Gill methods were applied to solve the time-dependent depletion equations. The reason that the matrix exponential method is popular may be that many burnup codes implemented the burnup routines from the ORIGEN code.[13)]

Table 3.1. A list of participation in Phase IIIB Benchmark

ID	Code	Nuclear Data	Contact Person	Institute	Country
A	CASMO4	ENDF/B-4	F. Masukawa & S. Mitake	NUPEC	Japan
B	WIMS7	JEF-2.2	P.R. Thorne & R.L. Bowden	BNFL	U.K.
C	APOLLO2	JEF-2.2	B. Roque	CEA	France
D	MKENO-BURN2	JENDL-3.2	K. Suyama	JAERI	Japan
E	BOXER	JEF-1, -2	P. Grimm	PSI	Switzerland
F	TRIPOLI4*1	JEF-2.2	Y.K. Lee	CE-SACLAY	France
G	WIMS7	JEF-2.2	Th. Maldague	Belgonucleaire	Belgium
H	TGBLA/ORIGEN2.1	ENDF/B-4, -5	Y. Ando	Toshiba	Japan
J	VMONT	ENDF/B-4, JENDL-2	M. Aoyama	Hitachi	Japan
K	HELIOS	ENDF/B-6	M. DeHart	ORNL	U.S.A.
L	FLEXBURN	JENDL-3.2	T. Kameyama	CRIEPI	Japan
M	SWAT	JENDL-3.2	K. Suyama	JAERI	Japan
N	SWAT*2	JENDL-3.2	K. Suyama	JAERI	Japan
P	SCALE4.3*3	ENDF/B-5	I. Nojiri	PNC	Japan
Q	SCALE4.4	ENDF/B-5, -6	I.C. Gauld & M.D. DeHart	ORNL	U.S.A.
R	KENOREST	JEF2.2	B. Gmal	GRS	Germany

*1 Fresh results only.
*2 Single pin-cell model.
*3 Multi-rods approximation (See Appendix IV.1).

Table 3.2. Countries and institutes participating in Phase IIIB Benchmark

No.	Country	Institute	No. of Participants
1	Belgium	Belgonucleaire	1
2	France	CEA-IPSN, CE-SACLAY	2
3	Germany	GRS	1
4	Japan	CRIEPI, Hitachi, JAERI(3)*, NUPEC, PNC, Toshiba	8
5	Switzerland	PSI	1
6	U.K.	BNFL	1
7	U.S.A.	ORNL(2)*	2
Total	7	13(16)*	16

* If a participant applied different methods, the number of methods is shown in ( ).

Table 3.3. Evaluated nuclear data and burnup codes applied to the benchmark calculations

Evaluated Nuclear Data*1	Computer Code (**ID***2)	No. of Participants	
ENDF-B4	CASMO4(**A**), TGBLA/ORIGEN2.1(**H**) , VMONT(**J**)	3	6
ENDF-B5	SCALE4.3(**P**), SCALE4.3(**Q**),	2	
ENDF-B6	HELIOS(**K**)	1	
JEF-1	BOXER(**E**)	1	6
JEF-2.2	APOLLO2(**C**), WIMS7(**B**,**G**) , TRIPOLI4(**F**), KENOREST(**R**)	5	
JENDL-3.2	MKENO-BURN2(**D**), FLEXBURN(**L**), SWAT(**M**,**N**)	4	4
Total		16	

*1 For the main actinides.
*2 See **Table 3.1**.

Table 3.4. Burnup codes applied in the benchmark calculations

Burnup Calculation Method	Computer Code	Version (**ID***2)	No. of Participants	
Bateman	APOLLO*1	2(**C**)	1	5
	HELIOS*1	1.4(**K**)	1	
	MKENO-BURN	2(**D**)	1	
	WIMS	7(**B**, **G**)	2	
Matrix Exponential	BOXER*1	(**E**)	1	9
	CASMO	4(**A**)	1	
	FLEXBURN	(**L**)	1	
	KENOREST	1998**(R)**	1	
	SCALE	4.3(**P**), 4.4(**Q**)	2	
	SWAT	(**M**, **N**)	2	
	TGBLA/ORIGEN2.1	(**H**)	1	
Runge-Kutta-Gill	VMONT	(**J**)	1	1
Total			15	

*1 To be confirmed.
*2 See **Table 3.1**.

4. Results and Discussion

4.1 Actinide Nuclides

The atomic number densities (i.e., nuclide concentrations) calculated by participants are provided in the upper part of **Tables 4.1** through **4.6** for all six cases listed in **Table 2.1**. The average, two times the standard deviation and two times the relative standard deviations (TRSDs) of submitted results for each nuclide are shown in the last three columns, respectively, of those tables. These are defined as:

$$\text{Ave.} = \frac{1}{n}\sum_{\mathbf{i=A}}^{\mathbf{R}} N_{\mathbf{i}}, \tag{1}$$

$$2\sigma = \frac{2}{n-1}\sum_{\mathbf{i=A}}^{\mathbf{R}} \left(N_{\mathbf{i}} - \text{Ave.}\right)^2, \text{ and} \tag{2}$$

$$2\sigma^{(r)} = 2\sigma/\text{Ave.}, \tag{3}$$

where

$N_{\mathbf{i}}$: atomic number density calculated by participant **i** (see below), and

n: number of participants, in this case n = 13 (see below).

Participants are identified by alphabets from **A** to **R** as shown in the 1st column of **Table 3.1**. Participant **F** submitted the results of k_∞ in the fresh case only, therefore his results are not listed in **Tables 4.1 - 4.6**. Results from Participants **N** and **P**, which are shown in **Tables 4.1 - 4.6**, are omitted from the average because of their crude approximations: Participant **N** applied the single pin-cell model, and Participant **P** adopted a multi-rods approximation (see Appendix IV.1 for this approximation). As mentioned in the previous Chapter, Participants **I** and **O** have withdrawn their results, therefore they are not included in the summation.

The TRSDs of actinide concentrations calculated by the participants are shown in **Figure 4.1**. The TRSDs of actinide nuclides for no void and 40% void cases (Cases 1a, 1b, 2a and 2b) are less than 20% except ^{243}Am. For 70% void cases (Cases 3a and 3b), the TRSDs are larger than those for no void and 40% void cases irrespective of the cooling time, except ^{243}Am. The TRSDs of ^{238}Pu, ^{239}Pu, ^{241}Pu, ^{241}Am, ^{243}Am and ^{237}Np concentrations are larger than 20% for the 70% void cases. The large deviations of ^{243}Am concentrations were observed also for the Phase IB Benchmark results.[8] Variations in the ^{243}Am and ^{242}Pu thermal capture cross sections were suggested as the reason for the large deviation.

Relative differences from the average of the submitted results were calculated and are tabulated in **Tables 4.7** through **4.12**. They are also illustrated as bar graphs in **Figures 4.2** through **4.7**. From these figures, it is clearly seen that the above mentioned large deviations of ^{243}Am concentrations mainly come from the contribution of Participants **D** and **Q**. It may be worth pointing out that those showing remarkable negative deviations of ^{238}Pu concentrations (**B**, **D** and **G**) adopted Bateman method in their burnup calculations.

For 70% void cases, the first contribution to the large deviations of ^{238}Pu, ^{239}Pu, ^{241}Pu and ^{241}Am concentrations from the average comes from Participant **K** (see **Figures 4.6** and **4.7**). The largest contribution to the deviations of ^{237}Np concentrations originates from Participant **B**. The Phase IB report pointed out that the deficiencies in concentration of ^{238}Pu for WIMS code used by participants **B** and **G** was caused by a lack of an alpha-decay path of ^{242}Cm in the WIMS data library.

Noticeable deviations of ^{238}U concentrations are also observed from the figures; it can be confirmed from the tables that Participants **D** and **Q** have several per mill deviations and Participant **K** has the same order deviations only for 70% void cases.

4.2 Fission Product Nuclides

The calculated concentrations of fission product (FP) nuclides are shown in the lower part of **Tables 4.1** through **4.6**. The TRSDs of the results can be viewed in **Figure 4.8**. It is clearly seen from this figure that the two relative standard deviations for ^{155}Eu and gadolinium isotopes are larger than 50%. The TRSDs of ^{149}Sm and ^{151}Sm concentrations for 70% void cases are almost 40% and over twice those observed for the null and 40% void cases. Furthermore, TRSDs in nuclide concentrations of ^{109}Ag and ^{152}Sm are about 20%, however, those of other nuclides are far less than 20%.

The relative differences of nuclide concentrations from the averaged values are tabulated in **Tables 4.7** through **4.12**. They are also displayed in bar graphs as **Figures 4.9** through **4.14**. As Participant **L** cannot consider decay of FP nuclides, his results of FP nuclides for the 5-y cooling cases (Cases 1b, 2b and 3b) were not included in the corresponding tables and figures (see **Tables 4.2**, **4.4** and **4.6** and **Figures 4.3**, **4.5** and **4.7**).

For some FP nuclides, large relative standard deviations are caused by outlying results from a few, or sometimes one participant. As an example for ^{109}Ag, Participant **A** gave a smaller value than others, and a group consisted of Participants **M**, **Q** and **R** supplied larger values than the average. It may be worth pointing out that this isotope has interesting features about fission yield data: the cumulative fission yield of ^{109}Ag is about 0.03% for ^{235}U thermal fission, whereas about 1.88% for ^{239}Pu thermal fission. Therefore, not only the fission yield data but also the amount of fission by ^{235}U and ^{239}Pu should be compared for to investigate the differences.

Another example for the case of ^{155}Eu, Participants **A**, **H** and **R** gave more than 40% larger values than the average irrespective of the void fraction or cooling time. This isotope shows large differences even among the assembly design codes. This isotope is generated by the neutron capture reaction (one-grouped cross section is 260 b) from ^{154}Eu, and this generation chain is effectively started from the ^{149}Nd (cumulative fission yield of ^{235}U: 1.06%) or ^{147}Nd (cumulative fission yield of ^{235}U: 2.25%). This means that it is difficult to identify the direct cause of discrepancies found for ^{155}Eu by this benchmark.

For ^{155}Eu, we have related information. In a post irradiation examination analysis by the SWAT code for the parent isotope ^{154}Eu, the C/E values showed 0.8.[14] It is reported that the narrow resonance approximation without the mutual shielding effect between ^{238}U and ^{152}Sm leads to an under-estimation of one-grouped capture cross section of ^{152}Sm,[15] and that the underestimation of ^{154}Eu concentration is expected to be improved by including this effect.

For 70% void case, the TRSD of ^{149}Sm and ^{151}Sm are almost 40%, as mentioned above in this section. The main contributor for this deviation is Participant **K**. The large deviation for gadolinium isotopes, will be discussed further in Section **4.5**.

4.3 Neutron Multiplication Factor

The neutron multiplication factor during burnup and cooling time was calculated for three values of void fractions during burnup, 0, 40 and 70%. The results submitted by participants are listed in **Tables 4.13** through **4.15**. They are also changed into graphs as shown in **Figures 4.15** through **4.17**. We can observe that k_∞ results agree well, typically in ±2%Δk band) except the major deviation (**K** for Case 3) and some minor deviations (**D**, **L**, **R** and **Q**).

As the void fraction increases, the initial value of k_∞ is somewhat depressed, and the change in k_∞ as a function of fuel burnup is retarded compared to the no void case. A larger void fraction induces a harder neutron spectrum, which depresses fission of ^{235}U and produces more ^{239}Pu by neutron absorption of ^{238}U.

4.4 Pinwise Burnup

Burnup results for nine kinds of fuel rods identified by **Figure 2.2** are compared in this section. They are summarized in **Tables 4.16** through **4.18**. Note that Participants **N**, **P** and **Q** either provide "nodata" or 40.0 GWd/tHM irrespective of the rod position, because of the approximation they have applied.

The results are also shown in bar graphs in **Figures 4.18** through **4.20**. From these figures it is observed that

(1) Participant **D** gives an exceptionally large burnup value compared to others for Rod Position #8, which is near the center (See **Figure 2.2**).

(2) Results from Participant **K** deviate from others for Case 3 (70% void), especially at the rod position #9, which is adjacent to the water rod.

However, with these exceptions, the overall agreement is very good.

4.5 Gadolinium (Gd) Composition in Gd Pins

As large deviations from the averaged value were observed for gadolinium (Gd) isotopes, atomic number densities (concentrations) of Gd isotopes in Gd pins were further requested. Eight participants **A**, **C**, **E**, **H**, **J**, **L**, **M** and **P** submitted their results . They are shown in **Table 4.19**, and also in bar graphs as **Figures 4.21** through **4.26**. Participant **L** submitted no-cooling results only because of their incomplete decay chain treatment. The differences in Gd-155 densities become profound after 5 y cooling. One reason is that the submitted results from Participant **A** are the same both for 0 and 5 y cooling time, because their code does not treat the decay during cooling time. Other differences in Gd-155 results after 5 y cooling should be rendered to their decay chain treatment, which needs further check.

Depletion of Gd-155 and -157 during burnup is reduced when the void fraction increases, i.e., the system becomes less thermal. B. Roque et al. point out this fact (See Appendix III.2). The relative differences in atomic number densities of these isotopes among participants, however, are not so profound even though the void fraction changes.

An extremely large value and rapid change of cross section in time and spatial distribution of Gd could result in predictive errors of its residual concentrations. A future study in these points should be conducted.

4.6 Discussion of the discrepancies among the codes

In the Phase IB benchmark (PWR pin-cell depletion), eight isotopes (^{238}Pu, ^{243}Am, ^{109}Ag, ^{149}Sm, ^{151}Sm, ^{155}Gd, ^{237}Np and ^{135}Cs) were identified that showed poor agreements among participants' results. In the present benchmark, TRSDs show more than 20% for following isotopes.

- ^{238}Pu , ^{239}Pu, ^{241}Pu, ^{241}Am, ^{237}Np, ^{149}Sm and ^{151}Sm for Cases 3a and 3b (70% void cases).
- ^{243}Am, ^{109}Ag, ^{155}Eu and ^{155,156,157,158}Gd for all cases.

The isotopes that showed large differences in Phase IB Benchmark also show large differences among the participants in Phase IIIB Benchmark. To study the reason, we selected several codes which are used for fuel assembly design, then evaluated the average and TRSDs among them. This is because these codes are believed to be reliable, especially for BWR fuel assembly calculations. The selected codes correspond to Participants **A**, **B**, **C**, **G**, **H** and **J**. In this evaluation, however, Gd concentrations submitted by Participant **A** (for Cases 1b, 2b and 3b) and **G** were not included. Participant **A** said that their code could not treat Gd decay correctly and Participant **G** described that given Gd isotopes nuclide densities did not include residual Gd of Gd pins.

Tables 4.20 through **4.25** provide the difference of each code from the averaged value of assembly design codes. **Figure 4.27** shows that the differences among the assembly design codes are generally smaller than shown in **Figures 4.1** and **4.8**. Especially for Gd isotopes, the TRSDs are reduced remarkably, i.e., they become less than 10%, except for ^{155}Gd and ^{157}Gd.

Gadolinium-155 shows 60% deviations for the 5 y cooling case (Case1b, 2b and 3b). The reason for this discrepancy is that the values given by Participant **H** are larger than others. This should be intimately related to their amounts of ^{155}Eu concentration. For ^{157}Gd, differences are about 40% for the cases without cooling. The main contribution for this discrepancy is from participant **A**. Their code gives about 30% smaller values from the average. Since the cases with 5 y cooling also show considerably large differences, about 20%, we can conclude that accuracy of ^{157}Gd evaluation needs further investigation.

For other isotopes except ^{237}Np, ^{109}Ag and ^{155}Eu, the TRSDs are less than 20%. It is therefore concluded that the differences among assembly design codes are small except for some isotopes.

In **Tables 4.1** through **4.6**, the average values and TRSDs were evaluated using the results from 13 participants: **A**, **B**, **C**, **D**, **E**, **G**, **H**, **J**, **K**, **L**, **M**, **Q** and **R**. However, it seems better to discard from the evaluation the results of Participants **A** only for Gd isotopes with 5 y cooling (for not treating decay of Gd isotopes correctly), **D** (for a serious inconsistency), and **K** for 70% void cases (for a serious inconsistency), and **Q** (for one-dimensional treatment). **Figure 4.28** shows the TRSDs for each case after excluding the above-mentioned results from the evaluation. Since the results for actinides are almost the same as **Figure 4.27**, it may be concluded that the difference among assembly design and calculation codes for many isotopes are less than 20%, many of these even less than 10% in TRSD. However, for 70% void cases, TRSDs have become larger than the 0 and 40% void cases. The outlier of the group is Participant **R**, which supplied about 20% larger values than the others for the outstanding cases. The TRSDs for Gd isotopes have become larger, which is due to smaller values from Participant **K** than others.

Table 4.1. Results for Case 1a (No void, 40 GWd/tHM, Not cooling) actinides and FPs [$10^{24}/cm^3$] reported by participants*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	Ave.	2σ	$2\sigma^{(r)}$
U-234	4.65E-06	4.60E-06	4.54E-06	4.71E-06	4.55E-06	4.61E-06	4.59E-06	5.00E-06	4.56E-06	4.54E-06	4.81E-06	4.65E-06	4.52E-06	4.47E-06	4.46E-06	4.62E-06	2.97E-07	0.06
U-235	1.60E-04	1.59E-04	1.58E-04	1.68E-04	1.63E-04	1.64E-04	1.58E-04	1.54E-04	1.55E-04	1.50E-04	1.65E-04	1.53E-04	1.54E-04	1.49E-04	1.59E-04	1.59E-04	1.13E-05	0.07
U-236	1.18E-04	1.16E-04	1.15E-04	1.12E-04	1.17E-04	1.15E-04	1.17E-04	1.19E-04	1.18E-04	1.15E-04	1.14E-04	1.14E-04	1.17E-04	1.19E-04	1.14E-04	1.16E-04	4.37E-06	0.04
U-238	2.12E-02	2.12E-02	2.12E-02	2.13E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.11E-02	2.13E-02	2.12E-02	2.12E-02	8.73E-05	0.00
Pu-238	3.42E-06	2.93E-06	3.42E-06	3.01E-06	3.52E-06	3.11E-06	3.46E-06	3.52E-06	2.85E-06	3.72E-06	3.13E-06	3.18E-06	3.34E-06	3.70E-06	3.57E-06	3.33E-06	5.86E-07	0.18
Pu-239	8.33E-05	8.53E-05	8.30E-05	7.66E-05	8.54E-05	8.75E-05	8.09E-05	8.22E-05	7.76E-05	7.87E-05	8.32E-05	8.02E-05	7.98E-05	8.82E-05	8.82E-05	8.31E-05	7.71E-06	0.09
Pu-240	4.96E-05	5.26E-05	5.20E-05	4.66E-05	5.40E-05	5.16E-05	5.27E-05	5.01E-05	5.22E-05	4.93E-05	5.37E-05	5.13E-05	5.12E-05	5.12E-05	4.85E-05	5.11E-05	4.31E-06	0.08
Pu-241	2.15E-05	2.16E-05	2.16E-05	1.94E-05	2.17E-05	2.19E-05	2.19E-05	2.17E-05	1.98E-05	2.12E-05	2.29E-05	2.23E-05	2.07E-05	2.39E-05	2.38E-05	2.18E-05	2.59E-06	0.12
Pu-242	1.27E-05	1.25E-05	1.29E-05	1.12E-05	1.23E-05	1.23E-05	1.30E-05	1.29E-05	1.21E-05	1.35E-05	1.34E-05	1.30E-05	1.46E-05	1.42E-05	1.41E-05	1.29E-05	1.64E-06	0.13
Am-241	8.40E-07	8.41E-07	7.47E-07	7.81E-07	8.03E-07	8.62E-07	8.47E-07	8.55E-07	7.54E-07	7.84E-07	9.17E-07	8.80E-07	8.15E-07	9.41E-07	9.03E-07	8.37E-07	1.22E-07	0.15
Am-243	2.08E-06	1.95E-06	2.07E-06	1.51E-06	1.96E-06	2.05E-06	2.10E-06	2.01E-06	1.94E-06	1.93E-06	2.11E-06	1.98E-06	2.62E-06	2.71E-06	2.25E-06	2.05E-06	5.23E-07	0.26
Np-237	9.87E-06	7.89E-06	9.68E-06	9.73E-06	9.52E-06	8.49E-06	9.68E-06	1.00E-05	8.12E-06	1.09E-05	9.17E-06	9.48E-06	9.52E-06	1.02E-05	9.95E-06	9.48E-06	1.70E-06	0.18
Mo-95	nodata	4.82E-05	4.74E-05	nodata	5.21E-05	4.80E-05	4.73E-05	4.86E-05	4.78E-05	nodata	4.80E-05	4.81E-05	4.83E-05	4.87E-05	4.81E-05	4.84E-05	2.77E-06	0.06
Tc-99	nodata	5.27E-05	5.20E-05	4.99E-05	5.20E-05	5.18E-05	5.25E-05	5.22E-05	5.16E-05	5.17E-05	5.28E-05	5.24E-05	5.18E-05	5.23E-05	5.34E-05	5.21E-05	1.71E-06	0.03
Ru-101	nodata	5.01E-05	5.05E-05	nodata	5.01E-05	4.99E-05	4.93E-05	4.91E-05	4.95E-05	nodata	4.92E-05	4.91E-05	4.96E-05	4.98E-05	4.92E-05	4.97E-05	9.72E-07	0.02
Rh-103	2.34E-05	2.56E-05	2.59E-05	2.52E-05	2.54E-05	2.55E-05	2.68E-05	2.55E-05	2.55E-05	2.65E-05	2.62E-05	2.57E-05	2.55E-05	2.61E-05	2.70E-05	2.57E-05	1.77E-06	0.07
Ag-109	3.38E-06	4.01E-06	4.29E-06	nodata	4.12E-06	3.97E-06	4.31E-06	4.35E-06	4.15E-06	nodata	4.86E-06	4.63E-06	4.82E-06	4.86E-06	4.84E-06	4.29E-06	8.98E-07	0.21
Cs-133	5.40E-05	5.44E-05	5.54E-05	5.34E-05	5.39E-05	5.34E-05	5.50E-05	5.54E-05	5.55E-05	5.64E-05	5.62E-05	5.55E-05	5.60E-05	5.63E-05	5.53E-05	5.50E-05	2.11E-06	0.04
Sm-147	4.61E-06	4.61E-06	4.09E-06	nodata	4.67E-06	4.47E-06	4.56E-06	4.71E-06	4.68E-06	nodata	4.72E-06	4.71E-06	4.60E-06	4.54E-06	4.48E-06	4.56E-06	3.57E-07	0.08
Sm-149	5.26E-08	4.84E-08	5.10E-08	5.11E-08	5.34E-08	4.94E-08	4.94E-08	4.82E-08	4.78E-08	4.93E-08	4.80E-08	4.57E-08	5.49E-08	5.60E-08	5.51E-08	5.07E-08	5.52E-09	0.11
Sm-150	1.17E-05	1.14E-05	1.20E-05	1.09E-05	1.21E-05	1.13E-05	1.25E-05	1.15E-05	1.13E-05	1.22E-05	1.09E-05	1.13E-05	1.26E-05	1.23E-05	1.20E-05	1.17E-05	1.06E-06	0.09
Sm-151	3.48E-07	3.23E-07	3.36E-07	3.28E-07	3.12E-07	3.40E-07	3.93E-07	3.15E-07	3.17E-07	3.41E-07	3.56E-07	3.15E-07	3.99E-07	4.19E-07	3.45E-07	3.44E-07	6.20E-08	0.18
Sm-152	4.98E-06	5.10E-06	5.17E-06	5.48E-06	4.76E-06	5.39E-06	5.68E-06	5.70E-06	5.83E-06	6.49E-06	6.00E-06	5.58E-06	5.77E-06	5.70E-06	5.59E-06	5.53E-06	9.24E-07	0.17
Nd-143	3.24E-05	3.17E-05	3.17E-05	3.13E-05	3.16E-05	3.17E-05	3.23E-05	3.35E-05	3.09E-05	3.19E-05	3.24E-05	3.21E-05	3.14E-05	3.24E-05	3.21E-05	3.20E-05	1.29E-06	0.04
Nd-145	2.96E-05	3.05E-05	3.03E-05	2.99E-05	3.04E-05	3.05E-05	3.01E-05	3.06E-05	3.02E-05	3.11E-05	3.06E-05	3.06E-05	3.06E-05	3.06E-05	3.03E-05	3.04E-05	7.49E-07	0.02
Eu-153	4.52E-06	4.89E-06	5.04E-06	4.34E-06	4.81E-06	4.82E-06	4.39E-06	4.18E-06	4.39E-06	4.43E-06	4.37E-06	4.31E-06	4.31E-06	4.89E-06	4.84E-06	4.61E-06	5.56E-07	0.12
Eu-155	5.90E-07	2.41E-07	2.37E-07	2.92E-07	2.52E-07	2.45E-07	4.77E-07	2.70E-07	2.09E-07	3.15E-07	2.91E-07	2.87E-07	4.55E-07	2.22E-07	4.82E-07	3.17E-07	2.40E-07	0.76
Gd-155	1.26E-08	1.29E-08	1.33E-08	1.76E-30	1.49E-08	1.13E-09	1.22E-08	1.31E-08	1.20E-09	1.18E-08	1.47E-08	1.64E-09	1.28E-08	1.51E-09	1.64E-08	9.67E-09	1.23E-08	1.28
Gd-156	6.87E-05	7.02E-05	7.11E-05	3.42E-05	7.15E-05	2.78E-06	6.99E-05	7.11E-05	3.19E-06	6.79E-05	7.12E-05	3.07E-06	7.02E-05	3.32E-06	7.48E-05	5.23E-05	5.97E-05	1.14
Gd-157	7.67E-09	1.26E-08	1.02E-08	0.00E+00	1.12E-08	2.14E-09	1.20E-08	1.17E-08	1.87E-09	9.44E-09	1.30E-08	1.84E-09	8.29E-09	2.10E-09	1.18E-08	8.13E-09	9.61E-09	1.18
Gd-158	8.18E-05	8.36E-05	8.19E-05	4.15E-05	8.25E-05	7.18E-07	8.31E-05	8.28E-05	6.44E-07	8.25E-05	8.32E-05	5.81E-07	8.26E-05	6.51E-07	8.60E-05	6.08E-05	7.23E-05	1.19
Xe-131	2.06E-05	2.09E-05	2.13E-05	2.15E-05	2.11E-05	2.06E-05	2.06E-05	2.20E-05	2.09E-05	2.16E-05	2.16E-05	2.10E-05	2.13E-05	2.08E-05	2.07E-05	2.11E-05	9.18E-07	0.04

* Participants **N** and **P** are omitted from the average and standard deviations.

Table 4.2. Results for Case 1b (No void, 40 GWd/tHM, 5 y cooling) actinides and FPs [$10^{24}/cm^3$] reported by participants*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	Ave.	2σ	$2\sigma^{(r)}$
U-234	4.80E-06	4.72E-06	4.68E-06	4.84E-06	4.70E-06	4.74E-06	4.73E-06	5.15E-06	4.56E-06	4.69E-06	4.95E-06	4.79E-06	4.67E-06	4.63E-06	4.61E-06	4.75E-06	3.12E-07	0.07
U-235	1.60E-04	1.59E-04	1.58E-04	1.68E-04	1.63E-04	1.64E-04	1.58E-04	1.54E-04	1.55E-04	1.50E-04	1.65E-04	1.53E-04	1.54E-04	1.49E-04	1.59E-04	1.59E-04	1.13E-05	0.07
U-236	1.18E-04	1.16E-04	1.15E-04	1.12E-04	1.17E-04	1.15E-04	1.17E-04	1.19E-04	1.18E-04	1.15E-04	1.14E-04	1.14E-04	1.18E-04	1.19E-04	1.14E-04	1.16E-04	4.36E-06	0.04
U-238	2.12E-02	2.12E-02	2.12E-02	2.13E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.11E-02	2.13E-02	2.12E-02	2.12E-02	8.73E-05	0.00
Pu-238	3.60E-06	3.12E-06	3.58E-06	3.15E-06	3.68E-06	3.29E-06	3.65E-06	3.71E-06	3.03E-06	3.86E-06	3.33E-06	3.38E-06	3.52E-06	3.89E-06	3.77E-06	3.51E-06	5.84E-07	0.17
Pu-239	8.46E-05	8.66E-05	8.45E-05	7.77E-05	8.66E-05	8.88E-05	8.23E-05	8.35E-05	7.89E-05	7.87E-05	8.45E-05	8.15E-05	8.12E-05	8.96E-05	8.96E-05	8.43E-05	8.06E-06	0.10
Pu-240	4.97E-05	5.27E-05	5.21E-05	4.67E-05	5.40E-05	5.16E-05	5.28E-05	5.02E-05	5.21E-05	4.93E-05	5.38E-05	5.14E-05	5.13E-05	5.13E-05	4.85E-05	5.11E-05	4.33E-06	0.08
Pu-241	1.69E-05	1.70E-05	1.70E-05	1.52E-05	1.70E-05	1.72E-05	1.72E-05	1.70E-05	1.55E-05	1.67E-05	1.80E-05	1.75E-05	1.62E-05	1.88E-05	1.88E-05	1.71E-05	2.09E-06	0.12
Pu-242	1.27E-05	1.25E-05	1.29E-05	1.12E-05	1.23E-05	1.23E-05	1.30E-05	1.29E-05	1.21E-05	1.35E-05	1.34E-05	1.30E-05	1.46E-05	1.42E-05	1.41E-05	1.29E-05	1.64E-06	0.13
Am-241	5.45E-06	5.45E-06	5.35E-06	4.97E-06	5.43E-06	5.54E-06	5.51E-06	5.47E-06	4.97E-06	5.20E-06	5.79E-06	5.62E-06	5.22E-06	6.05E-06	5.87E-06	5.47E-06	6.31E-07	0.12
Am-243	2.08E-06	1.95E-06	2.07E-06	1.51E-06	1.96E-06	2.05E-06	2.10E-06	2.01E-06	1.94E-06	1.93E-06	2.11E-06	1.98E-06	2.63E-06	2.71E-06	2.25E-06	2.05E-06	5.23E-07	0.26
Np-237	9.87E-06	8.01E-06	9.68E-06	9.90E-06	9.57E-06	8.62E-06	9.86E-06	1.02E-05	8.24E-06	1.09E-05	9.34E-06	9.65E-06	9.70E-06	1.04E-05	1.01E-05	9.59E-06	1.68E-06	0.18
Mo-95	nodata	5.29E-05	5.26E-05	nodata	5.21E-05	5.27E-05	5.19E-05	5.32E-05	5.23E-05	nodata	5.26E-05	5.27E-05	5.30E-05	5.33E-05	5.27E-05	5.26E-05	8.84E-07	0.02
Tc-99	nodata	5.27E-05	5.22E-05	5.01E-05	5.21E-05	5.18E-05	5.27E-05	5.23E-05	5.18E-05	nodata	5.29E-05	5.26E-05	5.20E-05	5.24E-05	5.36E-05	5.22E-05	1.78E-06	0.03
Ru-101	nodata	5.01E-05	5.05E-05	nodata	5.01E-05	4.99E-05	4.93E-05	4.91E-05	4.95E-05	nodata	4.92E-05	4.91E-05	4.96E-05	4.98E-05	4.92E-05	4.97E-05	9.72E-07	0.02
Rh-103	2.34E-05	2.74E-05	2.79E-05	2.69E-05	2.71E-05	2.73E-05	2.86E-05	2.73E-05	2.73E-05	nodata	2.80E-05	2.75E-05	2.73E-05	2.79E-05	2.88E-05	2.73E-05	2.70E-06	0.10
Ag-109	3.38E-06	4.01E-06	4.29E-06	nodata	4.12E-06	3.97E-06	4.32E-06	4.35E-06	4.15E-06	nodata	4.87E-06	4.63E-06	4.82E-06	4.86E-06	4.85E-06	4.29E-06	9.02E-07	0.21
Cs-133	5.40E-05	5.47E-05	5.58E-05	5.38E-05	5.42E-05	5.37E-05	5.53E-05	5.57E-05	5.58E-05	nodata	5.65E-05	5.58E-05	5.62E-05	5.66E-05	5.57E-05	5.52E-05	2.09E-06	0.04
Sm-147	9.55E-06	1.01E-05	9.65E-06	nodata	1.02E-05	9.66E-06	9.83E-06	1.03E-05	1.02E-05	nodata	1.02E-05	1.02E-05	9.87E-06	9.79E-06	9.68E-06	9.92E-06	5.39E-07	0.05
Sm-149	8.78E-08	8.30E-08	9.26E-08	8.42E-08	8.53E-08	8.39E-08	8.45E-08	8.42E-08	8.28E-08	nodata	7.88E-08	7.75E-08	9.24E-08	9.33E-08	9.29E-08	8.61E-08	9.17E-09	0.11
Sm-150	1.17E-05	1.14E-05	1.20E-05	1.09E-05	1.21E-05	1.13E-05	1.25E-05	1.15E-05	1.13E-05	nodata	1.09E-05	1.13E-05	1.26E-05	1.23E-05	1.20E-05	1.16E-05	1.06E-06	0.09
Sm-151	3.33E-07	3.17E-07	3.30E-07	3.21E-07	3.00E-07	3.34E-07	3.85E-07	3.10E-07	3.11E-07	nodata	3.49E-07	3.10E-07	3.91E-07	4.10E-07	3.39E-07	3.37E-07	6.37E-08	0.19
Sm-152	4.98E-06	5.10E-06	5.17E-06	5.48E-06	4.76E-06	5.39E-06	5.68E-06	5.70E-06	5.83E-06	nodata	6.00E-06	5.58E-06	5.77E-06	5.70E-06	5.59E-06	5.45E-06	7.51E-07	0.14
Nd-143	3.24E-05	3.23E-05	3.23E-05	3.20E-05	3.22E-05	3.23E-05	3.29E-05	3.43E-05	3.15E-05	nodata	3.30E-05	3.27E-05	3.20E-05	3.30E-05	3.27E-05	3.26E-05	1.38E-06	0.04
Nd-145	2.96E-05	3.05E-05	3.03E-05	3.00E-05	3.04E-05	3.05E-05	3.01E-05	3.06E-05	3.02E-05	nodata	3.06E-05	3.06E-05	3.06E-05	3.06E-05	3.04E-05	3.03E-05	6.22E-07	0.02
Eu-153	4.52E-06	4.91E-06	5.07E-06	4.37E-06	4.83E-06	4.85E-06	4.42E-06	4.21E-06	4.42E-06	nodata	4.39E-06	4.34E-06	4.34E-06	4.92E-06	4.87E-06	4.65E-06	5.75E-07	0.12
Eu-155	2.83E-07	1.20E-07	1.18E-07	1.44E-07	1.26E-07	1.22E-07	2.37E-07	1.34E-07	9.96E-08	nodata	1.45E-07	1.43E-07	2.17E-07	1.06E-07	2.40E-07	1.56E-07	1.22E-07	0.78
Gd-155	1.26E-08	1.34E-07	1.32E-07	1.76E-30	1.42E-07	1.24E-07	2.36E-07	1.49E-07	1.11E-07	nodata	1.61E-07	1.46E-07	2.51E-07	1.18E-07	2.59E-07	1.31E-07	1.48E-07	1.13
Gd-156	6.87E-05	7.03E-05	7.12E-05	3.42E-05	7.16E-05	2.89E-06	7.00E-05	7.13E-05	3.32E-06	nodata	7.13E-05	3.19E-06	7.03E-05	3.45E-06	7.49E-05	5.11E-05	6.15E-05	1.20
Gd-157	7.67E-09	1.31E-08	1.08E-08	0.00E+00	1.12E-08	2.71E-09	1.20E-08	1.27E-08	2.38E-09	nodata	1.30E-08	1.85E-09	8.80E-09	2.61E-09	1.23E-08	8.37E-09	1.00E-08	1.20
Gd-158	8.18E-05	8.36E-05	8.19E-05	4.15E-05	8.25E-05	7.18E-07	8.31E-05	8.28E-05	6.44E-07	nodata	8.32E-05	5.81E-07	8.26E-05	6.51E-07	8.60E-05	5.90E-05	7.43E-05	1.26
Xe-131	2.06E-05	2.12E-05	2.16E-05	2.17E-05	2.11E-05	2.08E-05	2.09E-05	2.22E-05	2.11E-05	nodata	2.19E-05	2.12E-05	2.15E-05	2.10E-05	2.09E-05	2.12E-05	9.76E-07	0.05

* Participants **N** and **P** are omitted from the average and standard deviations.

Table 4.3. Results for Case 2a (40% void, 40 GWd/tHM, Not cooling) actinides and FPs [10^{24}/cm^3] reported by participants*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	Ave.	2σ	$2\sigma^{(r)}$
U-234	4.51E-06	4.52E-06	4.45E-06	4.55E-06	4.48E-06	4.50E-06	4.49E-06	4.95E-06	4.34E-06	4.42E-06	4.73E-06	4.52E-06	4.39E-06	4.34E-06	4.35E-06	4.51E-06	3.38E-07	0.08
U-235	1.86E-04	1.85E-04	1.86E-04	1.90E-04	1.89E-04	1.89E-04	1.84E-04	1.78E-04	1.99E-04	1.81E-04	1.93E-04	1.83E-04	1.78E-04	1.76E-04	1.90E-04	1.87E-04	1.24E-05	0.07
U-236	1.16E-04	1.15E-04	1.13E-04	1.11E-04	1.16E-04	1.14E-04	1.16E-04	1.18E-04	1.17E-04	1.13E-04	1.13E-04	1.12E-04	1.17E-04	1.19E-04	1.13E-04	1.15E-04	4.94E-06	0.04
U-238	2.11E-02	2.11E-02	2.11E-02	2.12E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.13E-02	2.11E-02	2.11E-02	1.19E-04	0.01
Pu-238	4.16E-06	3.46E-06	4.05E-06	3.67E-06	4.33E-06	3.71E-06	4.16E-06	4.23E-06	4.03E-06	4.60E-06	3.79E-06	3.96E-06	4.10E-06	4.51E-06	4.45E-06	4.09E-06	7.00E-07	0.17
Pu-239	9.94E-05	1.02E-04	1.00E-04	8.94E-05	1.02E-04	1.05E-04	9.66E-05	9.77E-05	1.10E-04	9.86E-05	1.02E-04	1.02E-04	9.51E-05	1.06E-04	1.09E-04	1.01E-04	1.10E-05	0.11
Pu-240	5.20E-05	5.55E-05	5.51E-05	4.75E-05	5.73E-05	5.50E-05	5.58E-05	5.29E-05	5.64E-05	5.24E-05	5.68E-05	5.40E-05	5.39E-05	5.41E-05	5.07E-05	5.40E-05	5.57E-06	0.10
Pu-241	2.53E-05	2.50E-05	2.53E-05	2.26E-05	2.56E-05	2.55E-05	2.59E-05	2.54E-05	2.73E-05	2.58E-05	2.71E-05	2.76E-05	2.45E-05	2.83E-05	2.92E-05	2.60E-05	3.31E-06	0.13
Pu-242	1.28E-05	1.26E-05	1.29E-05	1.15E-05	1.25E-05	1.23E-05	1.30E-05	1.29E-05	1.22E-05	1.39E-05	1.35E-05	1.32E-05	1.45E-05	1.42E-05	1.45E-05	1.30E-05	1.69E-06	0.13
Am-241	1.03E-06	1.02E-06	9.15E-07	9.31E-07	9.75E-07	1.05E-06	1.04E-06	1.05E-06	1.15E-06	1.03E-06	1.14E-06	1.16E-06	1.02E-06	1.17E-06	1.18E-06	1.05E-06	1.73E-07	0.16
Am-243	2.44E-06	2.25E-06	2.36E-06	1.78E-06	2.29E-06	2.35E-06	2.43E-06	2.32E-06	2.46E-06	2.27E-06	2.45E-06	2.33E-06	2.98E-06	3.09E-06	2.66E-06	2.40E-06	5.77E-07	0.24
Np-237	1.11E-05	8.68E-06	1.08E-05	1.10E-05	1.04E-05	9.51E-06	1.08E-05	1.12E-05	1.03E-05	1.25E-05	1.03E-05	1.09E-05	1.09E-05	1.15E-05	1.16E-05	1.08E-05	1.94E-06	0.18
Mo-95	nodata	4.76E-05	4.67E-05	nodata	5.14E-05	4.75E-05	4.66E-05	4.80E-05	4.67E-05	nodata	4.73E-05	4.74E-05	4.76E-05	4.80E-05	4.74E-05	4.77E-05	2.78E-06	0.06
Tc-99	nodata	5.23E-05	5.16E-05	4.90E-05	5.16E-05	5.14E-05	5.22E-05	5.18E-05	5.08E-05	5.12E-05	5.23E-05	5.19E-05	5.08E-05	5.16E-05	5.28E-05	5.16E-05	1.95E-06	0.04
Ru-101	nodata	5.00E-05	5.03E-05	nodata	5.00E-05	4.98E-05	4.92E-05	4.89E-05	4.91E-05	nodata	4.90E-05	4.89E-05	4.94E-05	4.96E-05	4.90E-05	4.95E-05	1.02E-06	0.02
Rh-103	2.36E-05	2.58E-05	2.62E-05	2.53E-05	2.57E-05	2.59E-05	2.68E-05	2.58E-05	2.62E-05	2.73E-05	2.66E-05	2.62E-05	2.53E-05	2.63E-05	2.74E-05	2.61E-05	1.96E-06	0.08
Ag-109	3.43E-06	4.16E-06	4.43E-06	nodata	4.31E-06	4.10E-06	4.51E-06	4.54E-06	4.46E-06	nodata	5.08E-06	4.84E-06	4.88E-06	5.01E-06	5.08E-06	4.46E-06	9.76E-07	0.22
Cs-133	5.32E-05	5.40E-05	5.49E-05	5.24E-05	5.35E-05	5.28E-05	5.52E-05	5.50E-05	5.47E-05	5.57E-05	5.56E-05	5.48E-05	5.53E-05	5.56E-05	5.45E-05	5.44E-05	2.23E-06	0.04
Sm-147	4.36E-06	4.40E-06	3.89E-06	nodata	4.49E-06	4.23E-06	4.33E-06	4.50E-06	4.29E-06	nodata	4.49E-06	4.46E-06	4.25E-06	4.26E-06	4.23E-06	4.32E-06	3.47E-07	0.08
Sm-149	6.58E-08	5.98E-08	6.38E-08	6.06E-08	6.64E-08	6.14E-08	6.26E-08	6.01E-08	7.24E-08	6.17E-08	6.08E-08	6.02E-08	6.81E-08	7.10E-08	7.01E-08	6.43E-08	8.82E-09	0.14
Sm-150	1.19E-05	1.16E-05	1.22E-05	1.10E-05	1.23E-05	1.15E-05	1.26E-05	1.17E-05	1.16E-05	1.25E-05	1.11E-05	1.17E-05	1.30E-05	1.25E-05	1.20E-05	1.19E-05	1.07E-06	0.09
Sm-151	4.24E-07	3.88E-07	4.07E-07	3.83E-07	3.71E-07	4.15E-07	4.59E-07	3.75E-07	4.56E-07	4.25E-07	4.34E-07	3.88E-07	4.81E-07	5.14E-07	4.32E-07	4.22E-07	7.96E-08	0.19
Sm-152	4.74E-06	4.88E-06	4.92E-06	5.26E-06	4.46E-06	5.25E-06	5.47E-06	5.49E-06	5.53E-06	6.38E-06	5.87E-06	5.32E-06	5.44E-06	5.49E-06	5.41E-06	5.32E-06	1.00E-06	0.19
Nd-143	3.39E-05	3.31E-05	3.31E-05	3.22E-05	3.31E-05	3.31E-05	3.34E-05	3.51E-05	3.37E-05	3.38E-05	3.39E-05	3.39E-05	3.30E-05	3.40E-05	3.38E-05	3.36E-05	1.38E-06	0.04
Nd-145	2.91E-05	3.02E-05	3.00E-05	2.95E-05	3.01E-05	3.02E-05	2.96E-05	3.03E-05	2.96E-05	3.09E-05	3.02E-05	3.03E-05	3.02E-05	3.02E-05	2.99E-05	3.00E-05	9.09E-07	0.03
Eu-153	4.72E-06	4.98E-06	5.16E-06	4.46E-06	4.92E-06	4.93E-06	4.52E-06	4.28E-06	4.58E-06	4.57E-06	4.45E-06	4.43E-06	4.51E-06	4.98E-06	4.96E-06	4.73E-06	5.42E-07	0.11
Eu-155	6.78E-07	2.84E-07	2.79E-07	3.07E-07	3.05E-07	2.89E-07	5.41E-07	2.77E-07	2.21E-07	3.34E-07	3.01E-07	2.99E-07	5.45E-07	2.28E-07	5.45E-07	3.53E-07	2.82E-07	0.80
Gd-155	1.55E-08	1.59E-08	1.66E-08	1.51E-26	1.90E-08	1.69E-09	1.45E-08	1.59E-08	2.05E-09	1.48E-08	1.82E-08	2.31E-09	1.62E-08	2.10E-09	2.13E-08	1.21E-08	1.53E-08	1.26
Gd-156	6.82E-05	6.95E-05	7.05E-05	3.42E-05	7.10E-05	2.89E-06	6.90E-05	7.08E-05	3.32E-06	6.71E-05	7.06E-05	3.13E-06	6.98E-05	3.44E-06	7.41E-05	5.19E-05	5.90E-05	1.14
Gd-157	1.14E-08	1.85E-08	1.52E-08	0.00E+00	1.65E-08	2.79E-09	1.82E-08	1.62E-08	3.13E-09	1.50E-08	1.93E-08	2.68E-09	1.20E-08	2.84E-09	1.79E-08	1.21E-08	1.43E-08	1.19
Gd-158	8.20E-05	8.41E-05	8.22E-05	4.15E-05	8.27E-05	7.58E-07	8.35E-05	8.31E-05	7.10E-07	8.28E-05	8.36E-05	6.33E-07	8.33E-05	6.88E-07	8.63E-05	6.11E-05	7.26E-05	1.19
Xe-131	2.01E-05	2.05E-05	2.09E-05	2.12E-05	2.06E-05	2.01E-05	2.01E-05	2.17E-05	2.02E-05	2.14E-05	2.13E-05	2.06E-05	2.07E-05	2.03E-05	2.01E-05	2.07E-05	1.17E-06	0.06

* Participants **N** and **P** are omitted from the average and standard deviations.

Table 4.4. Results for Case 2b (40% void, 40 GWd/tHM, 5 y cooling) actinides and FPs [$10^{24}/cm^3$] reported by participants*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	Ave.	2σ	$2\sigma^{(r)}$
U-234	4.69E-06	4.66E-06	4.62E-06	4.71E-06	4.66E-06	4.66E-06	4.66E-06	5.13E-06	4.34E-06	4.61E-06	4.90E-06	4.69E-06	4.56E-06	4.53E-06	4.54E-06	4.67E-06	3.72E-07	0.08
U-235	1.86E-04	1.85E-04	1.86E-04	1.90E-04	1.89E-04	1.89E-04	1.84E-04	1.78E-04	1.99E-04	1.81E-04	1.93E-04	1.83E-04	1.78E-04	1.76E-04	1.90E-04	1.87E-04	1.24E-05	0.07
U-236	1.16E-04	1.15E-04	1.13E-04	1.11E-04	1.16E-04	1.14E-04	1.16E-04	1.18E-04	1.17E-04	1.13E-04	1.13E-04	1.12E-04	1.17E-04	1.19E-04	1.13E-04	1.15E-04	4.93E-06	0.04
U-238	2.11E-02	2.11E-02	2.11E-02	2.12E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.13E-02	2.11E-02	2.11E-02	1.19E-04	0.01
Pu-238	4.35E-06	3.66E-06	4.22E-06	3.82E-06	4.50E-06	3.90E-06	4.37E-06	4.43E-06	4.23E-06	4.75E-06	4.01E-06	4.17E-06	4.29E-06	4.70E-06	4.68E-06	4.28E-06	6.97E-07	0.16
Pu-239	1.01E-04	1.03E-04	1.02E-04	9.06E-05	1.03E-04	1.06E-04	9.79E-05	9.90E-05	1.11E-04	9.86E-05	1.03E-04	1.03E-04	9.63E-05	1.07E-04	1.11E-04	1.03E-04	1.13E-05	0.11
Pu-240	5.22E-05	5.56E-05	5.52E-05	4.76E-05	5.74E-05	5.51E-05	5.59E-05	5.30E-05	5.64E-05	5.25E-05	5.69E-05	5.41E-05	5.39E-05	5.43E-05	5.08E-05	5.41E-05	5.56E-06	0.10
Pu-241	1.98E-05	1.97E-05	1.99E-05	1.77E-05	2.01E-05	2.00E-05	2.04E-05	1.99E-05	2.14E-05	2.04E-05	2.13E-05	2.17E-05	1.93E-05	2.22E-05	2.31E-05	2.05E-05	2.67E-06	0.13
Pu-242	1.28E-05	1.26E-05	1.29E-05	1.15E-05	1.25E-05	1.23E-05	1.30E-05	1.29E-05	1.22E-05	1.39E-05	1.35E-05	1.32E-05	1.45E-05	1.42E-05	1.45E-05	1.30E-05	1.69E-06	0.13
Am-241	6.44E-06	6.36E-06	6.30E-06	5.81E-06	6.43E-06	6.50E-06	6.55E-06	6.46E-06	6.97E-06	6.42E-06	6.90E-06	7.01E-06	6.27E-06	7.21E-06	7.27E-06	6.59E-06	8.04E-07	0.12
Am-243	2.44E-06	2.25E-06	2.36E-06	1.78E-06	2.29E-06	2.35E-06	2.43E-06	2.32E-06	2.46E-06	2.27E-06	2.45E-06	2.34E-06	2.98E-06	3.09E-06	2.66E-06	2.40E-06	5.77E-07	0.24
Np-237	1.11E-05	8.81E-06	1.08E-05	1.12E-05	1.05E-05	9.65E-06	1.10E-05	1.14E-05	1.04E-05	1.26E-05	1.05E-05	1.11E-05	1.11E-05	1.17E-05	1.18E-05	1.09E-05	1.93E-06	0.18
Mo-95	nodata	5.22E-05	5.19E-05	nodata	5.14E-05	5.20E-05	5.12E-05	5.26E-05	5.13E-05	nodata	5.19E-05	5.20E-05	5.22E-05	5.25E-05	5.20E-05	5.19E-05	9.69E-07	0.02
Tc-99	nodata	5.23E-05	5.18E-05	4.92E-05	5.18E-05	5.14E-05	5.24E-05	5.19E-05	5.09E-05	nodata	5.25E-05	5.21E-05	5.10E-05	5.17E-05	5.29E-05	5.17E-05	2.01E-06	0.04
Ru-101	nodata	5.00E-05	5.03E-05	nodata	5.00E-05	4.98E-05	4.92E-05	4.89E-05	4.91E-05	nodata	4.90E-05	4.89E-05	4.94E-05	4.96E-05	4.90E-05	4.95E-05	1.02E-06	0.02
Rh-103	2.36E-05	2.77E-05	2.83E-05	2.70E-05	2.74E-05	2.77E-05	2.87E-05	2.76E-05	2.81E-05	nodata	2.84E-05	2.81E-05	2.71E-05	2.82E-05	2.92E-05	2.76E-05	2.83E-06	0.10
Ag-109	3.43E-06	4.16E-06	4.43E-06	nodata	4.31E-06	4.10E-06	4.51E-06	4.55E-06	4.46E-06	nodata	5.08E-06	4.85E-06	4.89E-06	5.02E-06	5.08E-06	4.47E-06	9.80E-07	0.22
Cs-133	5.32E-05	5.43E-05	5.52E-05	5.28E-05	5.38E-05	5.31E-05	5.55E-05	5.53E-05	5.50E-05	nodata	5.60E-05	5.52E-05	5.57E-05	5.59E-05	5.49E-05	5.46E-05	2.26E-06	0.04
Sm-147	9.12E-06	9.77E-06	9.35E-06	nodata	9.98E-06	9.27E-06	9.45E-06	1.00E-05	9.58E-06	nodata	9.84E-06	9.77E-06	9.25E-06	9.34E-06	9.29E-06	9.54E-06	6.13E-07	0.06
Sm-149	1.01E-07	9.44E-08	1.05E-07	9.37E-08	9.87E-08	9.60E-08	9.74E-08	9.57E-08	1.07E-07	nodata	9.18E-08	9.18E-08	1.06E-07	1.08E-07	1.07E-07	9.97E-08	1.16E-08	0.12
Sm-150	1.19E-05	1.16E-05	1.22E-05	1.10E-05	1.23E-05	1.15E-05	1.26E-05	1.17E-05	1.16E-05	nodata	1.11E-05	1.17E-05	1.30E-05	1.25E-05	1.20E-05	1.18E-05	1.05E-06	0.09
Sm-151	4.06E-07	3.80E-07	3.99E-07	3.75E-07	3.58E-07	4.05E-07	4.49E-07	3.67E-07	4.45E-07	nodata	4.24E-07	3.80E-07	4.69E-07	5.01E-07	4.23E-07	4.11E-07	8.15E-08	0.20
Sm-152	4.74E-06	4.88E-06	4.92E-06	5.26E-06	4.46E-06	5.25E-06	5.47E-06	5.49E-06	5.53E-06	nodata	5.87E-06	5.32E-06	5.44E-06	5.49E-06	5.41E-06	5.23E-06	8.06E-07	0.15
Nd-143	3.39E-05	3.37E-05	3.37E-05	3.29E-05	3.37E-05	3.37E-05	3.40E-05	3.59E-05	3.43E-05	nodata	3.45E-05	3.45E-05	3.36E-05	3.46E-05	3.44E-05	3.41E-05	1.47E-06	0.04
Nd-145	2.91E-05	3.02E-05	3.00E-05	2.95E-05	3.01E-05	3.02E-05	2.96E-05	3.03E-05	2.96E-05	nodata	3.02E-05	3.03E-05	3.02E-05	3.02E-05	2.99E-05	2.99E-05	7.51E-07	0.03
Eu-153	4.72E-06	5.01E-06	5.19E-06	4.49E-06	4.94E-06	4.96E-06	4.54E-06	4.31E-06	4.61E-06	nodata	4.47E-06	4.46E-06	4.54E-06	5.01E-06	4.99E-06	4.77E-06	5.61E-07	0.12
Eu-155	3.26E-07	1.41E-07	1.39E-07	1.51E-07	1.52E-07	1.44E-07	2.69E-07	1.38E-07	1.05E-07	nodata	1.50E-07	1.49E-07	2.60E-07	1.09E-07	2.71E-07	1.74E-07	1.43E-07	0.82
Gd-155	1.55E-08	1.58E-07	1.57E-07	1.51E-26	1.73E-07	1.47E-07	2.68E-07	1.55E-07	1.18E-07	nodata	1.70E-07	1.53E-07	3.01E-07	1.21E-07	2.95E-07	1.48E-07	1.69E-07	1.14
Gd-156	6.82E-05	6.96E-05	7.07E-05	3.42E-05	7.11E-05	3.00E-06	6.92E-05	7.09E-05	3.44E-06	nodata	7.07E-05	3.25E-06	6.99E-05	3.57E-06	7.43E-05	5.07E-05	6.09E-05	1.20
Gd-157	1.14E-08	1.91E-08	1.58E-08	0.00E+00	1.65E-08	3.35E-09	1.82E-08	1.71E-08	3.61E-09	nodata	1.93E-08	2.68E-09	1.25E-08	3.33E-09	1.84E-08	1.22E-08	1.49E-08	1.22
Gd-158	8.20E-05	8.41E-05	8.22E-05	4.15E-05	8.27E-05	7.58E-07	8.35E-05	8.31E-05	7.10E-07	nodata	8.36E-05	6.33E-07	8.33E-05	6.88E-07	8.63E-05	5.93E-05	7.45E-05	1.26
Xe-131	2.01E-05	2.08E-05	2.11E-05	2.14E-05	2.06E-05	2.03E-05	2.04E-05	2.20E-05	2.04E-05	nodata	2.15E-05	2.08E-05	2.09E-05	2.05E-05	2.03E-05	2.08E-05	1.18E-06	0.06

* Participants **N** and **P** are omitted from the average and standard deviations.

Table 4.5. Results for Case 3a (70% void, 40 GWd/tHM, Not cooling) actinides and FPs [10^{24}/cm^3] reported by participants*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	Ave.	2σ	$2\sigma^{(r)}$
U-234	4.36E-06	4.47E-06	4.40E-06	4.39E-06	4.47E-06	4.39E-06	4.39E-06	4.89E-06	3.92E-06	4.28E-06	4.65E-06	4.35E-06	4.21E-06	4.18E-06	4.22E-06	4.39E-06	4.61E-07	0.11
U-235	2.09E-04	2.06E-04	2.11E-04	2.17E-04	2.13E-04	2.11E-04	2.09E-04	2.01E-04	2.60E-04	2.14E-04	2.20E-04	2.16E-04	2.00E-04	1.99E-04	2.23E-04	2.15E-04	3.05E-05	0.14
U-236	1.16E-04	1.15E-04	1.12E-04	1.10E-04	1.17E-04	1.14E-04	1.16E-04	1.18E-04	1.20E-04	1.11E-04	1.13E-04	1.10E-04	1.17E-04	1.19E-04	1.14E-04	1.15E-04	6.18E-06	0.05
U-238	2.11E-02	2.11E-02	2.11E-02	2.12E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.09E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.12E-02	2.11E-02	2.11E-02	1.34E-04	0.01
Pu-238	4.98E-06	3.93E-06	4.61E-06	4.52E-06	5.25E-06	4.31E-06	4.94E-06	4.99E-06	6.32E-06	5.63E-06	4.51E-06	4.95E-06	5.01E-06	5.43E-06	5.59E-06	5.00E-06	1.29E-06	0.26
Pu-239	1.18E-04	1.19E-04	1.20E-04	1.07E-04	1.20E-04	1.26E-04	1.14E-04	1.16E-04	1.97E-04	1.28E-04	1.25E-04	1.33E-04	1.13E-04	1.26E-04	1.40E-04	1.27E-04	4.46E-05	0.35
Pu-240	5.51E-05	5.89E-05	5.88E-05	5.08E-05	6.11E-05	5.93E-05	5.95E-05	5.61E-05	6.46E-05	5.72E-05	6.05E-05	5.75E-05	5.78E-05	5.82E-05	5.40E-05	5.80E-05	6.96E-06	0.12
Pu-241	2.88E-05	2.79E-05	2.85E-05	2.63E-05	2.96E-05	2.87E-05	2.98E-05	2.90E-05	4.19E-05	3.12E-05	3.12E-05	3.43E-05	2.84E-05	3.24E-05	3.61E-05	3.09E-05	8.20E-06	0.27
Pu-242	1.26E-05	1.22E-05	1.26E-05	1.17E-05	1.23E-05	1.18E-05	1.28E-05	1.27E-05	1.10E-05	1.38E-05	1.32E-05	1.31E-05	1.41E-05	1.38E-05	1.45E-05	1.27E-05	1.91E-06	0.15
Am-241	1.21E-06	1.17E-06	1.06E-06	1.14E-06	1.13E-06	1.22E-06	1.23E-06	1.24E-06	1.93E-06	1.32E-06	1.37E-06	1.52E-06	1.22E-06	1.38E-06	1.53E-06	1.30E-06	4.52E-07	0.35
Am-243	2.73E-06	2.47E-06	2.56E-06	2.04E-06	2.54E-06	2.57E-06	2.73E-06	2.53E-06	2.92E-06	2.55E-06	2.73E-06	2.68E-06	3.25E-06	3.36E-06	3.04E-06	2.67E-06	6.29E-07	0.24
Np-237	1.23E-05	9.19E-06	1.15E-05	1.24E-05	1.09E-05	1.04E-05	1.18E-05	1.23E-05	1.37E-05	1.43E-05	1.13E-05	1.25E-05	1.21E-05	1.27E-05	1.34E-05	1.20E-05	2.80E-06	0.23
Mo-95	nodata	4.70E-05	4.60E-05	nodata	5.07E-05	4.68E-05	4.59E-05	4.74E-05	4.51E-05	nodata	4.66E-05	4.66E-05	4.68E-05	4.72E-05	4.66E-05	4.69E-05	2.98E-06	0.06
Tc-99	nodata	5.21E-05	5.13E-05	4.82E-05	5.15E-05	5.09E-05	5.19E-05	5.14E-05	4.94E-05	5.06E-05	5.19E-05	5.14E-05	4.96E-05	5.08E-05	5.21E-05	5.10E-05	2.32E-06	0.05
Ru-101	nodata	4.99E-05	5.00E-05	nodata	4.98E-05	4.97E-05	4.90E-05	4.87E-05	4.83E-05	nodata	4.88E-05	4.88E-05	4.90E-05	4.92E-05	4.87E-05	4.92E-05	1.21E-06	0.02
Rh-103	2.36E-05	2.59E-05	2.64E-05	2.58E-05	2.57E-05	2.61E-05	2.67E-05	2.60E-05	2.70E-05	2.82E-05	2.70E-05	2.67E-05	2.46E-05	2.63E-05	2.78E-05	2.63E-05	2.28E-06	0.09
Ag-109	3.43E-06	4.28E-06	4.55E-06	nodata	4.52E-06	4.19E-06	4.68E-06	4.69E-06	4.87E-06	nodata	5.27E-06	5.06E-06	4.85E-06	5.10E-06	5.32E-06	4.63E-06	1.08E-06	0.23
Cs-133	5.23E-05	5.37E-05	5.44E-05	5.16E-05	5.32E-05	5.21E-05	5.45E-05	5.45E-05	5.31E-05	5.49E-05	5.51E-05	5.41E-05	5.43E-05	5.47E-05	5.36E-05	5.37E-05	2.28E-06	0.04
Sm-147	4.11E-06	4.21E-06	3.71E-06	nodata	4.34E-06	3.98E-06	4.09E-06	4.31E-06	3.66E-06	nodata	4.25E-06	4.16E-06	3.81E-06	3.95E-06	3.97E-06	4.05E-06	4.52E-07	0.11
Sm-149	8.18E-08	7.22E-08	7.84E-08	7.48E-08	8.21E-08	7.52E-08	7.96E-08	7.43E-08	1.51E-07	8.04E-08	7.70E-08	8.39E-08	8.71E-08	8.97E-08	9.62E-08	8.56E-08	4.13E-08	0.48
Sm-150	1.22E-05	1.18E-05	1.23E-05	1.11E-05	1.25E-05	1.16E-05	1.26E-05	1.19E-05	1.18E-05	1.26E-05	1.12E-05	1.20E-05	1.34E-05	1.26E-05	1.21E-05	1.20E-05	1.05E-06	0.09
Sm-151	5.20E-07	4.59E-07	4.89E-07	4.64E-07	4.46E-07	5.03E-07	5.36E-07	4.48E-07	8.41E-07	5.43E-07	5.32E-07	4.96E-07	5.86E-07	6.31E-07	5.70E-07	5.37E-07	2.11E-07	0.39
Sm-152	4.52E-06	4.70E-06	4.69E-06	5.07E-06	4.16E-06	5.13E-06	5.27E-06	5.28E-06	5.05E-06	6.25E-06	5.75E-06	5.02E-06	5.06E-06	5.28E-06	5.26E-06	5.11E-06	1.07E-06	0.21
Nd-143	3.52E-05	3.41E-05	3.41E-05	3.33E-05	3.44E-05	3.43E-05	3.43E-05	3.65E-05	3.68E-05	3.56E-05	3.51E-05	3.56E-05	3.42E-05	3.53E-05	3.54E-05	3.50E-05	2.01E-06	0.06
Nd-145	2.86E-05	3.02E-05	2.96E-05	2.91E-05	2.99E-05	2.99E-05	2.91E-05	3.00E-05	2.85E-05	3.07E-05	2.99E-05	2.99E-05	2.97E-05	2.97E-05	2.94E-05	2.96E-05	1.23E-06	0.04
Eu-153	4.85E-06	4.99E-06	5.21E-06	4.59E-06	4.96E-06	4.97E-06	4.60E-06	4.36E-06	4.68E-06	4.68E-06	4.48E-06	4.52E-06	4.67E-06	5.00E-06	5.05E-06	4.80E-06	5.08E-07	0.11
Eu-155	7.77E-07	3.32E-07	3.29E-07	3.18E-07	3.78E-07	3.43E-07	6.15E-07	2.77E-07	2.48E-07	3.54E-07	3.12E-07	3.13E-07	6.74E-07	2.35E-07	6.22E-07	3.95E-07	3.33E-07	0.84
Gd-155	1.95E-08	1.98E-08	2.13E-08	2.02E-22	2.51E-08	2.51E-09	1.80E-08	1.98E-08	5.31E-09	1.95E-08	2.34E-08	3.44E-09	2.16E-08	2.81E-09	3.08E-08	1.60E-08	1.97E-08	1.23
Gd-156	6.78E-05	6.87E-05	7.00E-05	3.42E-05	7.05E-05	3.00E-06	6.81E-05	7.04E-05	3.50E-06	6.63E-05	6.99E-05	3.20E-06	6.94E-05	3.60E-06	7.34E-05	5.15E-05	5.83E-05	1.13
Gd-157	1.64E-08	2.65E-08	2.26E-08	0.00E+00	2.45E-08	3.64E-09	2.78E-08	2.25E-08	8.31E-09	2.47E-08	2.89E-08	4.19E-09	1.77E-08	3.95E-09	3.03E-08	1.85E-08	2.15E-08	1.16
Gd-158	8.22E-05	8.47E-05	8.25E-05	4.15E-05	8.29E-05	7.96E-07	8.39E-05	8.35E-05	8.25E-07	8.33E-05	8.40E-05	6.93E-07	8.33E-05	7.31E-07	8.66E-05	6.13E-05	7.28E-05	1.19
Xe-131	1.95E-05	2.01E-05	2.03E-05	2.10E-05	1.99E-05	1.95E-05	1.95E-05	2.13E-05	1.88E-05	2.13E-05	2.09E-05	2.01E-05	1.98E-05	1.97E-05	1.94E-05	2.01E-05	1.62E-06	0.08

* Participants **N** and **P** are omitted from the average and standard deviations.

Table 4.6. Results for Case 3b (70% void, 40 GWd/tHM, 5 y cooling) actinides and FPs [$10^{24}/cm^3$] reported by participants*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	Ave.	2σ	$2\sigma^{(r)}$
U-234	4.57E-06	4.63E-06	4.56E-06	4.58E-06	4.69E-06	4.57E-06	4.59E-06	5.10E-06	3.92E-06	4.51E-06	4.84E-06	4.56E-06	4.41E-06	4.40E-06	4.45E-06	4.57E-06	5.29E-07	0.12
U-235	2.09E-04	2.06E-04	2.11E-04	2.17E-04	2.13E-04	2.11E-04	2.09E-04	2.01E-04	2.60E-04	2.14E-04	2.20E-04	2.16E-04	2.00E-04	1.99E-04	2.23E-04	2.15E-04	3.05E-05	0.14
U-236	1.16E-04	1.15E-04	1.12E-04	1.10E-04	1.17E-04	1.14E-04	1.16E-04	1.18E-04	1.20E-04	1.11E-04	1.13E-04	1.10E-04	1.17E-04	1.19E-04	1.14E-04	1.15E-04	6.17E-06	0.05
U-238	2.11E-02	2.11E-02	2.11E-02	2.12E-02	2.11E-02	2.11E-02	2.11E-02	2.11E-02	2.09E-02	2.10E-02	2.10E-02	2.10E-02	2.10E-02	2.12E-02	2.11E-02	2.11E-02	1.34E-04	0.01
Pu-238	5.16E-06	4.14E-06	4.78E-06	4.68E-06	5.43E-06	4.51E-06	5.16E-06	5.20E-06	6.53E-06	5.77E-06	4.73E-06	5.18E-06	5.20E-06	5.62E-06	5.83E-06	5.20E-06	1.29E-06	0.25
Pu-239	1.19E-04	1.21E-04	1.22E-04	1.08E-04	1.22E-04	1.27E-04	1.16E-04	1.17E-04	1.98E-04	1.28E-04	1.26E-04	1.35E-04	1.14E-04	1.27E-04	1.42E-04	1.29E-04	4.48E-05	0.35
Pu-240	5.53E-05	5.90E-05	5.89E-05	5.09E-05	6.12E-05	5.95E-05	5.97E-05	5.63E-05	6.46E-05	5.73E-05	6.06E-05	5.77E-05	5.79E-05	5.83E-05	5.41E-05	5.81E-05	6.92E-06	0.12
Pu-241	2.26E-05	2.19E-05	2.24E-05	2.06E-05	2.33E-05	2.26E-05	2.34E-05	2.27E-05	3.29E-05	2.47E-05	2.46E-05	2.70E-05	2.23E-05	2.54E-05	2.85E-05	2.43E-05	6.48E-06	0.27
Pu-242	1.26E-05	1.22E-05	1.26E-05	1.17E-05	1.23E-05	1.18E-05	1.28E-05	1.27E-05	1.10E-05	1.38E-05	1.32E-05	1.31E-05	1.41E-05	1.38E-05	1.45E-05	1.27E-05	1.91E-06	0.15
Am-241	7.37E-06	7.13E-06	7.13E-06	6.82E-06	7.45E-06	7.36E-06	7.57E-06	7.41E-06	1.09E-05	7.84E-06	8.02E-06	8.81E-06	7.28E-06	8.28E-06	9.07E-06	7.87E-06	2.14E-06	0.27
Am-243	2.73E-06	2.47E-06	2.56E-06	2.05E-06	2.54E-06	2.57E-06	2.73E-06	2.53E-06	2.92E-06	2.54E-06	2.73E-06	2.68E-06	3.25E-06	3.36E-06	3.04E-06	2.67E-06	6.29E-07	0.24
Np-237	1.23E-05	9.32E-06	1.15E-05	1.26E-05	1.10E-05	1.05E-05	1.20E-05	1.25E-05	1.39E-05	1.43E-05	1.15E-05	1.27E-05	1.23E-05	1.29E-05	1.37E-05	1.22E-05	2.83E-06	0.23
Mo-95	nodata	5.16E-05	5.12E-05	nodata	5.07E-05	5.14E-05	5.05E-05	5.20E-05	4.95E-05	nodata	5.11E-05	5.11E-05	5.13E-05	5.18E-05	5.11E-05	5.11E-05	1.44E-06	0.03
Tc-99	nodata	5.21E-05	5.14E-05	4.84E-05	5.16E-05	5.09E-05	5.20E-05	5.15E-05	4.96E-05	nodata	5.20E-05	5.15E-05	4.97E-05	5.10E-05	5.22E-05	5.12E-05	2.39E-06	0.05
Ru-101	nodata	4.99E-05	5.00E-05	nodata	4.98E-05	4.97E-05	4.90E-05	4.87E-05	4.83E-05	nodata	4.88E-05	4.88E-05	4.91E-05	4.92E-05	4.87E-05	4.92E-05	1.21E-06	0.02
Rh-103	2.36E-05	2.77E-05	2.85E-05	2.75E-05	2.75E-05	2.79E-05	2.86E-05	2.78E-05	2.89E-05	nodata	2.88E-05	2.86E-05	2.64E-05	2.82E-05	2.97E-05	2.79E-05	3.03E-06	0.11
Ag-109	3.43E-06	4.28E-06	4.55E-06	nodata	4.52E-06	4.19E-06	4.69E-06	4.70E-06	4.87E-06	nodata	5.27E-06	5.07E-06	4.86E-06	5.11E-06	5.33E-06	4.63E-06	1.09E-06	0.24
Cs-133	5.23E-05	5.40E-05	5.47E-05	5.20E-05	5.35E-05	5.24E-05	5.49E-05	5.49E-05	5.34E-05	nodata	5.54E-05	5.44E-05	5.47E-05	5.50E-05	5.39E-05	5.39E-05	2.34E-06	0.04
Sm-147	8.69E-06	9.55E-06	9.09E-06	nodata	9.86E-06	8.89E-06	9.06E-06	9.72E-06	8.57E-06	nodata	9.49E-06	9.29E-06	8.43E-06	8.82E-06	8.88E-06	9.15E-06	8.75E-07	0.10
Sm-149	1.18E-07	1.07E-07	1.19E-07	1.08E-07	1.15E-07	1.10E-07	1.14E-07	1.10E-07	1.85E-07	nodata	1.08E-07	1.15E-07	1.26E-07	1.27E-07	1.33E-07	1.21E-07	4.33E-08	0.36
Sm-150	1.22E-05	1.18E-05	1.23E-05	1.11E-05	1.25E-05	1.16E-05	1.26E-05	1.19E-05	1.18E-05	nodata	1.12E-05	1.20E-05	1.34E-05	1.26E-05	1.21E-05	1.20E-05	1.03E-06	0.09
Sm-151	4.98E-07	4.48E-07	4.78E-07	4.53E-07	4.30E-07	4.91E-07	5.23E-07	4.38E-07	8.16E-07	nodata	5.18E-07	4.84E-07	5.70E-07	6.14E-07	5.56E-07	5.22E-07	2.14E-07	0.41
Sm-152	4.52E-06	4.70E-06	4.69E-06	5.07E-06	4.16E-06	5.13E-06	5.27E-06	5.28E-06	5.05E-06	nodata	5.75E-06	5.02E-06	5.06E-06	5.28E-06	5.26E-06	5.01E-06	8.53E-07	0.17
Nd-143	3.52E-05	3.47E-05	3.48E-05	3.40E-05	3.49E-05	3.48E-05	3.49E-05	3.73E-05	3.74E-05	nodata	3.57E-05	3.63E-05	3.48E-05	3.59E-05	3.60E-05	3.55E-05	2.10E-06	0.06
Nd-145	2.86E-05	3.02E-05	2.96E-05	2.91E-05	2.99E-05	2.99E-05	2.91E-05	3.00E-05	2.85E-05	nodata	2.99E-05	2.99E-05	2.97E-05	2.97E-05	2.94E-05	2.95E-05	1.09E-06	0.04
Eu-153	4.85E-06	5.02E-06	5.24E-06	4.62E-06	4.98E-06	5.00E-06	4.63E-06	4.39E-06	4.70E-06	nodata	4.51E-06	4.55E-06	4.70E-06	5.03E-06	5.08E-06	4.84E-06	5.27E-07	0.11
Eu-155	3.73E-07	1.65E-07	1.64E-07	1.57E-07	1.88E-07	1.70E-07	3.06E-07	1.38E-07	1.18E-07	nodata	1.55E-07	1.56E-07	3.21E-07	1.12E-07	3.10E-07	1.96E-07	1.69E-07	0.86
Gd-155	1.95E-08	1.87E-07	1.87E-07	2.02E-22	2.15E-07	1.75E-07	3.08E-07	1.59E-07	1.35E-07	nodata	1.80E-07	1.61E-07	3.74E-07	1.26E-07	3.44E-07	1.70E-07	1.97E-07	1.16
Gd-156	6.78E-05	6.88E-05	7.01E-05	3.42E-05	7.06E-05	3.11E-06	6.82E-05	7.05E-05	3.62E-06	nodata	7.00E-05	3.32E-06	6.95E-05	3.73E-06	7.35E-05	5.04E-05	6.01E-05	1.19
Gd-157	1.64E-08	2.71E-08	2.31E-08	0.00E+00	2.45E-08	4.19E-09	2.78E-08	2.33E-08	8.78E-09	nodata	2.89E-08	4.20E-09	1.82E-08	4.44E-09	3.08E-08	1.83E-08	2.21E-08	1.21
Gd-158	8.22E-05	8.47E-05	8.25E-05	4.15E-05	8.29E-05	7.96E-07	8.39E-05	8.35E-05	8.25E-07	nodata	8.40E-05	6.93E-07	8.33E-05	7.31E-07	8.66E-05	5.95E-05	7.48E-05	1.26
Xe-131	1.95E-05	2.04E-05	2.06E-05	2.12E-05	1.99E-05	1.97E-05	1.98E-05	2.16E-05	1.90E-05	nodata	2.12E-05	2.03E-05	2.00E-05	2.00E-05	1.96E-05	2.02E-05	1.57E-06	0.08

* Participants **N** and **P** are omitted from the average and standard deviations.

Table 4.7. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 1a (No void, 40 GWd/tHM, No cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	0.70	-0.56	-1.82	1.87	-1.57	-0.25	-0.79	8.25	-1.38	-1.81	4.15	0.63	-2.27	-3.28	-3.50
U-235	0.81	0.47	-0.18	6.07	2.53	3.54	-0.55	-3.19	-2.30	-5.27	3.95	-3.63	-2.72	-6.09	0.22
U-236	1.43	-0.29	-1.25	-3.86	0.98	-0.69	1.15	2.58	1.46	-0.94	-1.40	-2.12	1.27	2.58	-1.73
U-238	-0.09	-0.10	-0.12	0.34	-0.11	-0.11	-0.10	-0.07	-0.03	-0.08	-0.14	-0.03	-0.26	0.54	0.07
Pu-238	2.49	-12.07	2.52	-9.83	5.66	-6.76	3.67	5.48	-14.55	11.45	-6.15	-4.69	0.31	11.00	7.10
Pu-239	0.23	2.66	-0.15	-7.82	2.78	5.27	-2.57	-1.12	-6.57	-5.24	0.20	-3.44	-3.99	6.16	6.16
Pu-240	-2.97	2.96	1.83	-8.74	5.63	0.95	3.23	-1.86	2.10	-3.56	5.23	0.50	0.24	0.24	-5.05
Pu-241	-0.99	-0.84	-0.58	-10.86	-0.32	0.60	0.68	-0.43	-9.12	-2.75	5.37	2.50	-5.05	9.87	9.41
Pu-242	-1.15	-2.55	0.57	-12.90	-4.25	-4.19	0.93	0.30	-5.85	5.19	4.03	0.77	13.06	10.32	9.54
Am-241	0.44	0.50	-10.77	-6.69	-3.97	3.04	1.26	2.24	-9.85	-6.25	9.64	5.19	-2.59	12.48	7.94
Am-243	1.48	-5.04	0.79	-26.45	-4.37	-0.31	2.43	-1.94	-5.45	-5.90	3.01	-3.62	27.86	32.08	9.66
Np-237	4.13	-16.71	2.16	2.65	0.47	-10.39	2.18	5.84	-14.37	14.61	-3.19	0.01	0.48	7.63	4.99
Mo-95	nodata	-0.36	-2.13	nodata	7.68	-0.78	-2.38	0.28	-1.37	nodata	-0.84	-0.70	-0.26	0.57	-0.67
Tc-99	nodata	1.17	-0.09	-4.17	-0.24	-0.46	0.91	0.16	-0.83	-0.74	1.31	0.64	-0.49	0.43	2.54
Ru-101	nodata	0.94	1.67	nodata	0.89	0.44	-0.71	-1.19	-0.42	nodata	-0.97	-1.22	-0.08	0.28	-0.93
Rh-103	-8.86	-0.49	0.53	-2.21	-1.36	-0.81	3.97	-1.04	-0.90	2.95	1.83	-0.09	-0.85	1.45	4.95
Ag-109	-21.14	-6.36	0.16	nodata	-3.83	-7.45	0.63	1.40	-3.18	nodata	13.45	7.94	12.38	13.40	12.93
Cs-133	-1.81	-0.96	0.85	-2.82	-1.95	-2.87	0.02	0.75	0.98	2.57	2.23	0.94	1.80	2.42	0.60
Sm-147	1.20	1.13	-10.34	nodata	2.47	-1.85	0.02	3.24	2.66	nodata	3.61	3.40	0.90	-0.42	-1.74
Sm-149	3.62	-4.68	0.56	0.69	5.26	-2.66	-2.57	-4.96	-5.90	-2.85	-5.46	-9.89	8.13	10.35	8.58
Sm-150	-0.28	-2.48	2.37	-7.16	3.08	-3.53	7.10	-1.48	-3.09	4.49	-6.86	-2.99	7.59	5.19	2.63
Sm-151	1.00	-6.02	-2.39	-4.77	-9.38	-1.07	14.17	-8.39	-7.86	-0.83	3.48	-8.35	16.11	21.78	0.27
Sm-152	-9.98	-7.69	-6.48	-0.98	-13.92	-2.45	2.77	3.09	5.48	17.44	8.58	0.91	4.27	3.07	1.08
Nd-143	1.28	-0.77	-0.96	-2.13	-1.10	-0.99	0.86	4.69	-3.50	-0.33	1.35	0.36	-1.84	1.28	0.34
Nd-145	-2.65	0.50	-0.05	-1.35	0.19	0.33	-0.97	0.70	-0.45	2.50	0.66	0.73	0.89	0.79	-0.19
Eu-153	-1.87	6.03	9.36	-5.71	4.37	4.56	-4.80	-9.33	-4.68	-3.86	-5.23	-6.45	-6.42	6.13	5.04
Eu-155	85.97	-24.06	-25.33	-8.01	-20.39	-22.88	50.58	-14.85	-34.11	-0.55	-8.38	-9.43	43.41	-29.99	52.01
Gd-155	29.96	33.29	37.12	-100.00	54.39	-88.28	26.43	35.53	-87.59	22.48	51.52	-83.04	32.51	-84.39	69.54
Gd-156	31.39	34.27	35.86	-34.62	36.69	-94.68	33.67	35.99	-93.90	29.83	36.14	-94.13	34.17	-93.65	43.01
Gd-157	-5.65	54.55	25.09	-100.00	38.30	-73.62	47.15	44.48	-77.04	16.21	59.46	-77.33	2.04	-74.16	45.22
Gd-158	34.45	37.39	34.64	-31.70	35.61	-98.82	36.63	36.03	-98.94	35.55	36.72	-99.04	35.70	-98.93	41.37
Xe-131	-2.24	-0.77	1.17	1.90	0.00	-2.45	-2.14	4.14	-1.16	2.28	2.55	-0.40	0.88	-1.40	-1.88

* Participants **N** and **P** are omitted from the average.

Table 4.8. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 1b (No void, 40 GWd/tHM, 5 y cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	0.94	-0.70	-1.53	1.73	-1.20	-0.25	-0.47	8.37	-4.11	-1.29	4.09	0.71	-1.72	-2.59	-3.01
U-235	0.80	0.47	-0.19	6.07	2.52	3.55	-0.54	-3.19	-2.30	-5.27	3.95	-3.62	-2.73	-6.09	0.21
U-236	1.42	-0.28	-1.26	-3.85	0.97	-0.67	1.16	2.57	1.46	-0.95	-1.39	-2.11	1.32	2.57	-1.74
U-238	-0.09	-0.10	-0.12	0.34	-0.11	-0.11	-0.10	-0.07	-0.03	-0.08	-0.14	-0.03	-0.26	0.54	0.07
Pu-238	2.36	-11.13	2.03	-10.27	4.76	-6.28	4.02	5.52	-13.80	9.84	-5.10	-3.85	0.21	10.73	7.32
Pu-239	0.32	2.75	0.18	-7.77	2.74	5.30	-2.40	-0.96	-6.41	-6.62	0.28	-3.28	-3.71	6.29	6.29
Pu-240	-2.90	2.96	1.85	-8.77	5.67	0.96	3.26	-1.78	1.92	-3.54	5.24	0.50	0.29	0.31	-5.17
Pu-241	-1.19	-0.85	-0.61	-11.26	-0.41	0.58	0.65	-0.56	-9.23	-2.30	5.35	2.49	-5.12	9.91	9.91
Pu-242	-1.15	-2.55	0.57	-12.90	-4.25	-4.19	0.93	0.30	-5.85	5.19	4.04	0.77	13.06	10.32	9.54
Am-241	-0.29	-0.25	-2.15	-9.12	-0.70	1.42	0.73	0.15	-9.02	-4.81	5.93	2.83	-4.44	10.69	7.40
Am-243	1.48	-5.04	0.74	-26.42	-4.34	-0.31	2.48	-1.94	-5.49	-5.95	3.05	-3.58	27.94	32.08	9.66
Np-237	2.91	-16.43	0.96	3.19	-0.23	-10.09	2.82	6.26	-14.06	13.51	-2.61	0.64	1.16	8.45	5.32
Mo-95	nodata	0.51	0.01	nodata	-0.93	0.03	-1.43	1.11	-0.58	nodata	-0.11	0.11	0.64	1.26	0.12
Tc-99	nodata	0.86	-0.08	-4.16	-0.29	-0.76	0.89	0.17	-0.86	nodata	1.29	0.63	-0.48	0.32	2.62
Ru-101	nodata	0.94	1.67	nodata	0.89	0.44	-0.71	-1.19	-0.42	nodata	-0.97	-1.22	-0.08	0.28	-0.93
Rh-103	-14.16	0.32	2.15	-1.58	-0.96	-0.04	4.56	-0.17	-0.05	nodata	2.36	0.68	-0.06	2.14	5.43
Ag-109	-21.19	-6.42	0.10	nodata	-3.88	-7.51	0.70	1.48	-3.24	nodata	13.53	8.03	12.48	13.33	13.10
Cs-133	-2.14	-0.75	1.14	-2.48	-1.79	-2.66	0.31	1.06	1.19	nodata	2.51	1.24	1.95	2.62	0.99
Sm-147	-3.71	1.46	-2.66	nodata	2.79	-2.57	-0.83	3.67	2.55	nodata	2.94	2.68	-0.47	-1.27	-2.38
Sm-149	2.00	-3.61	7.49	-2.17	-0.90	-2.60	-1.85	-2.27	-3.88	nodata	-8.44	-9.94	7.29	8.35	7.89
Sm-150	0.10	-2.11	2.76	-6.81	3.47	-3.17	7.50	-1.11	-2.73	nodata	-6.51	-2.62	7.99	5.59	3.01
Sm-151	-1.16	-5.71	-1.87	-4.56	-10.77	-0.87	14.25	-7.95	-7.50	nodata	3.66	-7.93	16.10	21.78	0.70
Sm-152	-8.66	-6.33	-5.10	0.48	-12.65	-1.01	4.28	4.61	7.04	nodata	10.18	2.40	5.81	4.59	2.57
Nd-143	-0.52	-0.74	-0.70	-1.83	-1.26	-0.98	0.98	5.16	-3.25	nodata	1.42	0.49	-1.72	1.32	0.40
Nd-145	-2.48	0.68	0.12	-1.16	0.37	0.51	-0.77	0.87	-0.28	nodata	0.85	0.93	1.08	0.97	0.31
Eu-153	-2.73	5.72	9.12	-5.99	4.01	4.25	-5.01	-9.52	-4.93	nodata	-5.51	-6.71	-6.56	5.84	4.76
Eu-155	81.38	-23.30	-24.58	-7.93	-19.59	-22.15	52.08	-13.96	-36.17	nodata	-7.43	-8.48	38.95	-32.09	53.75
Gd-155	-90.44	1.89	0.64	-100.00	7.90	-5.58	79.42	13.18	-15.95	nodata	22.21	11.05	90.79	-10.25	96.99
Gd-156	34.49	37.65	39.30	-33.08	40.12	-94.34	37.04	39.43	-93.51	nodata	39.58	-93.76	37.52	-93.25	46.57
Gd-157	-8.42	56.94	28.47	-100.00	34.24	-67.61	42.83	52.18	-71.59	nodata	54.86	-77.92	5.15	-68.82	46.93
Gd-158	38.55	41.59	38.75	-29.62	39.75	-98.78	40.80	40.18	-98.91	nodata	40.90	-99.02	39.85	-98.90	45.69
Xe-131	-2.94	-0.39	1.70	2.27	-0.71	-2.06	-1.71	4.53	-0.78	nodata	2.90	-0.01	1.22	-1.17	-1.64

* Participants **N** and **P** are omitted from the average.

Table 4.9. Relative differences of nuclide densities in units of % of each participant from the averaged result, Case 2a (40% void, 40 GWd/tHM, No cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	0.05	0.16	-1.32	0.94	-0.65	-0.16	-0.51	9.74	-3.84	-2.04	4.97	0.21	-2.73	-3.78	-3.56
U-235	-0.40	-0.99	-0.48	1.85	1.29	1.16	-1.45	-4.45	6.70	-2.86	3.61	-1.95	-4.68	-5.74	1.76
U-236	1.27	-0.26	-1.74	-3.89	1.12	-0.56	1.10	2.77	1.97	-1.82	-1.67	-2.92	1.61	3.46	-1.75
U-238	-0.07	-0.07	-0.11	0.40	-0.10	-0.09	-0.08	-0.05	-0.21	-0.12	-0.14	-0.06	-0.21	0.80	-0.15
Pu-238	1.74	-15.45	-1.04	-10.14	5.89	-9.22	1.83	3.53	-1.45	12.47	-7.37	-3.22	0.40	10.34	8.87
Pu-239	-1.90	0.26	-1.13	-11.75	0.45	3.66	-4.65	-3.58	8.65	-2.68	0.42	0.31	-6.10	4.64	7.60
Pu-240	-3.56	2.91	2.07	-11.99	6.14	1.90	3.36	-2.02	4.60	-2.87	5.24	0.16	-0.10	0.26	-6.04
Pu-241	-2.90	-3.88	-2.68	-13.21	-1.69	-2.01	-0.47	-2.44	4.92	-0.74	4.06	5.92	-5.63	8.79	12.25
Pu-242	-1.22	-3.14	-0.42	-11.37	-3.55	-5.41	0.33	-0.44	-6.42	6.85	3.80	1.47	11.82	9.34	11.65
Am-241	-1.87	-3.15	-13.04	-11.51	-7.32	-0.16	-0.92	-0.54	8.97	-2.53	8.64	10.00	-2.85	11.25	12.20
Am-243	1.89	-6.24	-1.64	-25.74	-4.51	-1.83	1.38	-3.01	2.74	-5.19	2.18	-2.56	24.45	28.96	11.01
Np-237	3.64	-19.27	0.12	2.66	-3.06	-11.62	0.52	4.50	-4.57	16.55	-4.23	1.47	0.89	6.92	7.85
Mo-95	nodata	-0.27	-2.10	nodata	7.75	-0.56	-2.31	0.52	-2.05	nodata	-0.87	-0.70	-0.21	0.58	-0.68
Tc-99	nodata	1.54	0.14	-4.93	0.16	-0.37	1.29	0.42	-1.48	-0.76	1.47	0.76	-1.39	0.09	2.42
Ru-101	nodata	1.08	1.57	nodata	1.02	0.69	-0.65	-1.14	-0.79	nodata	-0.96	-1.13	-0.22	0.19	-1.02
Rh-103	-9.63	-0.87	0.57	-3.06	-1.45	-0.76	2.91	-1.13	0.57	4.75	2.16	0.63	-2.90	0.86	5.08
Ag-109	-23.19	-6.76	-0.70	nodata	-3.45	-8.22	0.95	1.66	0.00	nodata	13.73	8.44	9.35	12.21	13.78
Cs-133	-2.26	-0.68	0.91	-3.57	-1.64	-2.96	1.45	1.06	0.50	2.39	2.33	0.84	1.61	2.24	0.22
Sm-147	1.09	1.86	-9.80	nodata	4.02	-2.03	0.31	4.37	-0.54	nodata	3.98	3.26	-1.57	-1.28	-1.98
Sm-149	2.31	-7.03	-0.85	-5.78	3.22	-4.60	-2.76	-6.66	12.51	-4.07	-5.57	-6.39	5.85	10.34	8.94
Sm-150	0.32	-2.26	2.32	-7.70	3.78	-3.37	6.09	-1.29	-2.12	5.04	-6.99	-1.43	9.36	5.19	0.99
Sm-151	0.61	-8.03	-3.52	-9.22	-12.01	-1.69	8.86	-11.14	8.06	0.87	2.93	-8.07	14.01	21.86	2.42
Sm-152	-10.96	-8.21	-7.58	-1.11	-16.12	-1.37	2.89	3.25	3.99	19.93	10.42	0.00	2.27	3.19	1.69
Nd-143	1.05	-1.44	-1.45	-3.95	-1.27	-1.38	-0.50	4.67	0.47	0.78	0.95	1.12	-1.75	1.33	0.73
Nd-145	-3.02	0.66	-0.06	-1.61	0.49	0.67	-1.25	1.05	-1.17	3.08	0.78	0.91	0.80	0.68	-0.32
Eu-153	-0.29	5.33	9.01	-5.70	3.91	4.22	-4.54	-9.46	-3.21	-3.43	-5.96	-6.37	-4.64	5.28	4.85
Eu-155	92.10	-19.66	-20.85	-13.13	-13.49	-18.04	53.22	-21.61	-37.33	-5.49	-14.71	-15.25	54.29	-35.41	54.40
Gd-155	27.83	31.14	37.29	-100.00	56.40	-86.03	19.93	31.26	-83.09	21.85	50.36	-80.97	33.93	-82.67	75.73
Gd-156	31.46	33.88	35.89	-34.11	36.84	-94.43	33.02	36.33	-93.60	29.35	36.01	-93.97	34.43	-93.37	42.76
Gd-157	-5.65	53.14	26.09	-100.00	36.74	-76.91	50.52	34.57	-74.08	24.12	59.62	-77.82	-0.59	-76.47	48.32
Gd-158	34.20	37.68	34.57	-31.97	35.44	-98.76	36.72	36.09	-98.84	35.63	36.81	-98.96	36.32	-98.87	41.30
Xe-131	-2.70	-0.64	1.00	2.57	-0.32	-2.75	-2.56	5.16	-2.29	3.80	3.12	-0.27	0.18	-1.71	-2.68

* Participants **N** and **P** are omitted from the average.

Table 4.10. Relative differences of nuclide densities in units of % of each participant from the averaged result, Case 2b (40% void, 40 GWd/tHM, 5 y cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	0.38	-0.12	-1.06	0.82	-0.17	-0.22	-0.15	9.81	-7.11	-1.30	4.86	0.41	-2.28	-2.98	-2.76
U-235	-0.41	-0.99	-0.48	1.85	1.29	1.17	-1.44	-4.45	6.69	-2.86	3.62	-1.94	-4.68	-5.74	1.76
U-236	1.26	-0.24	-1.75	-3.88	1.11	-0.54	1.12	2.76	1.96	-1.83	-1.65	-2.91	1.64	3.45	-1.76
U-238	-0.07	-0.07	-0.11	0.40	-0.10	-0.09	-0.08	-0.05	-0.21	-0.12	-0.14	-0.06	-0.21	0.80	-0.15
Pu-238	1.55	-14.50	-1.42	-10.61	5.18	-8.75	2.22	3.61	-1.07	10.95	-6.39	-2.44	0.30	9.85	9.38
Pu-239	-1.81	0.34	-0.85	-11.66	0.46	3.70	-4.50	-3.43	8.61	-3.89	0.49	0.40	-6.07	4.33	8.23
Pu-240	-3.50	2.89	2.07	-12.04	6.16	1.90	3.37	-1.97	4.35	-2.87	5.23	0.14	-0.26	0.44	-6.04
Pu-241	-3.08	-3.89	-2.70	-13.58	-1.77	-2.02	-0.49	-2.56	4.82	-0.26	4.06	5.92	-5.82	8.54	12.94
Pu-242	-1.22	-3.14	-0.42	-11.37	-3.54	-5.41	0.34	-0.44	-6.42	6.85	3.80	1.47	11.82	9.34	11.65
Am-241	-2.24	-3.37	-4.32	-11.85	-2.39	-1.25	-0.55	-1.93	5.83	-2.54	4.73	6.51	-4.81	9.49	10.40
Am-243	1.89	-6.24	-1.69	-25.71	-4.48	-1.83	1.43	-3.01	2.68	-5.24	2.22	-2.52	24.56	28.96	11.01
Np-237	2.44	-19.02	-1.04	3.20	-3.69	-11.34	1.15	4.77	-4.28	15.49	-3.65	2.10	1.57	7.53	8.44
Mo-95	nodata	0.62	0.03	nodata	-0.93	0.27	-1.34	1.36	-1.23	nodata	-0.10	0.12	0.54	1.15	0.18
Tc-99	nodata	1.24	0.17	-4.90	0.12	-0.66	1.29	0.44	-1.48	nodata	1.46	0.76	-1.36	0.00	2.32
Ru-101	nodata	1.08	1.57	nodata	1.02	0.69	-0.65	-1.14	-0.80	nodata	-0.96	-1.13	-0.22	0.19	-1.02
Rh-103	-14.77	0.07	2.25	-2.25	-0.88	0.13	3.67	-0.14	1.49	nodata	2.83	1.48	-1.89	1.99	5.61
Ag-109	-23.24	-6.82	-0.76	nodata	-3.50	-8.28	1.03	1.74	-0.06	nodata	13.81	8.52	9.37	12.37	13.71
Cs-133	-2.61	-0.48	1.18	-3.25	-1.49	-2.76	1.72	1.38	0.69	nodata	2.60	1.13	2.07	2.42	0.59
Sm-147	-4.46	2.36	-2.00	nodata	4.52	-2.83	-1.00	4.77	0.32	nodata	3.13	2.38	-3.12	-2.14	-2.67
Sm-149	1.59	-5.33	5.33	-6.01	-0.96	-3.64	-2.30	-3.97	7.48	nodata	-7.90	-7.87	6.46	8.36	7.36
Sm-150	0.74	-1.84	2.75	-7.31	4.22	-2.96	6.53	-0.87	-1.71	nodata	-6.60	-1.01	9.82	5.64	1.41
Sm-151	-1.12	-7.62	-2.95	-8.86	-12.99	-1.38	9.16	-10.62	8.30	nodata	3.24	-7.60	14.09	21.91	2.93
Sm-152	-9.45	-6.67	-6.02	0.56	-14.71	0.30	4.63	4.99	5.74	nodata	12.29	1.69	4.03	4.93	3.40
Nd-143	-0.57	-1.31	-1.11	-3.57	-1.30	-1.27	-0.27	5.19	0.72	nodata	1.13	1.32	-1.49	1.47	0.88
Nd-145	-2.78	0.91	0.19	-1.34	0.74	0.92	-0.98	1.34	-0.92	nodata	1.05	1.19	1.05	0.93	-0.07
Eu-153	-1.12	5.07	8.82	-5.95	3.59	3.96	-4.72	-9.64	-3.45	nodata	-6.20	-6.60	-4.78	5.03	4.61
Eu-155	86.58	-19.19	-20.39	-13.41	-12.98	-17.60	54.10	-21.14	-39.55	nodata	-14.18	-14.72	48.89	-37.53	55.31
Gd-155	-89.54	6.99	6.07	-100.00	16.46	-0.61	81.17	4.64	-20.49	nodata	14.47	3.07	103.35	-18.31	99.16
Gd-156	34.48	37.17	39.25	-32.60	40.19	-94.09	36.28	39.71	-93.21	nodata	39.37	-93.60	37.85	-92.96	46.43
Gd-157	-6.41	56.59	29.80	-100.00	35.64	-72.50	49.31	40.88	-70.32	nodata	58.39	-77.94	2.70	-72.63	51.24
Gd-158	38.30	41.90	38.69	-29.89	39.58	-98.72	40.91	40.26	-98.80	nodata	40.99	-98.93	40.50	-98.84	45.62
Xe-131	-3.30	-0.13	1.67	3.06	-0.94	-2.24	-2.00	5.72	-1.77	nodata	3.61	0.26	0.61	-1.36	-2.32

* Participants **N** and **P** are omitted from the average.

Table 4.11. Relative differences of nuclide densities in units of % of each participant from the averaged result, Case 3a (70% void, 40 GWd/tHM, No cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-0.62	1.90	0.33	0.06	1.91	0.19	0.07	11.53	-10.57	-2.43	6.10	-0.73	-4.00	-4.69	-3.78
U-235	-2.73	-3.98	-1.92	1.16	-0.95	-1.97	-2.90	-6.46	21.10	-0.39	2.57	0.47	-7.00	-7.35	3.83
U-236	1.02	-0.28	-2.26	-4.69	1.39	-0.53	0.88	2.78	4.35	-3.35	-2.09	-4.16	1.87	3.56	-0.79
U-238	-0.01	0.01	-0.06	0.43	-0.05	-0.04	-0.02	0.01	-0.75	-0.18	-0.12	-0.13	-0.17	0.62	0.15
Pu-238	-0.47	-21.35	-7.87	-9.59	5.04	-13.74	-1.24	-0.13	26.29	12.50	-9.80	-1.07	0.10	8.59	11.79
Pu-239	-7.63	-6.34	-5.53	-15.82	-5.60	-1.16	-10.27	-9.23	54.50	0.29	-2.06	4.80	-11.42	-1.07	9.93
Pu-240	-4.98	1.49	1.38	-12.44	5.30	2.27	2.65	-3.24	11.38	-1.44	4.21	-0.84	-0.29	0.32	-6.92
Pu-241	-6.84	-9.69	-7.66	-14.76	-4.07	-7.03	-3.48	-6.24	35.64	1.08	1.20	11.14	-7.88	4.94	16.92
Pu-242	-0.85	-3.85	-0.93	-7.56	-3.07	-6.88	0.61	0.17	-13.26	8.50	3.92	3.17	11.54	8.84	14.36
Am-241	-6.81	-10.18	-18.60	-12.68	-13.09	-6.11	-5.27	-5.19	48.12	1.13	5.47	16.36	-6.62	5.86	17.37
Am-243	2.24	-7.70	-4.18	-23.54	-4.93	-3.79	1.99	-5.55	9.06	-4.81	1.89	0.05	21.63	25.63	13.67
Np-237	2.27	-23.54	-4.05	3.18	-9.29	-13.76	-1.90	2.54	13.93	19.03	-5.63	4.06	0.90	5.70	11.52
Mo-95	nodata	0.10	-1.93	nodata	8.02	-0.16	-2.10	0.91	-3.98	nodata	-0.75	-0.76	-0.26	0.59	-0.69
Tc-99	nodata	2.20	0.51	-5.42	0.97	-0.22	1.71	0.72	-3.11	-0.83	1.69	0.78	-2.79	-0.38	2.17
Ru-101	nodata	1.39	1.62	nodata	1.22	1.06	-0.46	-1.01	-1.85	nodata	-0.84	-0.90	-0.36	-0.06	-1.07
Rh-103	-10.58	-1.79	0.32	-2.18	-2.34	-0.96	1.52	-1.40	2.45	7.18	2.40	1.52	-6.61	-0.15	5.55
Ag-109	-25.89	-7.40	-1.77	nodata	-2.35	-9.41	1.21	1.36	5.24	nodata	13.82	9.40	4.83	10.22	14.98
Cs-133	-2.60	0.11	1.29	-3.84	-0.84	-2.85	1.56	1.60	-1.14	2.29	2.63	0.71	1.10	1.92	-0.13
Sm-147	1.37	3.89	-8.54	nodata	7.15	-1.77	1.00	6.23	-9.61	nodata	4.89	2.68	-5.94	-2.55	-2.06
Sm-149	-4.41	-15.59	-8.38	-12.52	-4.00	-12.09	-7.01	-13.22	76.07	-6.09	-10.04	-1.95	1.85	4.84	12.43
Sm-150	1.02	-2.03	2.23	-7.79	4.24	-3.24	5.09	-0.81	-2.13	5.12	-7.07	-0.10	11.73	4.76	0.61
Sm-151	-3.16	-14.61	-9.02	-13.54	-16.95	-6.31	-0.20	-16.52	56.64	1.04	-0.97	-7.71	9.01	17.48	6.12
Sm-152	-11.55	-7.91	-8.22	-0.67	-18.61	0.41	3.12	3.29	-1.06	22.40	12.50	-1.65	-0.91	3.35	2.96
Nd-143	0.68	-2.48	-2.44	-4.68	-1.63	-1.99	-1.79	4.47	5.34	1.92	0.36	1.94	-2.21	0.98	1.26
Nd-145	-3.32	2.06	0.01	-1.61	1.01	1.11	-1.52	1.45	-3.53	3.66	0.91	0.93	0.30	0.40	-0.62
Eu-153	1.06	3.88	8.44	-4.36	3.27	3.63	-4.25	-9.23	-2.61	-2.54	-6.66	-5.76	-2.69	4.16	5.20
Eu-155	96.59	-16.09	-16.79	-19.47	-4.28	-13.26	55.57	-29.97	-37.31	-10.53	-21.21	-20.92	70.54	-40.57	57.31
Gd-155	22.12	23.87	33.46	-100.00	56.72	-84.33	12.67	23.90	-66.77	21.96	46.18	-78.49	35.28	-82.43	92.64
Gd-156	31.67	33.45	35.93	-33.59	36.93	-94.17	32.32	36.69	-93.20	28.66	35.79	-93.78	34.77	-93.01	42.54
Gd-157	-11.30	43.73	22.15	-100.00	32.59	-80.29	50.72	21.77	-54.98	33.73	56.34	-77.29	-4.00	-78.60	64.14
Gd-158	33.94	38.01	34.47	-32.27	35.21	-98.70	36.81	36.14	-98.65	35.79	36.90	-98.87	35.80	-98.81	41.17
Xe-131	-3.00	0.15	1.23	4.40	-1.15	-2.99	-2.78	6.16	-6.50	5.90	4.06	-0.14	-1.74	-1.99	-3.49

* Participants **N** and **P** are omitted from the average.

Table 4.12. Relative differences of nuclide densities in units of % of each participant from the averaged result, Case 3b (70% void, 40 GWd/tHM, 5 y cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-0.12	1.38	-0.18	0.15	2.54	0.07	0.52	11.54	-14.19	-1.34	5.98	-0.19	-3.53	-3.73	-2.64
U-235	-2.73	-3.97	-1.93	1.17	-0.95	-1.97	-2.89	-6.47	21.09	-0.39	2.58	0.47	-7.01	-7.35	3.82
U-236	1.01	-0.26	-2.27	-4.68	1.38	-0.51	0.90	2.77	4.34	-3.36	-2.07	-4.15	1.86	3.55	-0.80
U-238	-0.01	0.01	-0.06	0.43	-0.05	-0.04	-0.02	0.01	-0.75	-0.18	-0.12	-0.13	-0.17	0.62	0.15
Pu-238	-0.68	-20.34	-8.02	-9.96	4.59	-13.27	-0.73	0.10	25.75	11.09	-8.88	-0.30	0.06	8.16	12.20
Pu-239	-7.50	-6.22	-5.25	-15.71	-5.53	-1.09	-10.10	-9.07	54.13	-0.75	-1.98	4.86	-11.26	-1.30	10.36
Pu-240	-4.90	1.50	1.40	-12.46	5.35	2.29	2.69	-3.15	11.09	-1.41	4.24	-0.83	-0.44	0.29	-6.93
Pu-241	-6.99	-9.67	-7.66	-15.12	-4.14	-7.03	-3.49	-6.31	35.53	1.58	1.22	11.16	-8.02	4.65	17.42
Pu-242	-0.85	-3.85	-0.93	-7.56	-3.06	-6.88	0.61	0.17	-13.27	8.49	3.92	3.17	11.54	8.84	14.36
Am-241	-6.35	-9.38	-9.45	-13.34	-5.35	-6.43	-3.77	-5.86	38.05	-0.43	1.86	11.95	-7.45	5.21	15.25
Am-243	2.24	-7.70	-4.23	-23.50	-4.89	-3.79	2.03	-5.55	9.01	-4.85	1.94	0.09	21.65	25.63	13.67
Np-237	1.05	-23.35	-5.19	3.69	-9.87	-13.55	-1.33	2.80	14.18	17.92	-5.10	4.66	1.43	6.08	12.66
Mo-95	nodata	0.97	0.22	nodata	-0.78	0.67	-1.14	1.71	-3.12	nodata	0.03	0.06	0.44	1.40	0.03
Tc-99	nodata	1.88	0.51	-5.42	0.91	-0.54	1.69	0.71	-3.14	nodata	1.67	0.76	-2.83	-0.31	2.04
Ru-101	nodata	1.38	1.62	nodata	1.22	1.06	-0.46	-1.01	-1.85	nodata	-0.84	-0.90	-0.33	-0.06	-1.07
Rh-103	-15.55	-0.68	2.17	-1.24	-1.48	0.09	2.49	-0.24	3.56	nodata	3.26	2.54	-5.20	1.12	6.50
Ag-109	-25.95	-7.47	-1.85	nodata	-2.42	-9.48	1.27	1.41	5.16	nodata	13.87	9.46	4.90	10.35	15.10
Cs-133	-2.95	0.31	1.57	-3.51	-0.67	-2.65	1.84	1.90	-0.94	nodata	2.92	1.02	1.63	2.11	0.06
Sm-147	-5.01	4.45	-0.64	nodata	7.83	-2.80	-0.96	6.21	-6.28	nodata	3.70	1.61	-7.87	-3.58	-2.92
Sm-149	-2.97	-11.90	-1.42	-10.90	-5.21	-9.12	-5.76	-9.29	52.70	nodata	-10.74	-4.71	3.99	4.83	9.78
Sm-150	1.46	-1.61	2.67	-7.40	4.69	-2.83	5.54	-0.38	-1.71	nodata	-6.68	0.33	12.21	5.21	1.04
Sm-151	-4.56	-14.20	-8.50	-13.19	-17.65	-6.00	0.15	-16.05	56.42	nodata	-0.64	-7.30	9.29	17.66	6.55
Sm-152	-9.87	-6.16	-6.48	1.22	-17.06	2.32	5.08	5.26	0.82	nodata	14.64	0.23	1.01	5.32	4.92
Nd-143	-0.77	-2.25	-2.00	-4.22	-1.53	-1.79	-1.47	5.08	5.57	nodata	0.66	2.21	-1.83	1.22	1.50
Nd-145	-3.04	2.37	0.31	-1.30	1.31	1.41	-1.20	1.78	-3.25	nodata	1.23	1.26	0.60	0.70	-0.32
Eu-153	0.29	3.70	8.32	-4.54	3.04	3.45	-4.35	-9.34	-2.77	nodata	-6.82	-5.93	-2.78	3.99	5.03
Eu-155	90.09	-15.97	-16.68	-20.09	-4.15	-13.18	55.78	-29.86	-39.80	nodata	-21.07	-20.78	63.58	-42.95	57.89
Gd-155	-88.49	10.05	10.13	-100.00	26.99	3.22	81.47	-6.24	-20.40	nodata	6.12	-5.29	120.56	-25.70	102.85
Gd-156	34.62	36.68	39.23	-32.10	40.23	-93.82	35.51	40.02	-92.81	nodata	39.08	-93.41	38.01	-92.59	45.94
Gd-157	-10.39	48.28	26.52	-100.00	33.94	-77.06	52.26	27.56	-51.94	nodata	57.97	-77.02	-0.29	-75.70	68.55
Gd-158	38.06	42.25	38.60	-30.19	39.37	-98.66	41.01	40.32	-98.61	nodata	41.11	-98.83	39.97	-98.77	45.51
Xe-131	-3.50	0.80	2.04	5.02	-1.66	-2.34	-2.08	6.81	-5.81	nodata	4.70	0.54	-0.97	-1.01	-2.99

* Participants **N** and **P** are omitted from the average.

Table 4.13. k_∞ results from participants for Case 1 (No void, Maximum 40 GWd/tHM)

ID	k_∞ at the following burnup [GWd/tHM]						Peak	
	0	0.2	10	20	30	40	k_∞	burnup [GWd/tHM]
A	1.091	1.064	1.183	1.126	1.020	0.914	1.202	12.0
B	1.093	1.066	1.191	1.124	1.017	0.913	1.204	11.6
C	1.096	1.068	1.200	1.132	1.024	0.918	1.213	11.5
D	1.087	1.057	1.168	1.144	1.041	0.941	1.206	12.5
E	1.094	1.066	1.192	1.127	1.022	0.919	1.207	11.5
F	1.107	nodata	nodata	nodata	nodata	nodata	nodata	nodata
G	1.099	1.071	1.180	1.127	1.021	0.918	1.203	12.2
H	1.094	1.067	1.190	1.123	1.012	0.904	1.205	11.8
J	1.097	1.071	1.188	1.131	1.022	0.914	1.208	12.0
K	1.104	1.075	1.221	1.134	1.020	0.906	1.221	10.0
L	1.101	1.073	1.166	1.120	1.008	0.898	1.195	12.5
M	1.082	1.055	1.202	1.137	1.033	0.933	1.218	11.5
N	1.447	1.399	1.282	1.171	1.060	0.950	nodata	nodata
P	1.110	1.111	1.291	1.187	1.072	0.957	1.293	10.3
Q	1.099	1.080	1.170	1.138	1.028	0.925	1.217	12.0
R	1.112	1.084	1.229	1.128	1.019	0.918	1.229	10.0
Average*	1.097	1.069	1.191	1.130	1.022	0.917	1.210	11.6

* Results from **N** and **P** are omitted from the average.

Table 4.14. k_∞ results from participants for Case 2 (40% void, Maximum 40 GWd/tHM)

ID	k_∞ at the following burnup [GWd/tHM]						Peak	
	0	0.2	10	20	30	40	k_∞	burnup [GWd/tHM]
A	1.071	1.046	1.159	1.114	1.022	0.935	1.178	12.5
B	1.082	1.055	1.156	1.104	1.011	0.925	1.171	12.1
C	1.083	1.057	1.166	1.117	1.025	0.938	1.183	12.1
D	1.071	1.046	1.154	1.127	1.039	0.957	1.191	14.5
E	1.073	1.047	1.163	1.114	1.023	0.939	1.180	12.0
F	1.079	nodata	nodata	nodata	nodata	nodata	nodata	nodata
G	1.081	1.053	1.154	1.114	1.022	0.936	1.178	12.2
H	1.068	1.043	1.164	1.109	1.013	0.924	1.179	12.1
J	1.074	1.051	1.164	1.121	1.027	0.934	1.184	12.0
K	1.078	1.052	1.178	1.122	1.035	0.953	1.178	10.0
L	1.074	1.048	1.138	1.103	1.01	0.922	1.165	13.0
M	1.066	1.04	1.162	1.121	1.032	0.951	1.187	12.0
N	1.418	1.371	1.253	1.151	1.059	0.972	nodata	nodata
P	1.084	1.097	1.253	1.183	1.084	0.988	1.266	11.4
Q	1.008	1.064	1.155	1.127	1.033	0.950	1.192	12.5
R	1.089	1.061	1.187	1.115	1.025	0.943	1.194	11.0
Average*	1.071	1.051	1.161	1.116	1.024	0.939	1.182	12.2

* Results from **N** and **P** are omitted from the average.

Table 4.15. k_∞ results from participants for Case 3 (70% void, Maximum 40 GWd/tHM)

ID	k_∞ at the following burnup [GWd/tHM]						Peak	
	0	0.2	10	20	30	40	k_∞	burnup [GWd/tHM]
A	1.051	1.028	1.133	1.098	1.016	0.942	1.151	12.5
B	1.074	1.049	1.126	1.084	1.002	0.929	1.140	12.4
C	1.071	1.046	1.132	1.100	1.018	0.944	1.152	13.0
D	1.040	1.017	1.120	1.112	1.034	0.964	1.156	14.5
E	1.052	1.029	1.132	1.095	1.015	0.943	1.149	12.5
F	1.050	nodata	nodata	nodata	nodata	nodata	nodata	nodata
G	1.058	1.033	1.128	1.097	1.015	0.941	1.151	12.8
H	1.047	1.025	1.130	1.089	1.005	0.930	1.146	12.6
J	1.056	1.031	1.138	1.105	1.021	0.941	1.157	12.0
K	1.014	0.993	1.064	1.046	0.983	0.931	1.064	10.0
L	1.040	1.018	1.101	1.076	0.998	0.929	1.124	13.0
M	1.047	1.023	1.122	1.100	1.023	0.955	1.151	13.0
N	1.375	1.330	1.209	1.116	1.039	0.972	nodata	nodata
P	1.068	1.084	1.205	1.179	1.090	1.006	1.234	13.4
Q	1.059	1.046	1.128	1.112	1.029	0.955	1.167	13.0
R	1.060	1.036	1.122	1.095	1.019	0.955	1.147	12.5
Average*	1.051	1.029	1.121	1.093	1.014	0.943	1.143	12.6

* Results from **N** and **P** are omitted from the average.

Table 4.16. Pinwise burnup results from participants for Case 1 (No void, 40 GWd/tHM)

ID	#1	#2	#3	#4	#5	#6	#7	#8	#9	Average
A	37.2	39.1	41.2	40.4	38.7	32.0	43.3	42.5	44.3	39.9
B	35.9	38.3	40.8	40.1	38.9	32.3	44.2	43.5	44.8	39.9
C	36.0	38.2	40.5	39.9	38.6	33.4	43.8	43.2	44.9	39.9
D	37.1	39.3	41.6	40.3	39.4	32.3	44.0	48.1	45.7	40.2
E	37.1	39.0	41.1	40.4	38.9	32.2	43.3	42.6	44.2	39.9
G	37.6	39.4	41.5	40.7	39.1	30.2	43.5	42.8	44.7	40.0
H	36.8	38.8	41.0	40.3	38.7	32.0	43.5	42.6	44.6	39.9
J	37.8	39.5	41.3	40.5	39.2	31.3	43.3	42.6	44.3	40.0
K	37.4	39.4	41.6	40.8	39.0	31.9	43.2	42.1	43.3	39.9
L	36.7	38.9	41.1	40.2	39.0	32.0	43.6	42.8	44.4	39.9
M	35.4	38.3	41.2	40.9	39.1	31.0	44.7	44.0	45.4	40.1
N	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata
P	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Q	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata
R	37.7	39.7	41.5	40.6	39.2	30.5	42.8	41.9	44.2	39.8
Average*	36.9	39.0	41.2	40.4	39.0	31.7	43.6	43.1	44.5	40.0

* Results from **P** are omitted from the average.

Table 4.17. Pinwise burnup results from participants for Case 2 (40% void, 40 GWd/tHM)

ID	#1	#2	#3	#4	#5	#6	#7	#8	#9	Average
A	39.0	40.1	41.7	40.7	38.7	31.8	42.3	41.5	43.3	39.9
B	37.8	39.4	41.4	40.5	38.9	32.0	43.1	42.2	43.7	39.9
C	38.3	39.5	41.0	40.2	38.5	32.9	42.5	41.7	44.1	39.9
D	38.2	39.8	41.8	40.5	39.0	31.5	42.8	44.6	43.9	40.2
E	38.6	39.9	41.3	40.4	39.1	32.3	42.6	41.8	43.3	39.9
G	39.1	40.2	41.8	40.8	38.9	30.0	42.6	41.9	44.1	39.9
H	38.4	39.8	41.5	40.6	38.9	31.9	42.7	41.6	43.4	39.9
J	39.4	40.3	41.7	40.8	39.3	31.3	42.5	41.7	43.2	40.0
K	38.3	39.7	41.4	40.5	38.7	32.0	42.6	42.1	43.9	39.9
L	38.4	39.9	41.5	40.4	39.2	32.0	42.8	41.8	43.2	39.9
M	37.3	39.4	41.9	41.4	39.0	30.6	43.6	42.7	44.2	40.1
N	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata
P	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Q	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata
R	39.5	40.7	42.0	40.8	39.5	30.5	42.4	41.3	43.1	40.0
Average*	38.5	39.9	41.6	40.6	39.0	31.6	42.7	42.1	43.6	40.0

* Results from **P** are omitted from the average.

Table 4.18. Pinwise burnup results from participants for Case 3 (70% void, 40 GWd/tHM)

ID	#1	#2	#3	#4	#5	#6	#7	#8	#9	Average
A	40.8	40.9	42.1	40.9	38.6	31.7	41.4	40.9	42.5	39.9
B	39.6	40.3	41.9	40.8	38.8	31.6	42.1	41.3	42.9	39.9
C	40.8	40.7	41.7	40.6	38.4	32.3	41.1	40.3	43.2	39.9
D	39.7	40.7	42.2	40.5	39.0	31.5	42.1	43.5	42.9	40.1
E	39.9	40.3	41.4	40.4	39.2	32.4	42.2	41.2	42.7	39.9
G	40.7	40.8	42.0	40.8	38.7	29.8	41.7	41.3	43.7	39.9
H	40.1	40.7	41.9	40.8	39.1	31.8	42.0	40.7	42.4	39.9
J	41.0	41.1	41.9	40.9	39.2	31.2	41.8	41.1	42.4	40.0
K	38.4	39.1	40.5	39.8	38.0	32.2	42.2	43.1	46.0	39.9
L	40.1	40.8	41.9	40.5	39.5	32.1	41.9	41.1	42.0	39.9
M	39.3	40.5	42.5	41.9	38.8	30.1	42.4	41.4	43.0	40.0
N	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata
P	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Q	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata	nodata
R	41.1	41.6	42.2	40.9	39.7	30.3	41.6	40.5	42.1	39.9
Average*	40.1	40.6	41.8	40.7	38.9	31.4	41.9	41.4	43.0	40.0

* Results from **P** are omitted from the average.

Table 4.19. Gadolinium (Gd) densities in Gd pins reported by some participants

Case No.	Cooling Time [y]	Nuclide	Atomic Number Densities in $10^{24}/cm^3$ Reported from Participants								Average
			A	**C**	**E**	**H**	**J**	**L**	**M**	**P**	
1	0	Gd-155	9.43E-08	9.05E-08	9.94E-08	7.52E-08	8.86E-08	8.89E-08	9.76E-08	7.78E-08	8.90E-08
		Gd-156	5.15E-04	5.15E-04	5.16E-04	5.05E-04	5.12E-04	5.09E-04	5.11E-04	5.08E-04	5.11E-04
		Gd-157	5.75E-08	6.36E-08	6.93E-08	8.04E-08	6.58E-08	7.08E-08	8.37E-08	4.94E-08	6.76E-08
		Gd-158	6.13E-04	6.14E-04	6.14E-04	6.20E-04	6.15E-04	6.18E-04	6.20E-04	6.15E-04	6.16E-04
	5	Gd-155	9.43E-08	2.10E-07	2.00E-07	2.43E-07	1.93E-07	nodata	2.03E-07	3.20E-07	2.09E-07
		Gd-156	5.15E-04	5.15E-04	5.16E-04	5.05E-04	5.12E-04	nodata	5.11E-04	5.08E-04	5.12E-04
		Gd-157	5.75E-08	6.42E-08	6.93E-08	8.04E-08	6.65E-08	nodata	8.37E-08	4.99E-08	6.74E-08
		Gd-158	6.13E-04	6.14E-04	6.14E-04	6.20E-04	6.15E-04	nodata	6.20E-04	6.15E-04	6.16E-04
2	0	Gd-155	1.16E-07	1.12E-07	1.23E-07	8.56E-08	1.07E-07	1.11E-07	1.20E-07	9.50E-08	1.09E-07
		Gd-156	5.12E-04	5.10E-04	5.11E-04	4.98E-04	5.08E-04	5.04E-04	5.06E-04	5.05E-04	5.07E-04
		Gd-157	8.54E-08	9.76E-08	1.04E-07	1.23E-07	9.49E-08	1.12E-07	1.26E-07	7.32E-08	1.02E-07
		Gd-158	6.15E-04	6.16E-04	6.15E-04	6.22E-04	6.17E-04	6.21E-04	6.22E-04	6.20E-04	6.19E-04
	5	Gd-155	1.16E-07	2.52E-07	2.46E-07	2.77E-07	2.11E-07	nodata	2.27E-07	3.87E-07	2.45E-07
		Gd-156	5.12E-04	5.10E-04	5.11E-04	4.98E-04	5.08E-04	nodata	5.06E-04	5.05E-04	5.07E-04
		Gd-157	8.54E-08	9.82E-08	1.04E-07	1.23E-07	9.55E-08	nodata	1.26E-07	7.37E-08	1.01E-07
		Gd-158	6.15E-04	6.16E-04	6.15E-04	6.22E-04	6.17E-04	nodata	6.22E-04	6.20E-04	6.18E-04
3	0	Gd-155	1.46E-07	1.41E-07	1.59E-07	1.01E-07	1.32E-07	1.46E-07	1.53E-07	1.22E-07	1.38E-07
		Gd-156	5.09E-04	5.06E-04	5.07E-04	4.91E-04	5.05E-04	4.97E-04	5.00E-04	5.01E-04	5.02E-04
		Gd-157	1.23E-07	1.47E-07	1.57E-07	1.90E-07	1.35E-07	1.85E-07	1.90E-07	1.10E-07	1.55E-07
		Gd-158	6.16E-04	6.19E-04	6.17E-04	6.25E-04	6.20E-04	6.25E-04	6.25E-04	6.20E-04	6.21E-04
	5	Gd-155	1.46E-07	3.06E-07	3.13E-07	3.20E-07	2.37E-07	nodata	2.62E-07	4.87E-07	2.96E-07
		Gd-156	5.09E-04	5.06E-04	5.07E-04	4.91E-04	5.05E-04	nodata	5.00E-04	5.01E-04	5.02E-04
		Gd-157	1.23E-07	1.48E-07	1.57E-07	1.90E-07	1.35E-07	nodata	1.90E-07	1.10E-07	1.50E-07
		Gd-158	6.16E-04	6.19E-04	6.17E-04	6.25E-04	6.20E-04	nodata	6.25E-04	6.20E-04	6.20E-04

Table 4.20. Relative differences of nuclide densities in unit of % for each participant from the averaged result, for Case 1a (No void, 40 GWd/tHM, No cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-0.22	-1.47	-2.72	0.94	-2.47	-1.16	-1.70	7.26	-2.28	-2.71	3.20	-0.29	-3.17	-4.17	-4.38
U-235	0.65	0.32	-0.33	5.91	2.38	3.39	-0.70	-3.33	-2.45	-5.41	3.79	-3.77	-2.87	-6.23	0.07
U-236	0.93	-0.77	-1.73	-4.33	0.49	-1.17	0.66	2.08	0.97	-1.42	-1.88	-2.60	0.78	2.08	-2.21
U-238	0.00	0.00	-0.03	0.43	-0.02	-0.01	0.00	0.03	0.07	0.02	-0.04	0.06	-0.16	0.64	0.17
Pu-238	3.30	-11.38	3.32	-9.13	6.49	-6.03	4.48	6.30	-13.87	12.33	-5.41	-3.94	1.10	11.87	7.94
Pu-239	-0.49	1.93	-0.87	-8.48	2.05	4.52	-3.26	-1.83	-7.24	-5.92	-0.52	-4.13	-4.67	5.40	5.40
Pu-240	-3.64	2.25	1.13	-9.36	4.91	0.26	2.52	-2.53	1.40	-4.22	4.51	-0.19	-0.44	-0.45	-5.70
Pu-241	-0.73	-0.58	-0.32	-10.63	-0.06	0.87	0.94	-0.17	-8.89	-2.50	5.64	2.77	-4.80	10.15	9.69
Pu-242	-0.14	-1.55	1.60	-12.00	-3.26	-3.21	1.96	1.33	-4.88	6.27	5.10	1.80	14.22	11.45	10.67
Am-241	0.99	1.05	-10.27	-6.18	-3.44	3.61	1.82	2.80	-9.36	-5.73	10.25	5.77	-2.05	13.10	8.53
Am-243	1.92	-4.63	1.22	-26.13	-3.96	0.12	2.87	-1.51	-5.04	-5.49	3.46	-3.20	28.41	32.65	10.14
Np-237	6.40	-14.90	4.39	4.88	2.66	-8.44	4.40	8.15	-12.50	17.11	-1.08	2.19	2.67	9.98	7.28
Mo-95	nodata	0.72	-1.07	nodata	8.85	0.30	-1.32	1.37	-0.30	nodata	0.24	0.37	0.82	1.66	0.41
Tc-99	nodata	0.83	-0.42	-4.49	-0.57	-0.80	0.57	-0.17	-1.17	-1.07	0.97	0.31	-0.83	0.09	2.20
Ru-101	nodata	0.71	1.43	nodata	0.66	0.21	-0.93	-1.42	-0.65	nodata	-1.20	-1.45	-0.31	0.05	-1.16
Rh-103	-7.83	0.63	1.67	-1.10	-0.25	0.31	5.15	0.08	0.22	4.11	2.98	1.04	0.27	2.59	6.13
Ag-109	-16.59	-0.95	5.94	nodata	1.73	-2.11	6.44	7.26	2.41	nodata	20.00	14.18	18.87	19.95	19.45
Cs-133	-1.14	-0.30	1.53	-2.16	-1.29	-2.21	0.70	1.43	1.66	3.26	2.92	1.62	2.49	3.11	1.28
Sm-147	2.33	2.25	-9.34	nodata	3.61	-0.76	1.13	4.39	3.80	nodata	4.76	4.55	2.02	0.69	-0.64
Sm-149	5.50	-2.95	2.38	2.52	7.17	-0.90	-0.80	-3.24	-4.19	-1.09	-3.74	-8.26	10.09	12.35	10.55
Sm-150	-0.56	-2.76	2.08	-7.42	2.79	-3.80	6.80	-1.76	-3.37	4.19	-7.13	-3.26	7.28	4.89	2.34
Sm-151	1.46	-5.60	-1.95	-4.34	-8.97	-0.62	14.68	-7.97	-7.44	-0.38	3.95	-7.93	16.64	22.33	0.73
Sm-152	-6.76	-4.39	-3.13	2.57	-10.84	1.05	6.45	6.78	9.26	21.65	12.46	4.52	8.01	6.76	4.70
Nd-143	0.59	-1.45	-1.63	-2.80	-1.77	-1.66	0.17	3.98	-4.15	-1.01	0.66	-0.32	-2.51	0.59	-0.34
Nd-145	-2.30	0.86	0.31	-1.00	0.55	0.69	-0.62	1.06	-0.09	2.87	1.02	1.09	1.25	1.16	0.16
Eu-153	-2.51	5.33	8.64	-6.33	3.69	3.87	-5.42	-9.92	-5.30	-4.49	-5.85	-7.06	-7.03	5.43	4.36
Eu-155	71.82	-29.84	-31.01	-15.01	-26.45	-28.75	39.12	-21.33	-39.12	-8.12	-15.36	-16.32	32.50	-35.32	40.44
Gd-155	-1.89	0.62	3.51	-100.00	16.55	-91.15	-4.56	2.31	-90.63	-7.54	14.38	-87.19	0.03	-88.22	27.99
Gd-156	-2.12	0.02	1.21	-51.29	1.83	-96.03	-0.42	1.31	-95.46	-3.28	1.42	-95.63	-0.05	-95.27	6.53
Gd-157	-29.13	16.10	-6.04	-100.00	3.89	-80.19	10.54	8.53	-82.75	-12.70	19.79	-82.97	-23.35	-80.59	9.09
Gd-158	-1.01	1.15	-0.87	-49.72	-0.16	-99.13	0.59	0.15	-99.22	-0.20	0.66	-99.30	-0.09	-99.21	4.08
Xe-131	-1.87	-0.39	1.55	2.29	0.38	-2.07	-1.76	4.54	-0.78	2.67	2.94	-0.02	1.27	-1.03	-1.50

* Participants **A**, **B**, **C**, **G** (except for Gd), **H** and **J** are used for the average.

Table 4.21. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 1b (No void, 40 GWd/tHM, 5 y cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-0.12	-1.74	-2.56	0.66	-2.24	-1.29	-1.52	7.23	-5.11	-2.32	3.00	-0.35	-2.75	-3.61	-4.03
U-235	0.65	0.32	-0.34	5.91	2.37	3.39	-0.69	-3.34	-2.45	-5.41	3.80	-3.77	-2.87	-6.23	0.06
U-236	0.92	-0.76	-1.74	-4.32	0.48	-1.16	0.67	2.07	0.96	-1.43	-1.87	-2.59	0.82	2.07	-2.22
U-238	0.00	0.00	-0.03	0.43	-0.02	-0.01	0.00	0.03	0.07	0.02	-0.04	0.06	-0.16	0.64	0.17
Pu-238	2.96	-10.62	2.63	-9.75	5.37	-5.73	4.62	6.14	-13.30	10.48	-4.55	-3.29	0.80	11.38	7.94
Pu-239	-0.54	1.86	-0.67	-8.56	1.86	4.39	-3.24	-1.80	-7.21	-7.42	-0.58	-4.11	-4.54	5.38	5.38
Pu-240	-3.60	2.22	1.12	-9.42	4.92	0.24	2.51	-2.49	1.18	-4.24	4.48	-0.23	-0.43	-0.41	-5.85
Pu-241	-0.86	-0.52	-0.28	-10.96	-0.08	0.91	0.98	-0.23	-8.92	-1.97	5.70	2.83	-4.81	10.27	10.27
Pu-242	-0.14	-1.55	1.60	-12.00	-3.26	-3.21	1.96	1.33	-4.88	6.27	5.10	1.81	14.22	11.45	10.67
Am-241	-0.23	-0.19	-2.09	-9.06	-0.64	1.49	0.80	0.22	-8.97	-4.75	6.00	2.89	-4.38	10.76	7.47
Am-243	1.92	-4.63	1.18	-26.10	-3.92	0.12	2.92	-1.51	-5.08	-5.54	3.50	-3.16	28.50	32.65	10.14
Np-237	5.29	-14.50	3.29	5.58	2.08	-8.01	5.20	8.72	-12.07	16.14	-0.35	2.96	3.50	10.96	7.76
Mo-95	nodata	0.46	-0.04	nodata	-0.98	-0.01	-1.47	1.06	-0.62	nodata	-0.16	0.06	0.59	1.21	0.07
Tc-99	nodata	0.64	-0.29	-4.36	-0.50	-0.98	0.68	-0.05	-1.07	nodata	1.07	0.41	-0.70	0.10	2.40
Ru-101	nodata	0.71	1.43	nodata	0.66	0.21	-0.93	-1.42	-0.65	nodata	-1.20	-1.45	-0.31	0.05	-1.16
Rh-103	-13.09	1.56	3.41	-0.36	0.27	1.20	5.86	1.07	1.18	nodata	3.63	1.92	1.17	3.40	6.74
Ag-109	-16.63	-1.00	5.89	nodata	1.68	-2.15	6.53	7.36	2.36	nodata	20.10	14.28	18.99	19.89	19.64
Cs-133	-1.64	-0.25	1.65	-1.98	-1.29	-2.16	0.82	1.57	1.71	nodata	3.03	1.76	2.47	3.14	1.50
Sm-147	-2.96	2.25	-1.91	nodata	3.59	-1.81	-0.05	4.48	3.35	nodata	3.74	3.48	0.31	-0.50	-1.62
Sm-149	2.14	-3.47	7.64	-2.03	-0.76	-2.46	-1.71	-2.14	-3.74	nodata	-8.31	-9.82	7.45	8.51	8.04
Sm-150	-0.56	-2.76	2.08	-7.42	2.79	-3.80	6.80	-1.76	-3.37	nodata	-7.13	-3.26	7.28	4.89	2.34
Sm-151	-0.61	-5.19	-1.32	-4.03	-10.28	-0.32	14.89	-7.44	-6.98	nodata	4.23	-7.42	16.75	22.46	1.25
Sm-152	-6.76	-4.39	-3.13	2.57	-10.84	1.04	6.45	6.78	9.26	nodata	12.47	4.53	8.01	6.76	4.70
Nd-143	-1.05	-1.27	-1.22	-2.35	-1.79	-1.50	0.44	4.60	-3.76	nodata	0.88	-0.05	-2.24	0.79	-0.13
Nd-145	-2.31	0.86	0.30	-0.98	0.55	0.69	-0.60	1.05	-0.10	nodata	1.04	1.11	1.26	1.15	0.49
Eu-153	-3.03	5.40	8.79	-6.28	3.69	3.94	-5.30	-9.80	-5.22	nodata	-5.80	-6.99	-6.84	5.52	4.44
Eu-155	67.57	-29.14	-30.32	-14.94	-25.71	-28.08	40.49	-20.52	-41.04	nodata	-14.48	-15.45	28.37	-37.27	42.04
Gd-155	-92.28	-17.69	-18.69	-100.00	-12.83	-23.72	44.95	-8.57	-32.10	nodata	-1.27	-10.29	54.14	-27.49	59.15
Gd-156	-2.79	-0.51	0.69	-51.63	1.28	-95.91	-0.95	0.77	-95.31	nodata	0.89	-95.49	-0.60	-95.12	5.94
Gd-157	-36.89	8.16	-11.46	-100.00	-7.49	-77.68	-1.57	4.88	-80.42	nodata	6.72	-84.79	-27.54	-78.51	1.25
Gd-158	-1.27	0.89	-1.12	-49.85	-0.41	-99.13	0.34	-0.11	-99.22	nodata	0.40	-99.30	-0.34	-99.21	3.82
Xe-131	-2.80	-0.24	1.85	2.41	-0.57	-1.92	-1.57	4.68	-0.64	nodata	3.05	0.14	1.37	-1.02	-1.49

* Participants **A** (except for Gd), **B**, **C**, **G** (except for Gd), **H** and **J** are used for the average.

Table 4.22. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 2a (40% void, 40 GWd/tHM, No cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-1.26	-1.15	-2.61	-0.39	-1.96	-1.47	-1.82	8.31	-5.10	-3.32	3.60	-1.10	-4.00	-5.04	-4.82
U-235	0.71	0.11	0.63	2.98	2.42	2.29	-0.35	-3.39	7.88	-1.78	4.77	-0.85	-3.61	-4.69	2.90
U-236	0.84	-0.69	-2.16	-4.30	0.68	-0.99	0.67	2.33	1.53	-2.24	-2.09	-3.34	1.18	3.02	-2.17
U-238	0.01	0.01	-0.03	0.48	-0.02	-0.01	0.00	0.03	-0.13	-0.04	-0.06	0.02	-0.13	0.88	-0.07
Pu-238	4.99	-12.74	2.13	-7.26	9.28	-6.32	5.09	6.85	1.71	16.07	-4.40	-0.13	3.61	13.87	12.35
Pu-239	-0.68	1.50	0.09	-10.65	1.69	4.95	-3.47	-2.39	10.00	-1.47	1.67	1.55	-4.93	5.94	8.94
Pu-240	-4.30	2.12	1.28	-12.67	5.32	1.12	2.56	-2.78	3.79	-3.62	4.43	-0.61	-0.87	-0.51	-6.77
Pu-241	-0.52	-1.52	-0.29	-11.08	0.72	0.40	1.97	-0.04	7.50	1.70	6.61	8.52	-3.32	11.46	15.00
Pu-242	0.50	-1.45	1.32	-9.82	-1.86	-3.76	2.09	1.30	-4.79	8.71	5.61	3.24	13.77	11.25	13.60
Am-241	1.46	0.13	-10.09	-8.51	-4.17	3.23	2.44	2.83	12.66	0.78	12.33	13.74	0.44	15.02	16.01
Am-243	3.52	-4.74	-0.06	-24.55	-2.99	-0.26	3.01	-1.46	4.38	-3.67	3.82	-1.00	26.45	31.02	12.79
Np-237	7.60	-16.18	3.95	6.59	0.65	-8.23	4.36	8.50	-0.92	21.01	-0.56	5.35	4.75	11.01	11.98
Mo-95	nodata	0.68	-1.17	nodata	8.78	0.39	-1.37	1.48	-1.12	nodata	0.07	0.24	0.74	1.54	0.27
Tc-99	nodata	0.93	-0.46	-5.50	-0.44	-0.97	0.68	-0.18	-2.07	-1.36	0.86	0.15	-1.98	-0.51	1.81
Ru-101	nodata	0.77	1.26	nodata	0.71	0.38	-0.96	-1.45	-1.10	nodata	-1.27	-1.43	-0.53	-0.12	-1.33
Rh-103	-8.27	0.63	2.08	-1.59	0.03	0.73	4.46	0.36	2.08	6.33	3.70	2.14	-1.43	2.38	6.66
Ag-109	-18.25	-0.76	5.69	nodata	2.77	-2.32	7.45	8.20	6.43	nodata	21.05	15.41	16.39	19.43	21.10
Cs-133	-1.86	-0.27	1.33	-3.17	-1.23	-2.56	1.87	1.48	0.92	2.82	2.75	1.26	2.03	2.67	0.63
Sm-147	1.80	2.58	-9.17	nodata	4.75	-1.34	1.02	5.11	0.16	nodata	4.71	3.99	-0.88	-0.59	-1.29
Sm-149	5.76	-3.89	2.50	-2.60	6.70	-1.38	0.52	-3.51	16.30	-0.83	-2.38	-3.23	9.42	14.06	12.61
Sm-150	0.02	-2.55	2.01	-7.98	3.47	-3.66	5.77	-1.58	-2.41	4.73	-7.27	-1.72	9.03	4.88	0.68
Sm-151	3.18	-5.69	-1.06	-6.91	-9.76	0.82	11.63	-8.88	10.81	3.44	5.55	-5.73	16.92	24.96	5.03
Sm-152	-7.57	-4.72	-4.07	2.65	-12.93	2.38	6.81	7.17	7.94	24.49	14.62	3.80	6.16	7.12	5.55
Nd-143	0.89	-1.59	-1.61	-4.10	-1.43	-1.53	-0.66	4.50	0.31	0.62	0.79	0.96	-1.91	1.17	0.57
Nd-145	-2.70	0.99	0.27	-1.29	0.81	1.00	-0.93	1.38	-0.85	3.42	1.11	1.24	1.13	1.01	0.01
Eu-153	-0.99	4.59	8.24	-6.37	3.17	3.48	-5.22	-10.10	-3.90	-4.12	-6.63	-7.03	-5.31	4.53	4.11
Eu-155	73.29	-27.53	-28.61	-21.64	-21.96	-26.07	38.21	-29.29	-43.47	-14.75	-23.06	-23.55	39.18	-41.74	39.27
Gd-155	-1.28	1.28	6.03	-100.00	20.78	-89.21	-7.39	1.37	-86.94	-5.90	16.12	-85.31	3.43	-86.62	35.71
Gd-156	-1.98	-0.18	1.32	-50.87	2.03	-95.85	-0.82	1.65	-95.23	-3.55	1.41	-95.50	0.24	-95.06	6.45
Gd-157	-28.38	16.25	-4.28	-100.00	3.80	-82.47	14.26	2.15	-80.32	-5.78	21.17	-83.16	-24.54	-82.14	12.59
Gd-158	-1.22	1.35	-0.95	-49.93	-0.31	-99.09	0.64	0.18	-99.14	-0.16	0.70	-99.24	0.35	-99.17	4.01
Xe-131	-2.29	-0.23	1.42	3.00	0.09	-2.35	-2.15	5.60	-1.88	4.24	3.55	0.15	0.60	-1.30	-2.28

* Participants **A**, **B**, **C**, **G** (except for Gd), **H** and **J** are used for the average.

Table 4.23. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 2b (40% void, 40 GWd/tHM, 5 y cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-1.04	-1.54	-2.46	-0.61	-1.59	-1.63	-1.57	8.25	-8.43	-2.71	3.37	-1.02	-3.67	-4.35	-4.14
U-235	0.70	0.11	0.62	2.99	2.42	2.30	-0.35	-3.39	7.88	-1.78	4.77	-0.85	-3.62	-4.69	2.89
U-236	0.83	-0.67	-2.18	-4.29	0.67	-0.97	0.68	2.32	1.52	-2.25	-2.07	-3.33	1.20	3.01	-2.19
U-238	0.01	0.01	-0.03	0.48	-0.02	-0.01	0.00	0.03	-0.13	-0.04	-0.06	0.02	-0.13	0.88	-0.07
Pu-238	4.57	-11.96	1.50	-7.95	8.30	-6.04	5.25	6.68	1.87	14.24	-3.61	0.46	3.28	13.11	12.63
Pu-239	-0.72	1.45	0.25	-10.69	1.57	4.84	-3.45	-2.36	9.81	-2.83	1.60	1.51	-5.03	5.48	9.43
Pu-240	-4.26	2.08	1.27	-12.73	5.33	1.10	2.55	-2.74	3.53	-3.64	4.41	-0.65	-1.04	-0.35	-6.78
Pu-241	-0.64	-1.46	-0.25	-11.41	0.70	0.44	2.01	-0.10	7.46	2.25	6.68	8.59	-3.45	11.28	15.79
Pu-242	0.50	-1.45	1.32	-9.82	-1.86	-3.76	2.09	1.30	-4.79	8.71	5.61	3.25	13.77	11.25	13.60
Am-241	0.04	-1.11	-2.09	-9.79	-0.11	1.05	1.77	0.35	8.29	-0.27	7.17	8.99	-2.59	12.04	12.97
Am-243	3.52	-4.74	-0.11	-24.52	-2.95	-0.26	3.05	-1.46	4.33	-3.72	3.86	-0.96	26.55	31.02	12.79
Np-237	6.53	-15.79	2.91	7.33	0.16	-7.80	5.19	8.95	-0.46	20.11	0.20	6.17	5.63	11.82	12.78
Mo-95	nodata	0.43	-0.16	nodata	-1.12	0.09	-1.53	1.17	-1.42	nodata	-0.28	-0.07	0.35	0.96	0.00
Tc-99	nodata	0.74	-0.33	-5.37	-0.37	-1.15	0.79	-0.05	-1.97	nodata	0.96	0.26	-1.85	-0.50	1.81
Ru-101	nodata	0.77	1.26	nodata	0.71	0.38	-0.96	-1.45	-1.10	nodata	-1.27	-1.43	-0.53	-0.12	-1.33
Rh-103	-13.50	1.56	3.77	-0.80	0.59	1.62	5.21	1.34	3.00	nodata	4.36	2.99	-0.43	3.51	7.18
Ag-109	-18.29	-0.81	5.63	nodata	2.72	-2.37	7.54	8.29	6.38	nodata	21.14	15.51	16.42	19.61	21.04
Cs-133	-2.36	-0.22	1.45	-2.99	-1.23	-2.51	1.99	1.64	0.96	nodata	2.87	1.40	2.34	2.69	0.85
Sm-147	-3.95	2.90	-1.48	nodata	5.07	-2.32	-0.48	5.33	0.86	nodata	3.67	2.92	-2.61	-1.62	-2.15
Sm-149	3.02	-4.00	6.81	-4.69	0.43	-2.29	-0.93	-2.62	8.99	nodata	-6.61	-6.57	7.95	9.89	8.87
Sm-150	0.02	-2.55	2.01	-7.98	3.47	-3.66	5.77	-1.58	-2.41	nodata	-7.27	-1.72	9.03	4.88	0.68
Sm-151	1.34	-5.33	-0.54	-6.60	-10.83	1.06	11.87	-8.40	10.99	nodata	5.80	-5.30	16.92	24.94	5.49
Sm-152	-7.57	-4.72	-4.07	2.65	-12.93	2.38	6.81	7.17	7.94	nodata	14.62	3.80	6.20	7.12	5.55
Nd-143	-0.68	-1.42	-1.22	-3.67	-1.41	-1.38	-0.39	5.08	0.60	nodata	1.02	1.21	-1.60	1.35	0.77
Nd-145	-2.71	0.98	0.26	-1.27	0.80	0.99	-0.91	1.40	-0.86	nodata	1.12	1.25	1.12	1.00	0.00
Eu-153	-1.51	4.66	8.39	-6.32	3.19	3.55	-5.09	-10.00	-3.83	nodata	-6.57	-6.96	-5.15	4.62	4.20
Eu-155	69.02	-26.80	-27.89	-21.57	-21.17	-25.36	39.59	-28.57	-45.24	nodata	-22.25	-22.75	34.88	-43.41	40.69
Gd-155	-91.61	-14.21	-14.96	-100.00	-6.62	-20.31	45.27	-16.10	-36.25	nodata	-8.22	-17.36	63.05	-34.50	59.69
Gd-156	-2.62	-0.68	0.83	-51.20	1.51	-95.72	-1.32	1.16	-95.09	nodata	0.92	-95.36	-0.18	-94.91	6.03
Gd-157	-35.07	8.63	-9.95	-100.00	-5.90	-80.92	3.58	-2.26	-79.41	nodata	9.88	-84.70	-28.76	-81.01	4.92
Gd-158	-1.52	1.04	-1.25	-50.08	-0.61	-99.09	0.33	-0.13	-99.15	nodata	0.40	-99.24	0.04	-99.17	3.69
Xe-131	-3.25	-0.08	1.71	3.11	-0.89	-2.19	-1.95	5.77	-1.72	nodata	3.66	0.31	0.66	-1.31	-2.27

* Participants **A**(except for Gd), **B**, **C**, **G** (except for Gd), **H** and **J** are used for the average.

Table 4.24. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 3a (70% void, 40 GWd/tHM, No cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-2.79	-0.33	-1.86	-2.13	-0.31	-1.99	-2.12	9.09	-12.52	-4.56	3.79	-2.90	-6.09	-6.77	-5.88
U-235	0.62	-0.67	1.45	4.64	2.46	1.40	0.45	-3.24	25.26	3.04	6.10	3.92	-3.80	-4.16	7.40
U-236	0.75	-0.55	-2.52	-4.95	1.12	-0.79	0.60	2.51	4.07	-3.61	-2.35	-4.42	1.59	3.29	-1.05
U-238	0.01	0.03	-0.04	0.45	-0.03	-0.02	0.00	0.02	-0.73	-0.16	-0.10	-0.11	-0.15	0.64	0.17
Pu-238	7.56	-15.00	-0.44	-2.30	13.52	-6.77	6.73	7.93	36.48	21.58	-2.52	6.91	8.18	17.35	20.81
Pu-239	-1.00	0.38	1.24	-9.78	1.17	5.93	-3.83	-2.72	65.59	7.48	4.96	12.32	-5.07	6.03	17.81
Pu-240	-4.91	1.56	1.46	-12.38	5.38	2.35	2.72	-3.18	11.46	-1.37	4.29	-0.77	-0.22	0.40	-6.85
Pu-241	-0.02	-3.07	-0.90	-8.52	2.95	-0.23	3.58	0.63	45.58	8.48	8.61	19.28	-1.13	12.62	25.48
Pu-242	1.13	-1.93	1.05	-5.72	-1.13	-5.02	2.61	2.16	-11.54	10.66	5.99	5.23	13.76	11.01	16.64
Am-241	2.06	-1.63	-10.85	-4.37	-4.81	2.83	3.75	3.84	62.23	10.76	15.52	27.44	2.27	15.94	28.54
Am-243	5.22	-5.01	-1.39	-21.31	-2.16	-0.99	4.96	-2.80	12.24	-2.03	4.86	2.96	25.17	29.29	16.98
Np-237	9.27	-18.31	2.52	10.25	-3.08	-7.86	4.82	9.55	21.73	27.18	0.83	11.18	7.80	12.93	19.16
Mo-95	nodata	0.74	-1.30	nodata	8.71	0.48	-1.47	1.55	-3.37	nodata	-0.11	-0.12	0.38	1.23	-0.06
Tc-99	nodata	1.21	-0.47	-6.34	-0.02	-1.19	0.72	-0.26	-4.05	-1.79	0.70	-0.20	-3.74	-1.35	1.17
Ru-101	nodata	0.86	1.10	nodata	0.70	0.53	-0.97	-1.52	-2.35	nodata	-1.35	-1.41	-0.88	-0.57	-1.58
Rh-103	-8.62	0.36	2.52	-0.03	-0.19	1.21	3.75	0.77	4.70	9.54	4.65	3.75	-4.56	2.05	7.87
Ag-109	-20.33	-0.45	5.60	nodata	4.98	-2.61	8.81	8.97	13.14	nodata	22.36	17.61	12.70	18.50	23.61
Cs-133	-2.45	0.26	1.44	-3.70	-0.69	-2.71	1.71	1.75	-1.00	2.44	2.78	0.86	1.25	2.07	0.02
Sm-147	1.00	3.51	-8.87	nodata	6.76	-2.12	0.63	5.85	-9.94	nodata	4.51	2.31	-6.28	-2.90	-2.41
Sm-149	6.35	-6.09	1.93	-2.67	6.81	-2.20	3.46	-3.45	95.89	4.48	0.09	9.09	13.32	16.64	25.09
Sm-150	0.65	-2.40	1.84	-8.14	3.85	-3.61	4.69	-1.18	-2.50	4.73	-7.42	-0.47	11.31	4.37	0.23
Sm-151	5.61	-6.87	-0.78	-5.71	-9.43	2.18	8.83	-8.96	70.82	10.19	8.00	0.64	18.88	28.12	15.73
Sm-152	-8.36	-4.59	-4.91	2.91	-15.68	4.02	6.83	7.01	2.51	26.81	16.55	1.90	2.66	7.07	6.67
Nd-143	1.28	-1.90	-1.86	-4.11	-1.04	-1.41	-1.21	5.09	5.97	2.52	0.96	2.54	-1.63	1.58	1.87
Nd-145	-3.29	2.10	0.04	-1.58	1.04	1.15	-1.48	1.48	-3.50	3.70	0.94	0.97	0.33	0.43	-0.58
Eu-153	0.47	3.28	7.80	-4.91	2.67	3.02	-4.81	-9.76	-3.17	-3.10	-7.20	-6.31	-3.26	3.55	4.59
Eu-155	74.47	-25.53	-26.15	-28.53	-15.05	-23.02	38.07	-37.85	-44.36	-20.59	-30.08	-29.82	51.35	-47.25	39.61
Gd-155	-0.88	0.54	8.32	-100.00	27.21	-87.28	-8.55	0.56	-73.03	-1.01	18.65	-82.54	9.80	-85.74	56.36
Gd-156	-1.75	-0.42	1.43	-50.44	2.18	-95.65	-1.26	2.00	-94.93	-3.99	1.33	-95.36	0.57	-94.78	6.36
Gd-157	-29.28	14.60	-2.60	-100.00	5.72	-84.28	20.17	-2.90	-64.10	6.63	24.66	-81.89	-23.46	-82.94	30.87
Gd-158	-1.42	1.57	-1.04	-50.15	-0.49	-99.05	0.69	0.19	-99.01	-0.06	0.75	-99.17	-0.05	-99.12	3.90
Xe-131	-2.80	0.36	1.44	4.61	-0.95	-2.79	-2.58	6.38	-6.31	6.12	4.27	0.06	-1.54	-1.79	-3.29

* Participants **A**, **B**, **C**, **G** (except for Gd), **H** and **J** are used for the average.

Table 4.25. Relative differences of nuclide densities in units of % of each participant from the averaged result, for Case 3b (70% void, 40 GWd/tHM, 5 y cooling)*

Nuclide	**A**	**B**	**C**	**D**	**E**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**
U-234	-2.27	-0.80	-2.33	-2.01	0.33	-2.08	-1.65	9.14	-16.04	-3.46	3.69	-2.34	-5.61	-5.81	-4.73
U-235	0.61	-0.67	1.45	4.65	2.46	1.41	0.45	-3.25	25.26	3.03	6.10	3.93	-3.81	-4.16	7.40
U-236	0.73	-0.53	-2.53	-4.94	1.10	-0.78	0.62	2.49	4.05	-3.63	-2.34	-4.41	1.58	3.27	-1.07
U-238	0.01	0.03	-0.04	0.45	-0.03	-0.02	0.00	0.02	-0.73	-0.16	-0.10	-0.11	-0.15	0.64	0.17
Pu-238	6.98	-14.20	-0.93	-3.01	12.65	-6.58	6.92	7.81	35.45	19.66	-1.86	7.38	7.78	16.50	20.85
Pu-239	-1.03	0.34	1.37	-9.82	1.08	5.83	-3.81	-2.71	64.91	6.19	4.88	12.20	-5.05	5.61	18.08
Pu-240	-4.87	1.53	1.43	-12.44	5.38	2.32	2.72	-3.12	11.12	-1.39	4.27	-0.80	-0.41	0.32	-6.91
Pu-241	-0.15	-3.02	-0.86	-8.86	2.92	-0.19	3.62	0.59	45.51	9.06	8.67	19.34	-1.25	12.36	26.07
Pu-242	1.13	-1.93	1.05	-5.72	-1.13	-5.02	2.61	2.16	-11.54	10.66	6.00	5.23	13.76	11.01	16.64
Am-241	0.56	-2.69	-2.77	-6.95	1.63	0.47	3.33	1.09	48.23	6.91	9.37	20.21	-0.62	12.98	23.76
Am-243	5.22	-5.01	-1.44	-21.27	-2.12	-0.99	5.01	-2.80	12.19	-2.08	4.91	3.01	25.20	29.29	16.98
Np-237	8.19	-17.94	1.50	11.01	-3.51	-7.44	5.64	10.05	22.24	26.24	1.60	12.05	8.59	13.57	20.62
Mo-95	nodata	0.48	-0.27	nodata	-1.26	0.18	-1.62	1.22	-3.59	nodata	-0.45	-0.43	-0.04	0.91	-0.45
Tc-99	nodata	1.02	-0.34	-6.21	0.06	-1.38	0.83	-0.14	-3.95	nodata	0.81	-0.08	-3.65	-1.15	1.18
Ru-101	nodata	0.86	1.10	nodata	0.70	0.53	-0.97	-1.52	-2.35	nodata	-1.35	-1.41	-0.84	-0.57	-1.58
Rh-103	-13.86	1.30	4.21	0.73	0.49	2.08	4.53	1.75	5.63	nodata	5.32	4.58	-3.31	3.14	8.62
Ag-109	-20.36	-0.49	5.55	nodata	4.93	-2.66	8.91	9.06	13.08	nodata	22.46	17.71	12.81	18.67	23.78
Cs-133	-2.95	0.31	1.57	-3.52	-0.68	-2.65	1.83	1.90	-0.94	nodata	2.91	1.01	1.62	2.10	0.06
Sm-147	-5.20	4.23	-0.85	nodata	7.61	-3.01	-1.16	5.99	-6.48	nodata	3.48	1.40	-8.06	-3.78	-3.13
Sm-149	4.05	-5.53	5.71	-4.46	1.65	-2.55	1.05	-2.73	63.75	nodata	-4.29	2.18	11.51	12.41	17.72
Sm-150	0.65	-2.40	1.84	-8.14	3.85	-3.61	4.69	-1.18	-2.50	nodata	-7.42	-0.47	11.31	4.37	0.23
Sm-151	3.96	-6.55	-0.33	-5.45	-10.30	2.39	9.09	-8.56	70.38	nodata	8.22	0.97	19.05	28.16	16.05
Sm-152	-8.36	-4.59	-4.92	2.91	-15.68	4.02	6.83	7.01	2.50	nodata	16.55	1.90	2.70	7.07	6.67
Nd-143	-0.23	-1.73	-1.48	-3.71	-1.00	-1.26	-0.94	5.64	6.14	nodata	1.20	2.76	-1.31	1.76	2.04
Nd-145	-3.30	2.09	0.03	-1.57	1.03	1.14	-1.46	1.50	-3.51	nodata	0.95	0.98	0.32	0.42	-0.59
Eu-153	-0.05	3.34	7.95	-4.86	2.69	3.09	-4.68	-9.65	-3.10	nodata	-7.14	-6.25	-3.11	3.64	4.67
Eu-155	70.19	-24.77	-25.41	-28.46	-14.18	-22.27	39.47	-37.21	-46.10	nodata	-29.33	-29.07	46.46	-48.93	41.36
Gd-155	-90.70	-11.14	-11.08	-100.00	2.53	-16.66	46.52	-24.30	-35.73	nodata	-14.32	-23.53	78.08	-40.01	63.78
Gd-156	-2.35	-0.86	1.00	-50.75	1.72	-95.52	-1.71	1.57	-94.78	nodata	0.89	-95.22	0.11	-94.63	5.86
Gd-157	-35.38	6.94	-8.75	-100.00	-3.40	-83.45	9.81	-8.00	-65.34	nodata	13.93	-83.43	-28.09	-82.48	21.56
Gd-158	-1.77	1.21	-1.39	-50.33	-0.84	-99.05	0.33	-0.16	-99.01	nodata	0.40	-99.17	-0.41	-99.13	3.53
Xe-131	-3.78	0.51	1.74	4.72	-1.94	-2.62	-2.36	6.50	-6.08	nodata	4.40	0.24	-1.26	-1.30	-3.27

* Participants **A**(except for Gd), **B**, **C**, **G** (except for Gd), **H** and **J** are used for the average.

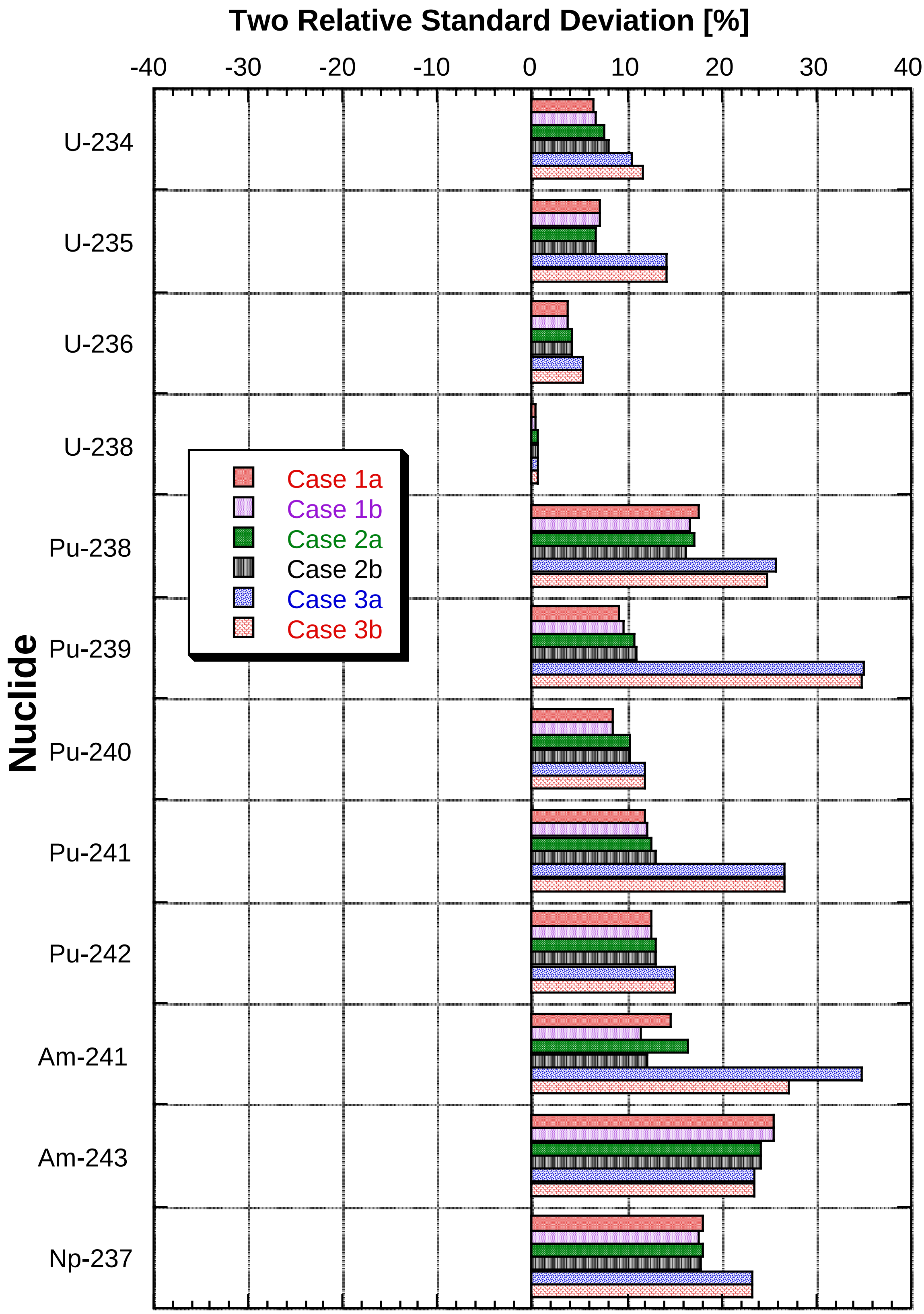

Figure 4.1. Two relative standard deviations of actinide concentrations calculated by participants.

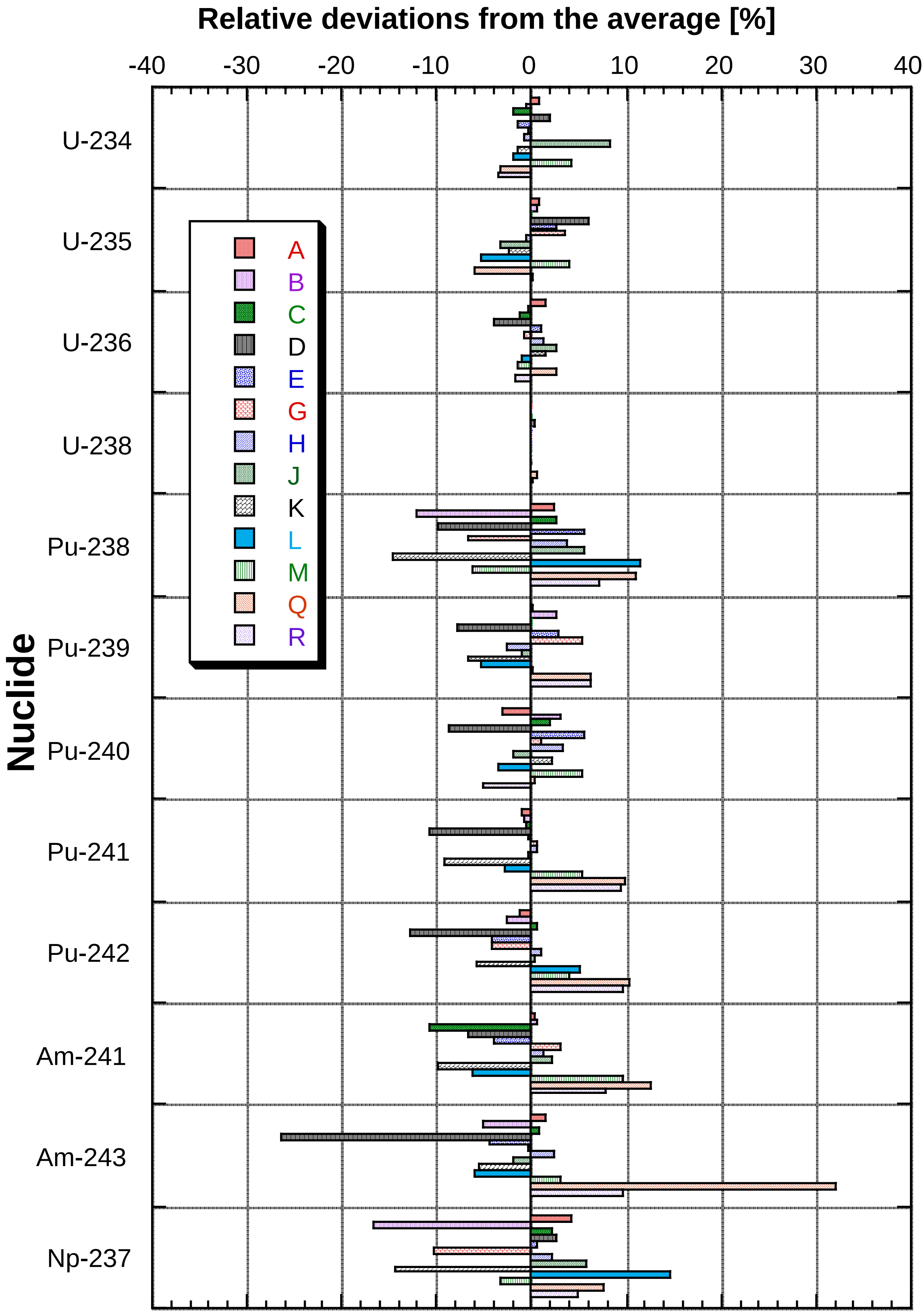

Figure 4.2. Atomic number densities of actinides reported from participants relative to the average for Case 1a. (No void, 40 GWd/tHM, Not cooling.)

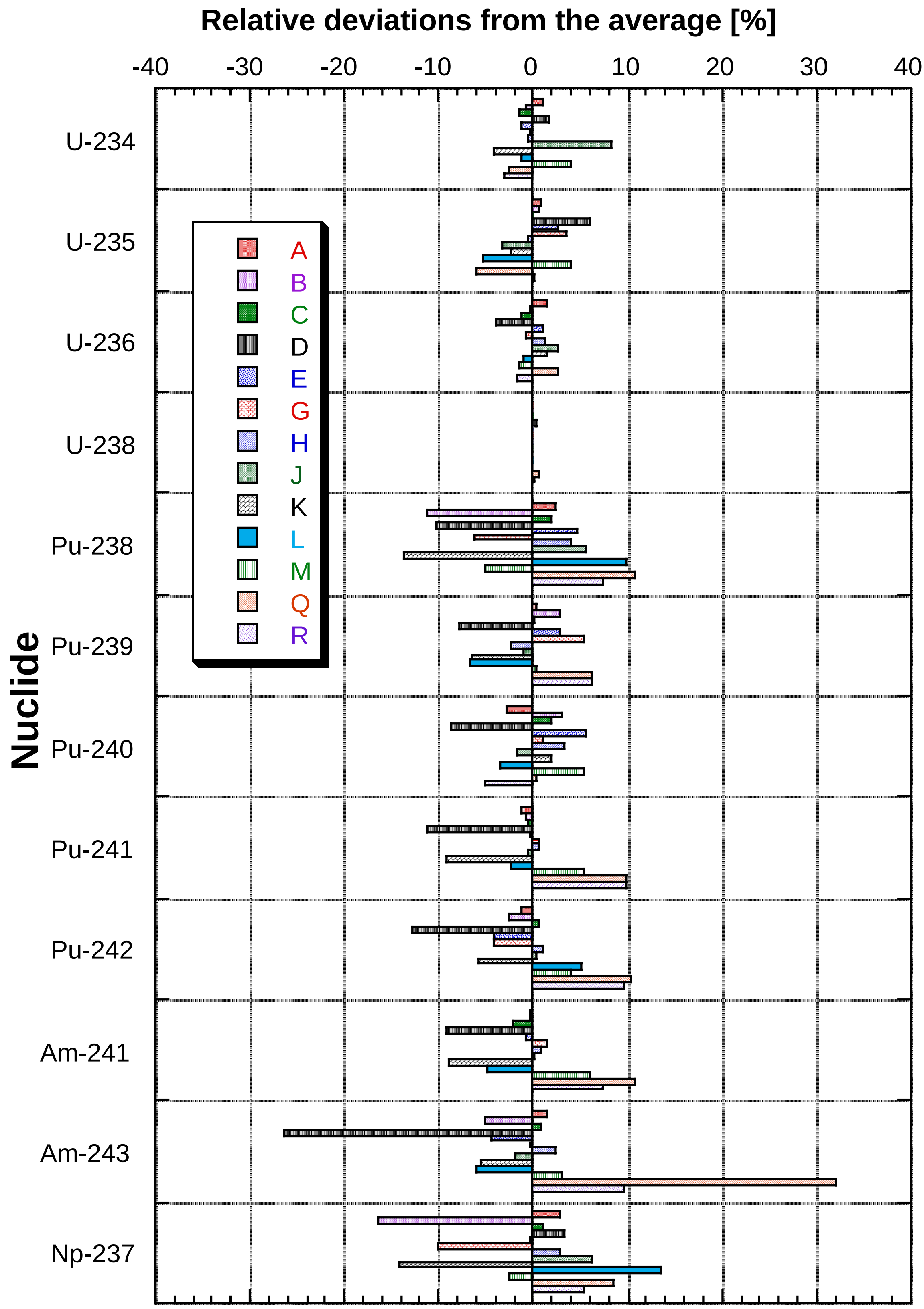

Figure 4.3. Atomic number densities of actinides reported from participants relative to the average for Case 1b. (No void, 40 GWd/tHM, 5 y cooling.)

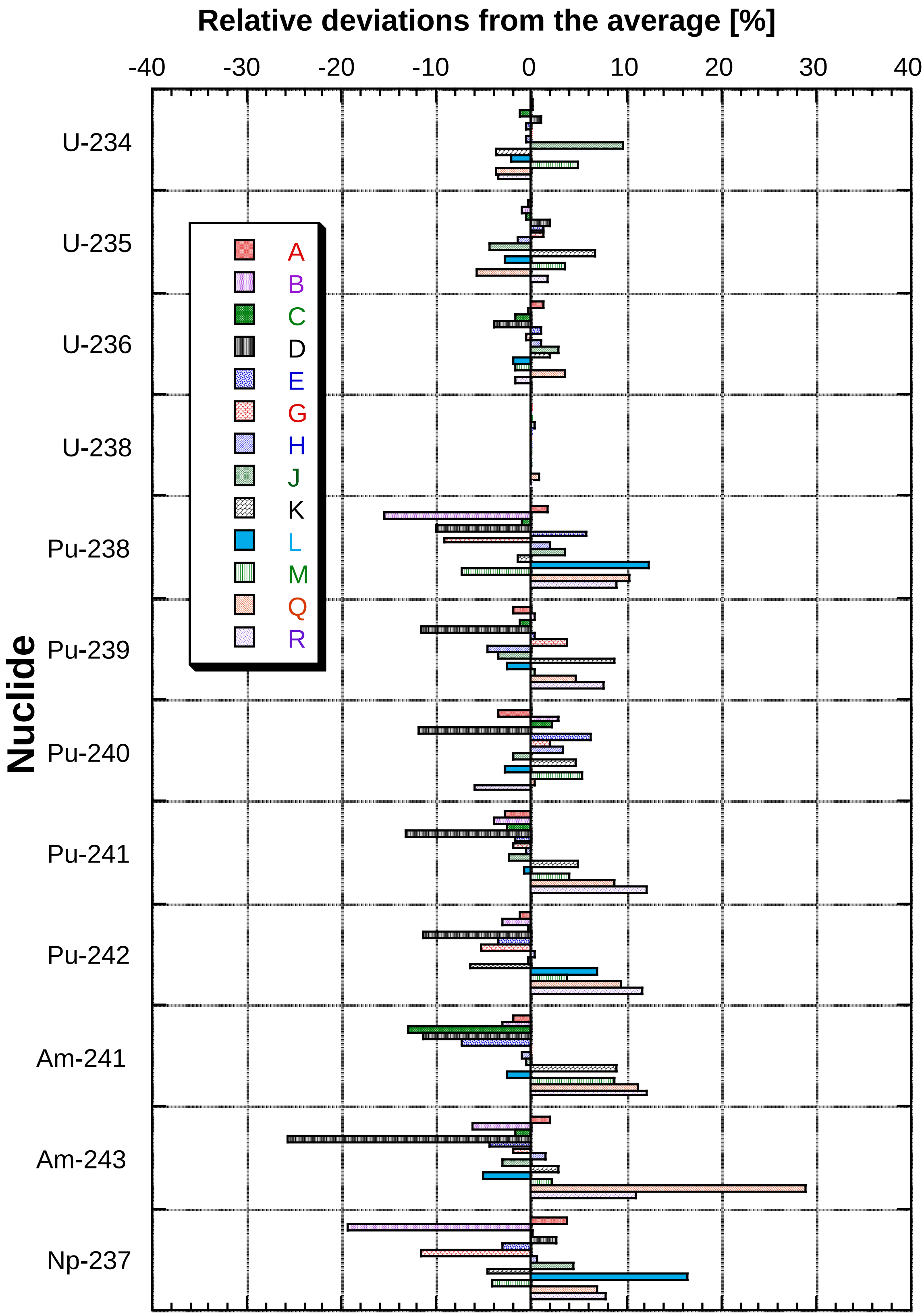

Figure 4.4. Atomic number densities of actinides reported from participants relative to the average for Case 2a. (40% void, 40 GWd/tHM, Not cooling.)

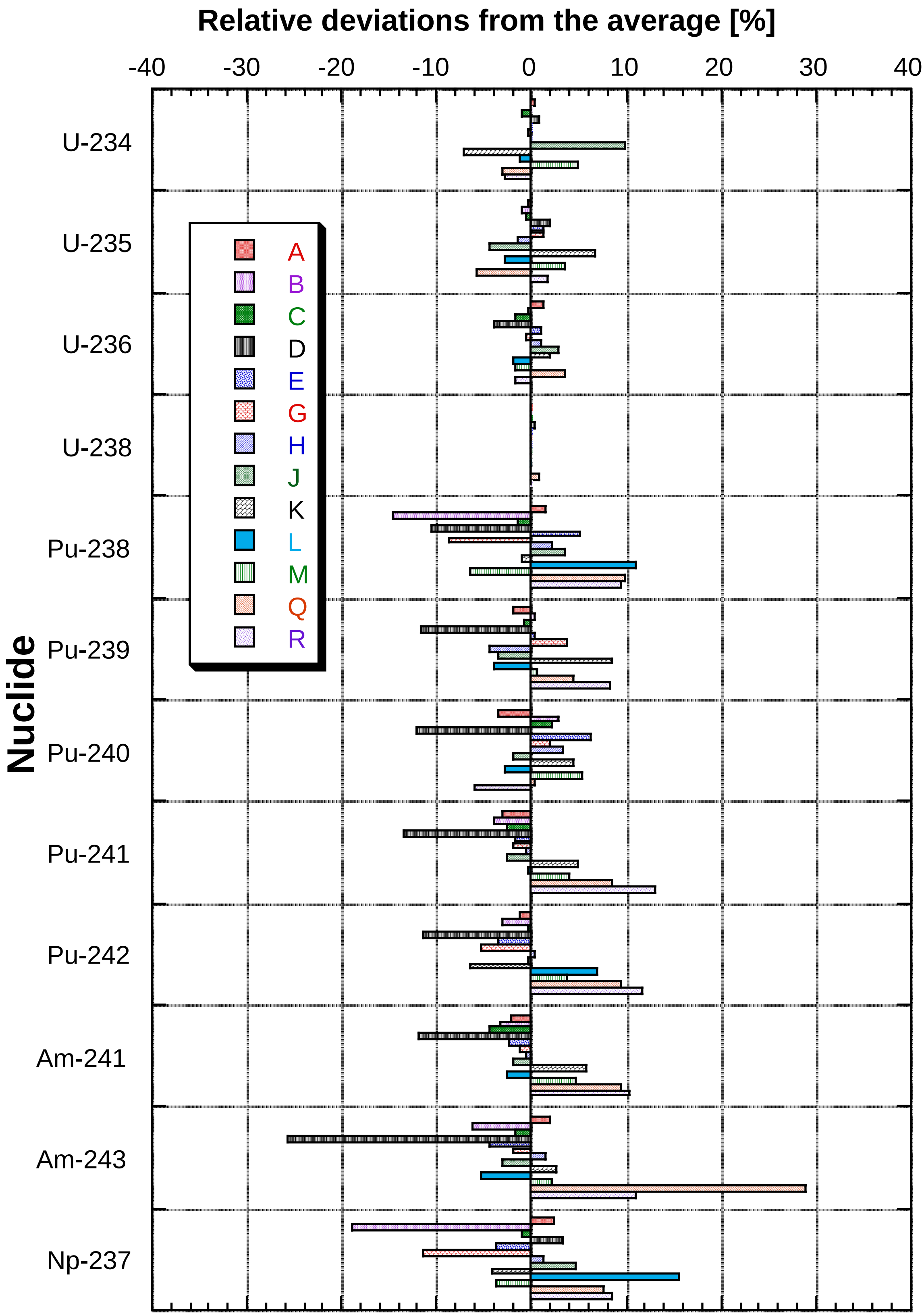

Figure 4.5. Atomic number densities of actinides reported from participants relative to the average for Case 2b. (40% void, 40 GWd/tHM, 5 y cooling.)

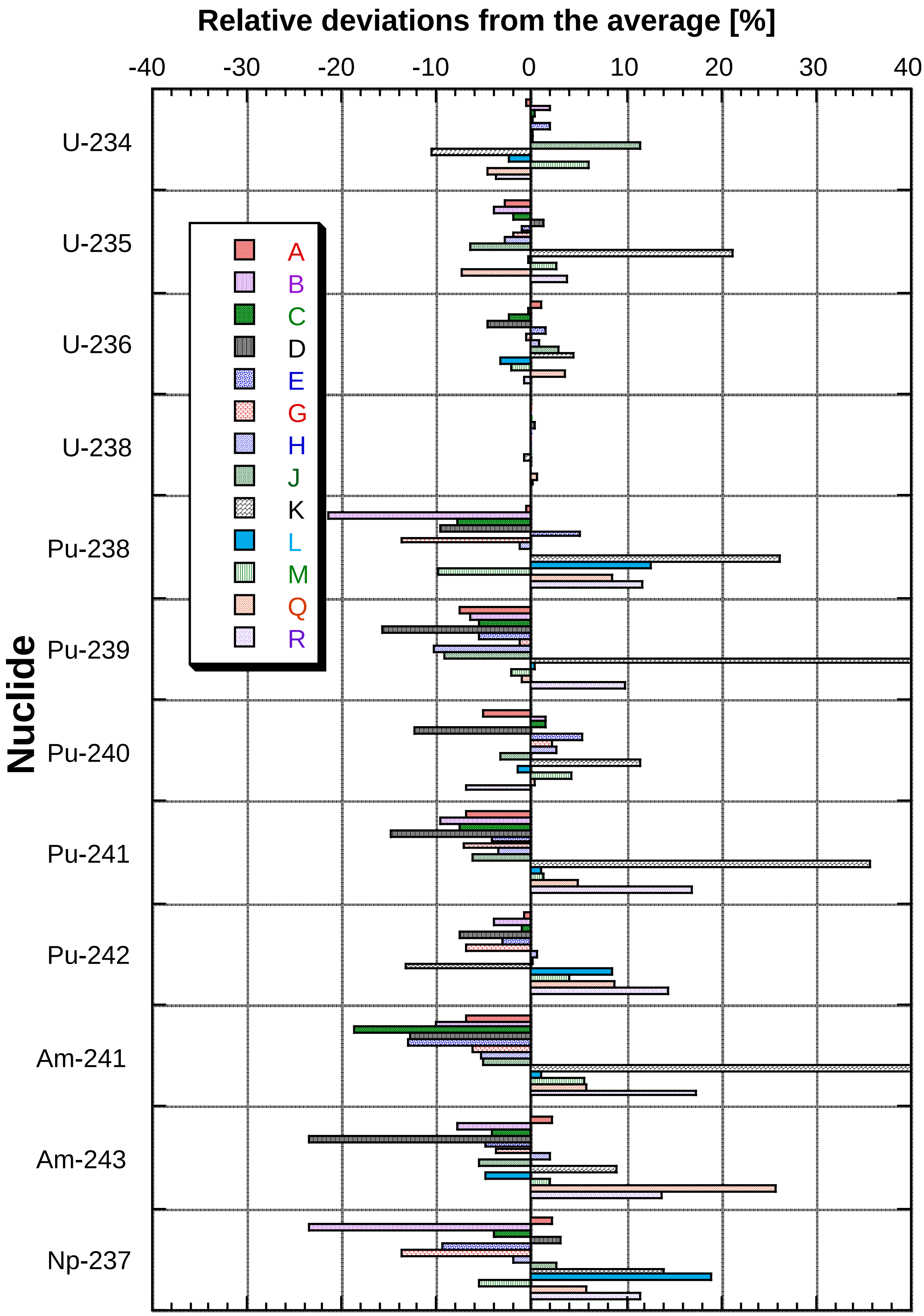

Figure 4.6. Atomic number densities of actinides reported from participants relative to the average for Case 3a. (70% void, 40 GWd/tHM, No cooling.)

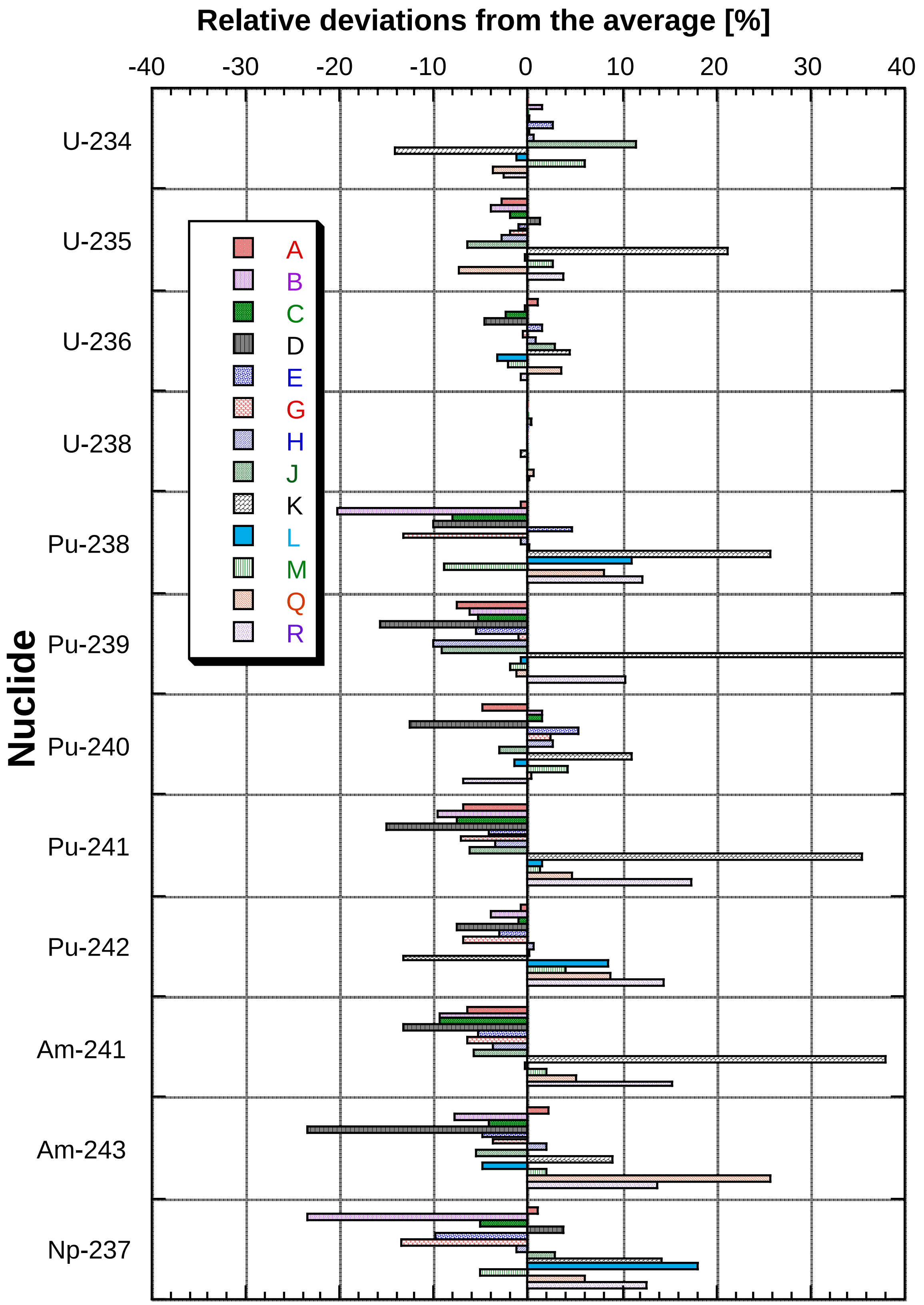

Figure 4.7. Atomic number densities of actinides reported from participants relative to the average for Case 3b. (70% void, 40 GWd/tHM, 5 y cooling.)

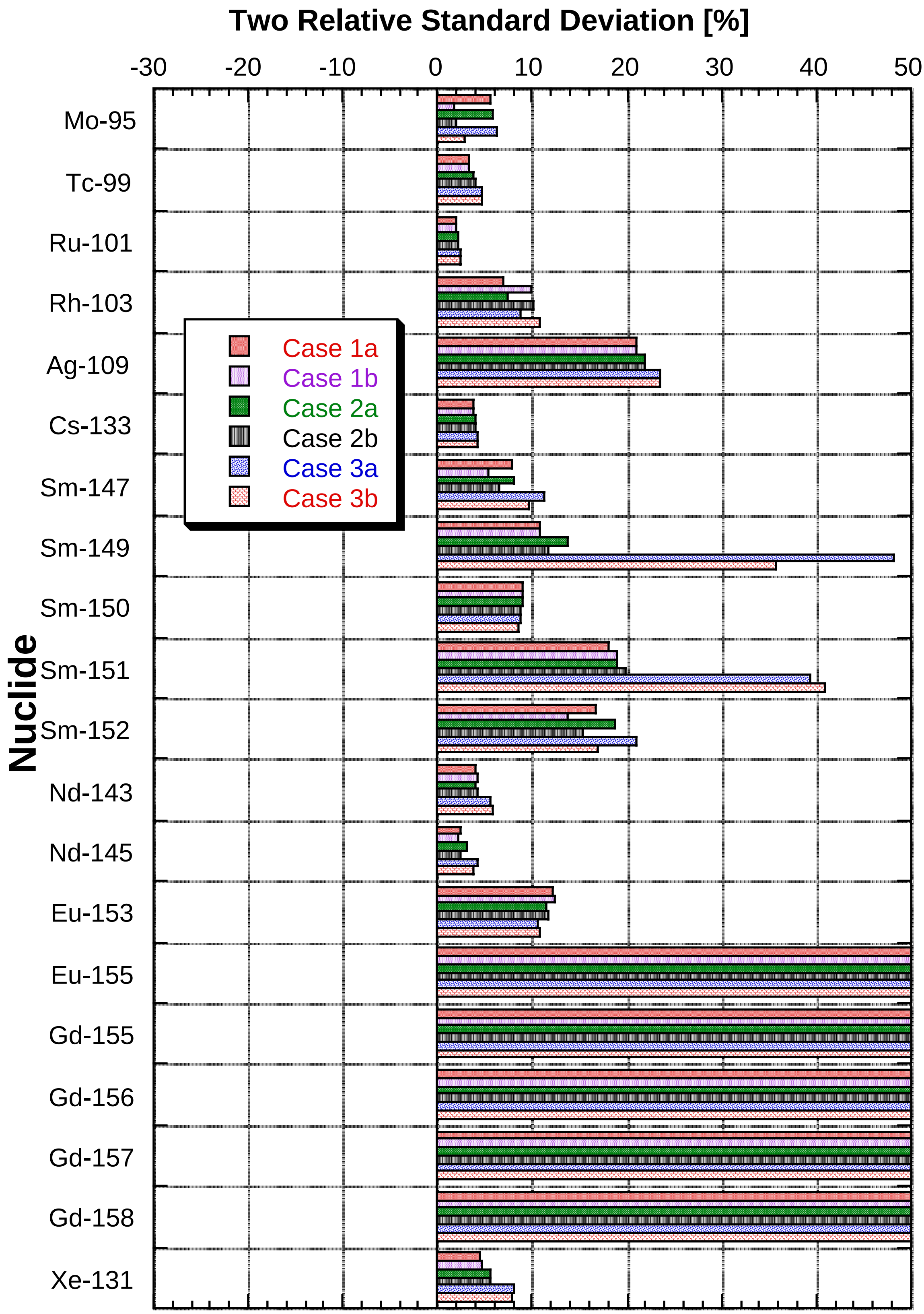

Figure 4.8. Two relative standard deviations of FP nuclide concentrations calculated by participants.

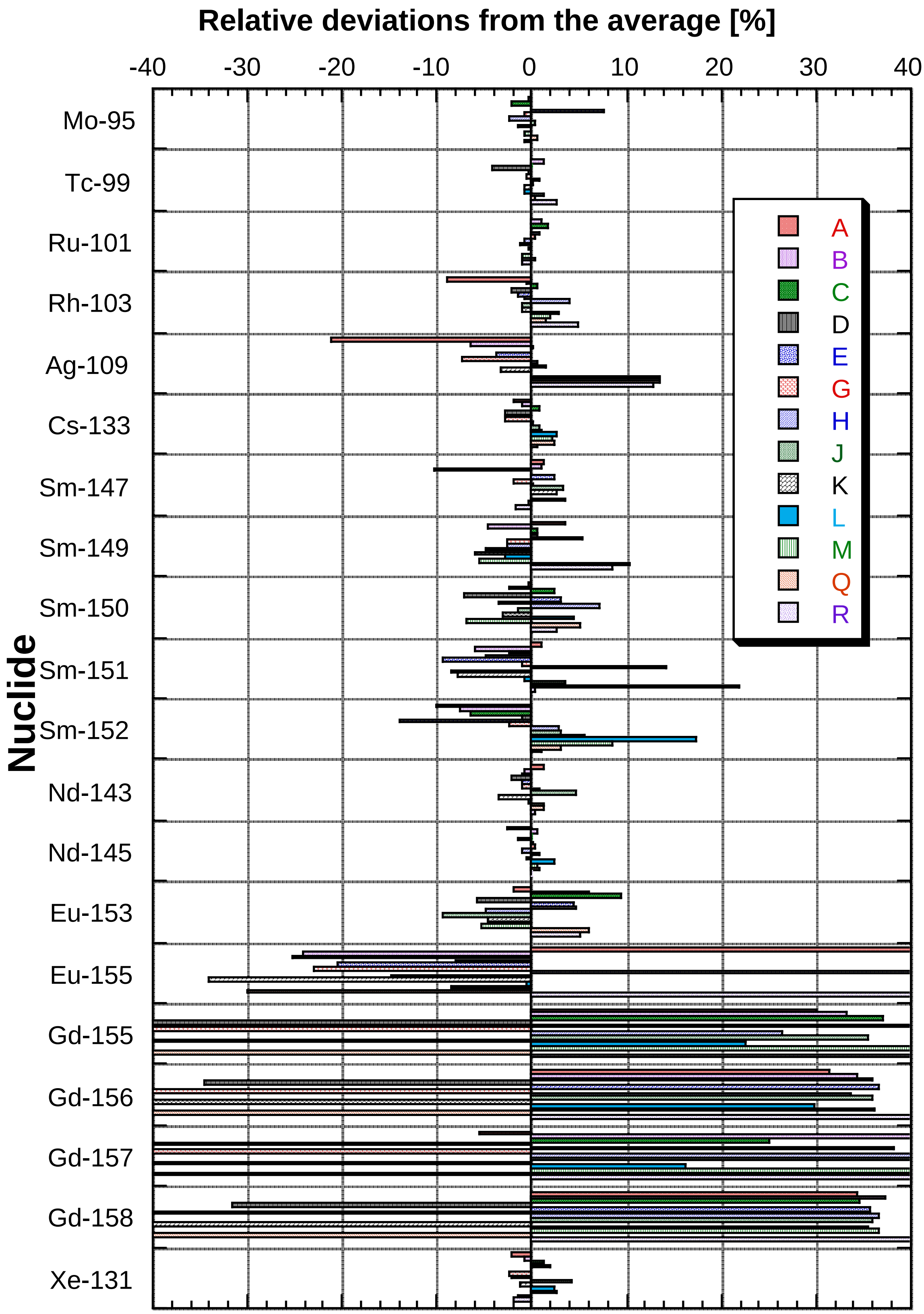

Figure 4.9. Atomic number densities of FPs reported from participants relative to the average for Case 1a. (No void, 40 GWd/tHM, No cooling.)

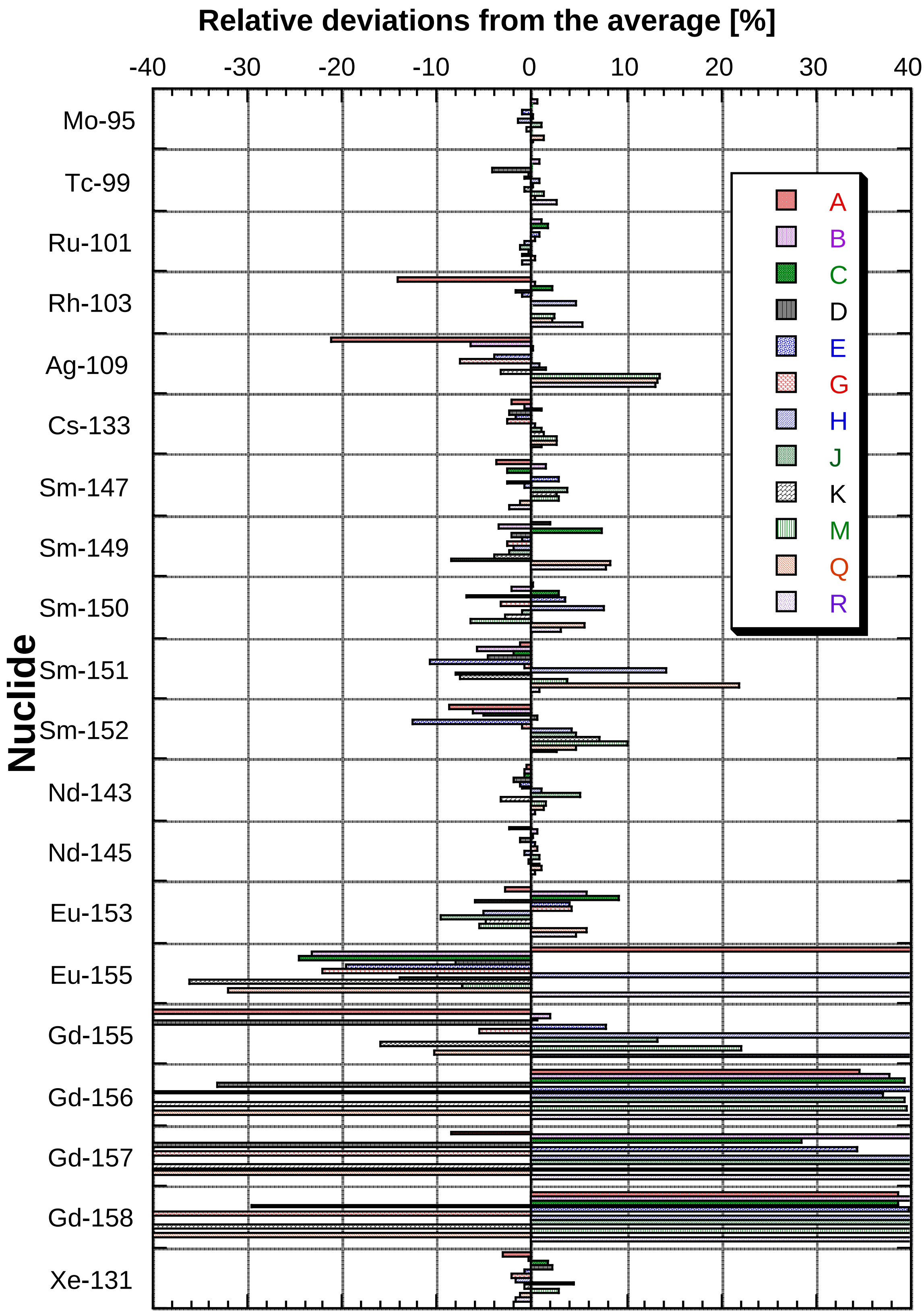

Figure 4.10. Atomic number densities of FPs reported from participants relative to the average for Case 1b. (No void, 40 GWd/tHM, 5 y cooling.)

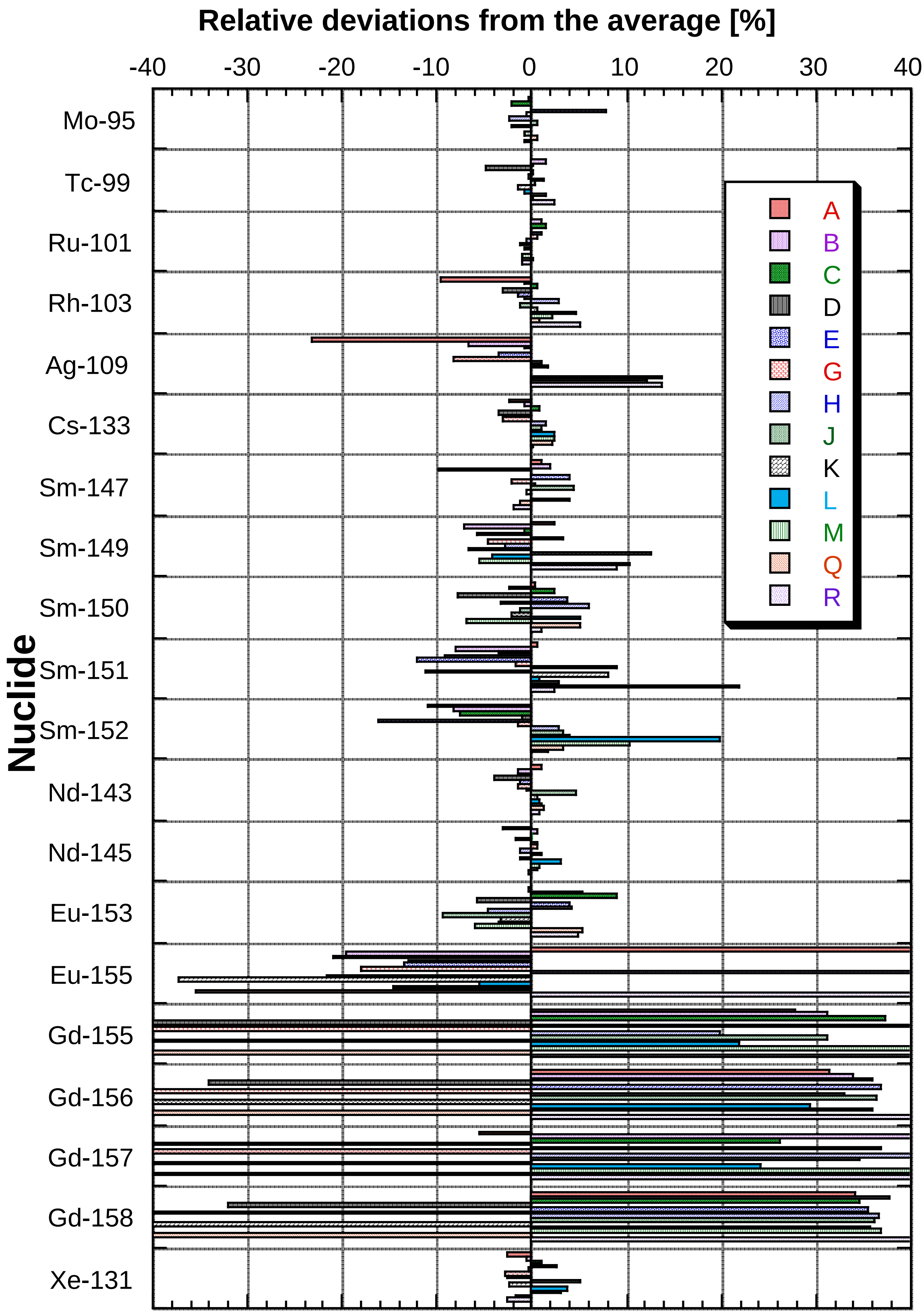

Figure 4.11. Atomic number densities of FPs reported from participants relative to the average for Case 2a. (40% void, 40 GWd/tHM, No cooling.)

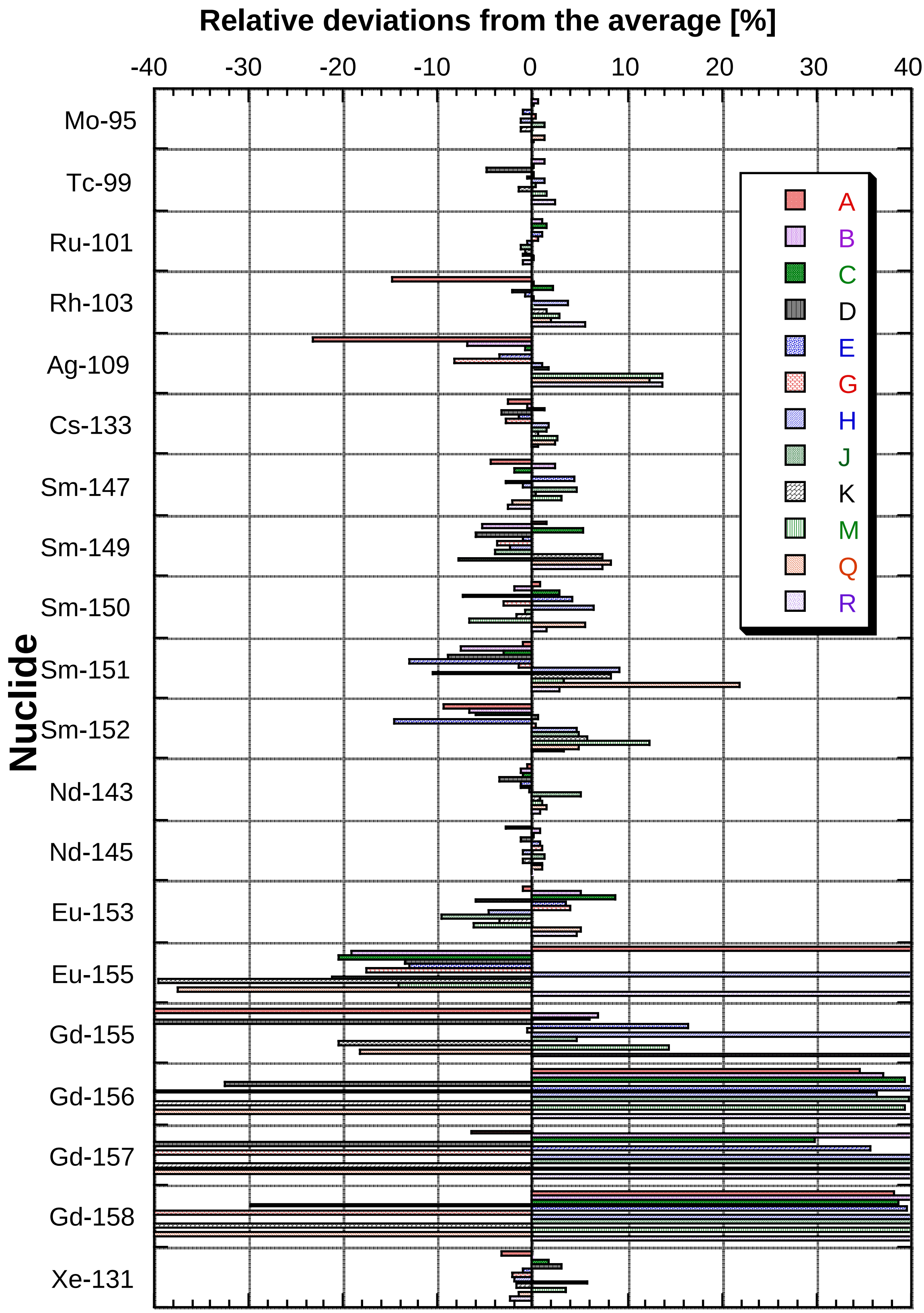

Figure 4.12. Atomic number densities of FPs reported from participants relative to the average for Case 2b. (40% void, 40 GWd/tHM, 5 y cooling.)

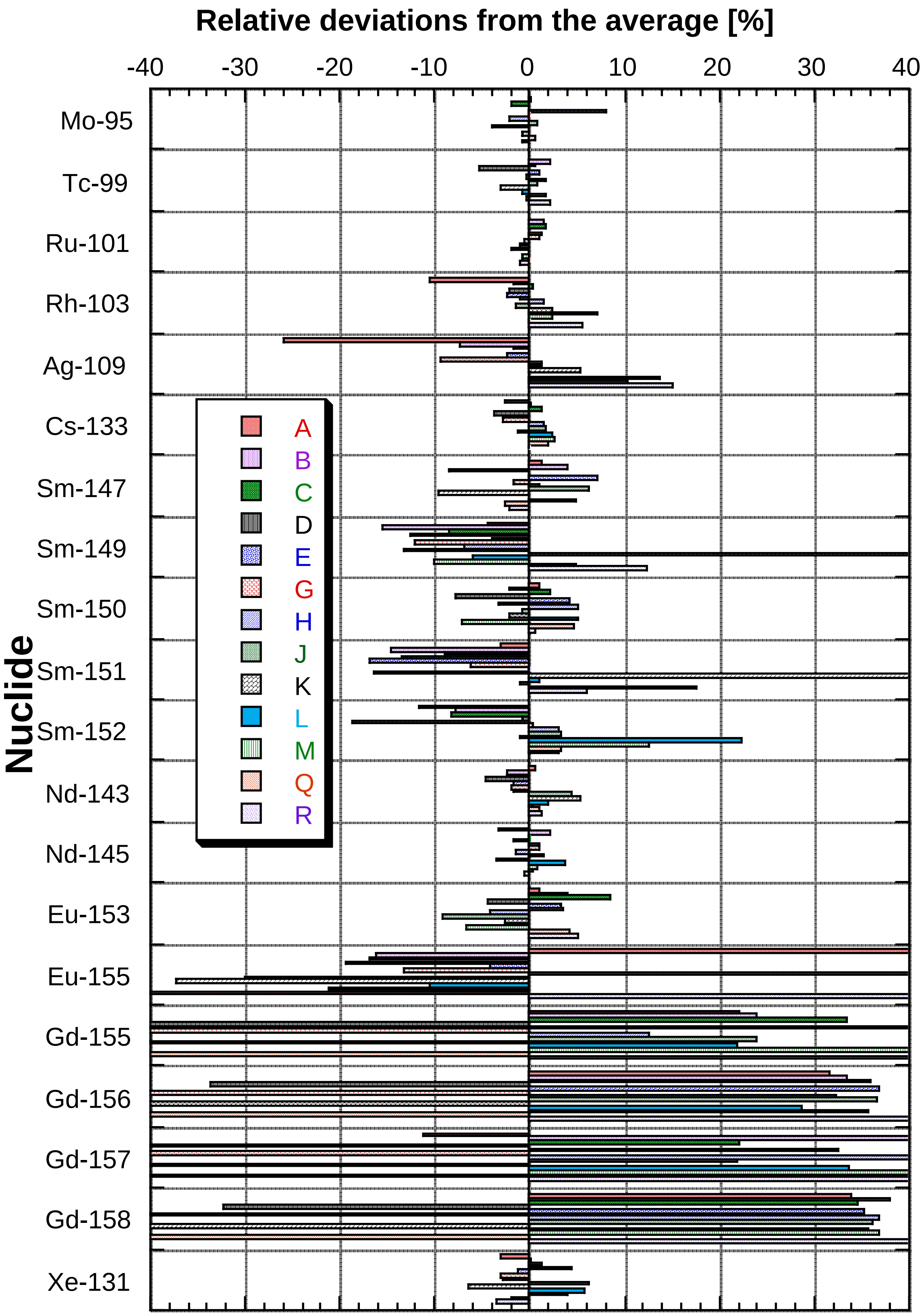

Figure 4.13. Atomic number densities of FPs reported from participants relative to the average for Case 3a. (70% void, 40 GWd/tHM, No cooling.)

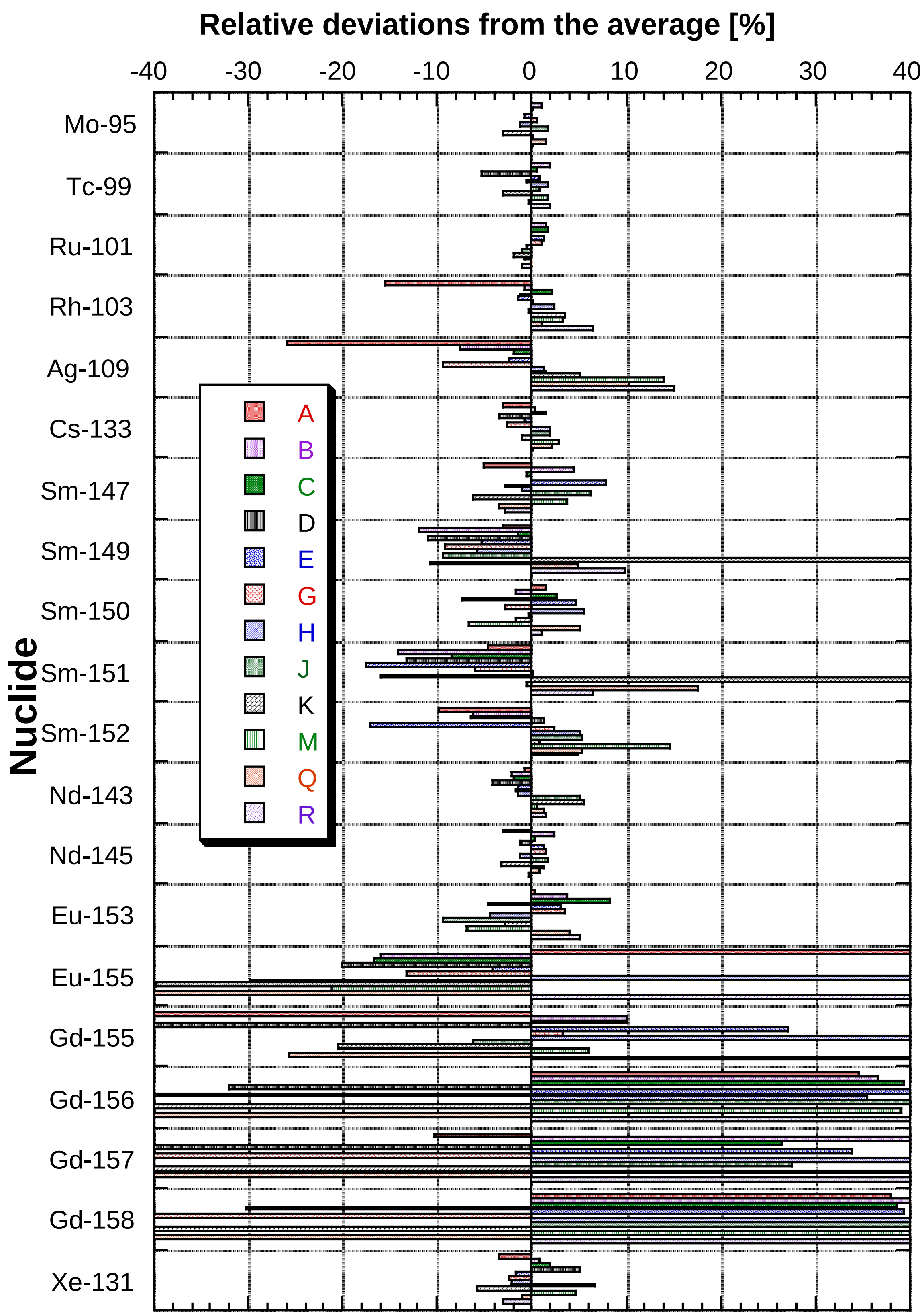

Figure 4.14. Atomic number densities of FPs reported from participants relative to the average for Case 3b. (70% void, 40 GWd/tHM, 5 y cooling.)

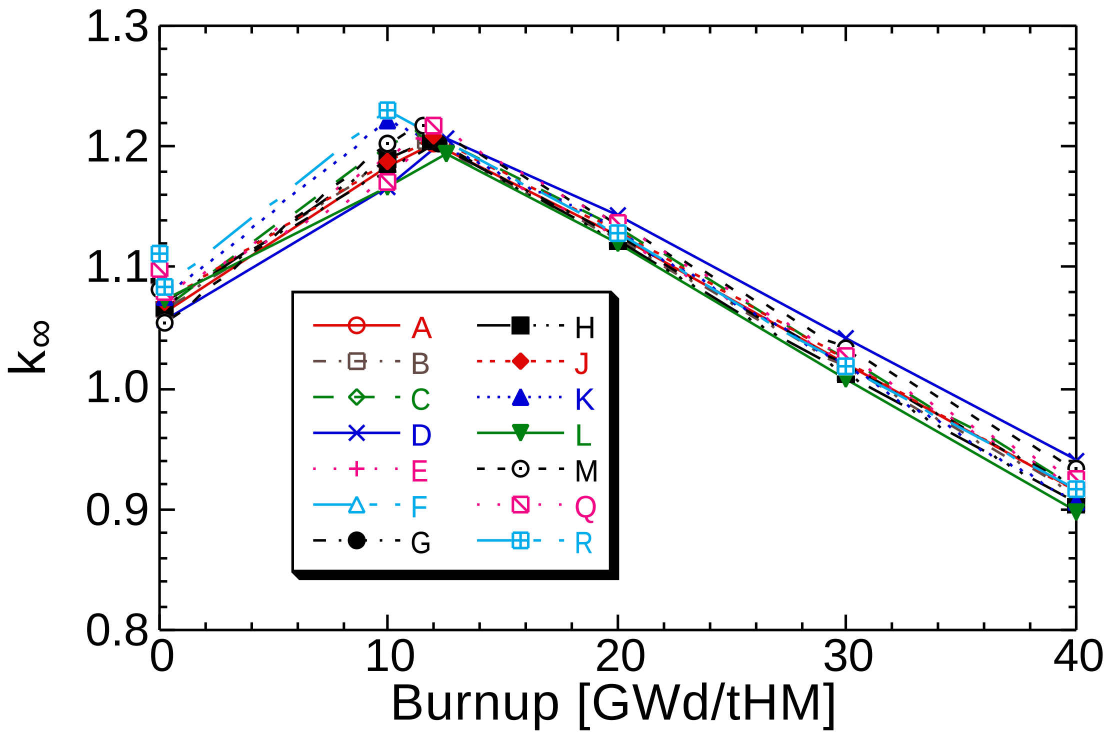

Figure 4.15. k_∞ results from participants for Case 1. (No void, Maximum 40 GWd/tHM.)

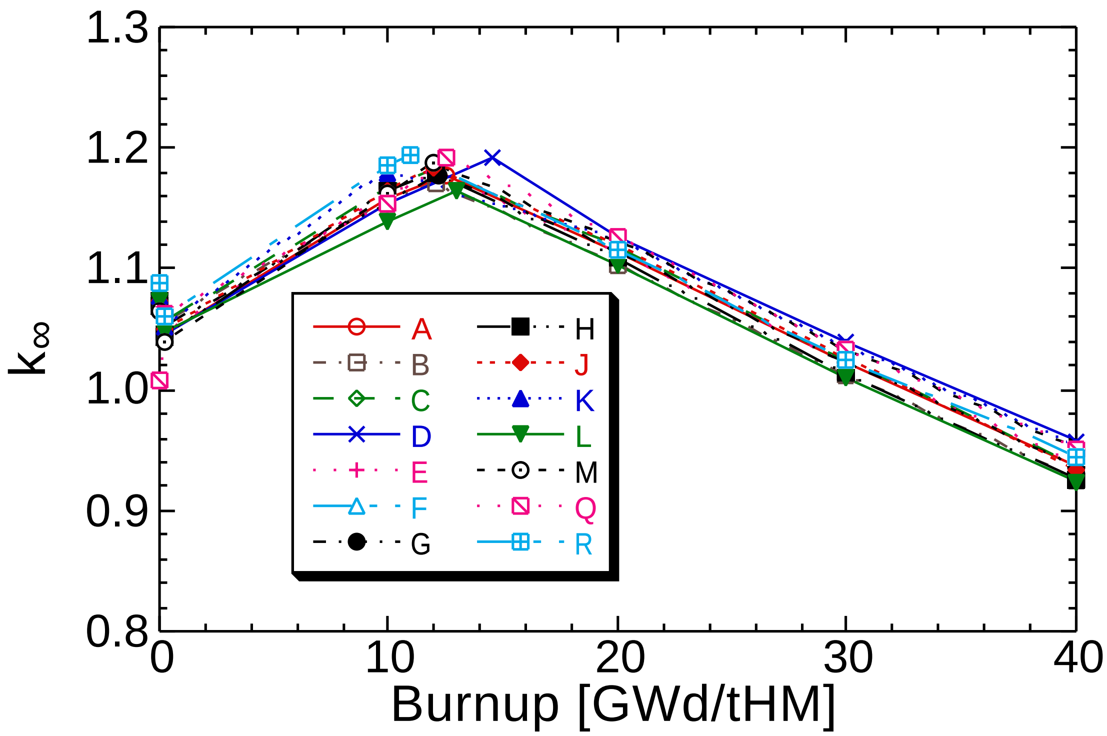

Figure 4.16. k_∞ results from participants for Case 2. (40% void, Maximum 40 GWd/tHM.)

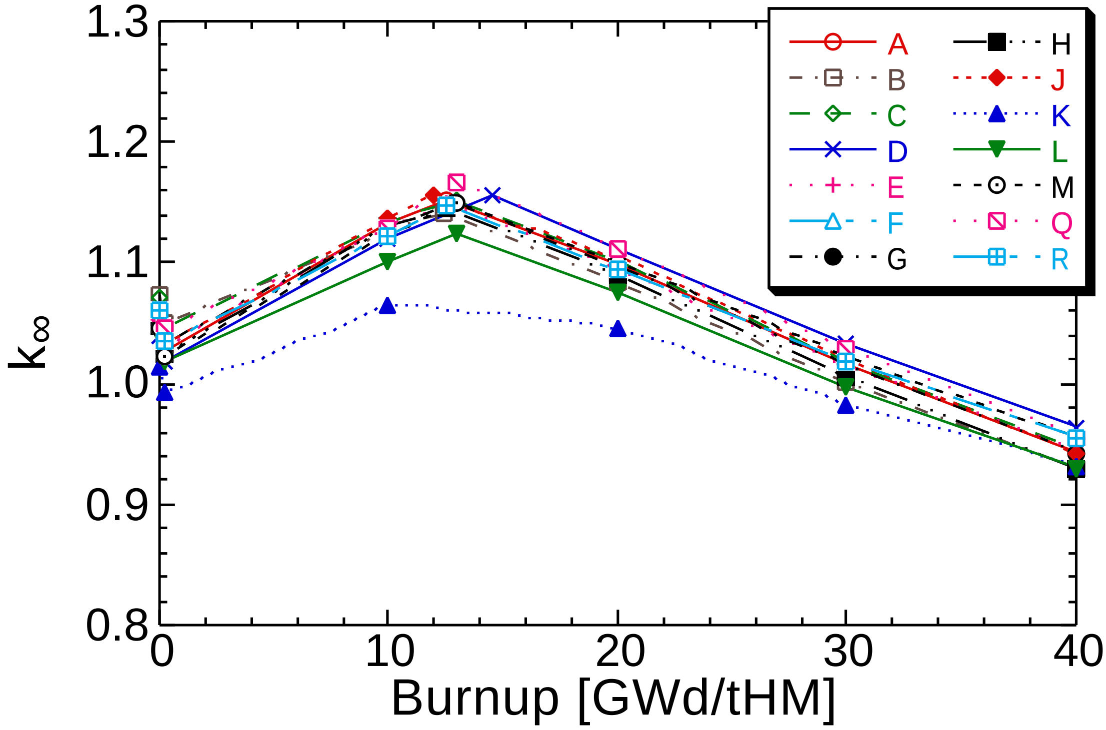

Figure 4.17. k∞ results from participants for Case 3. (70% void, Maximum 40 GWd/tHM.)

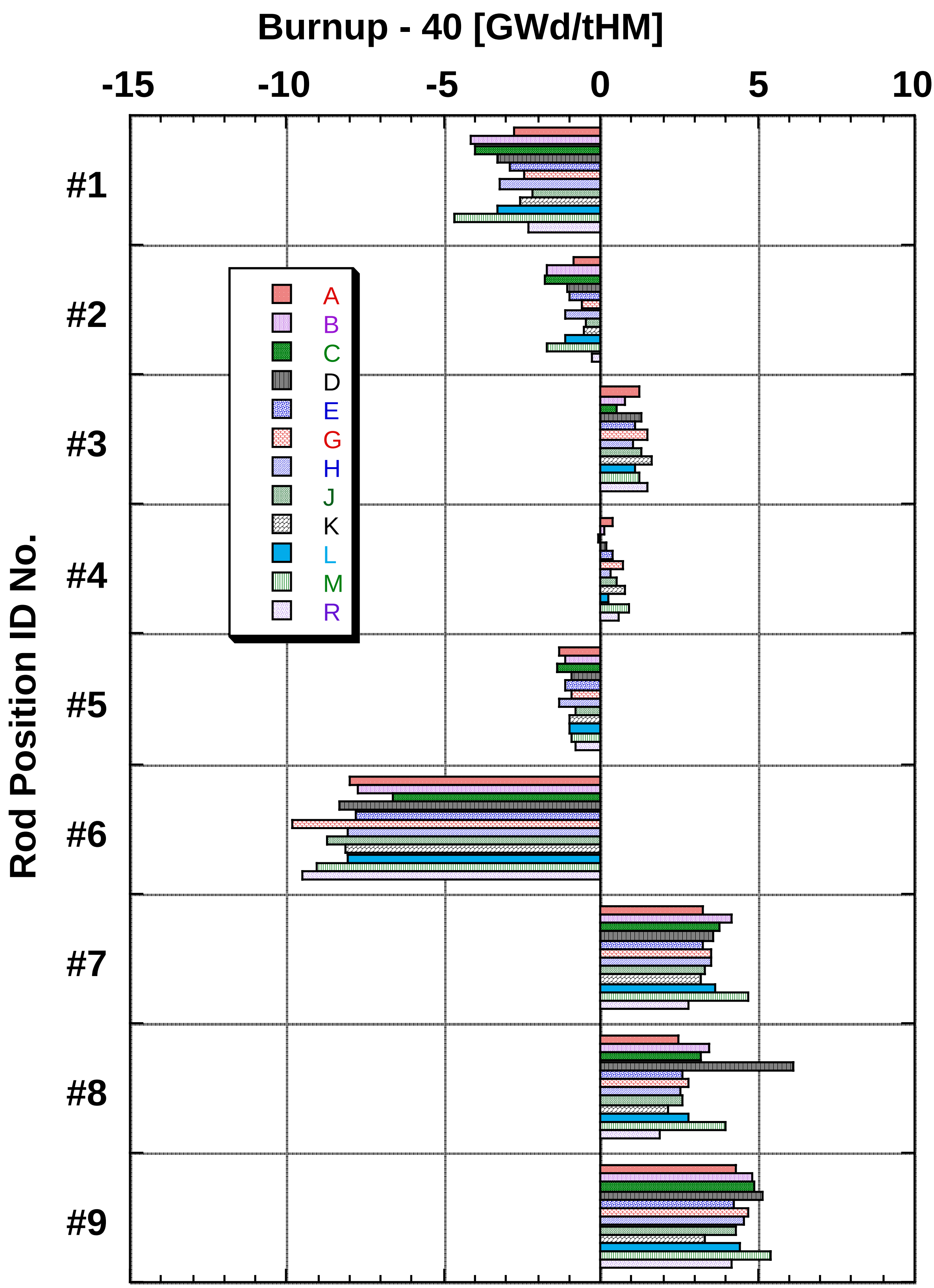

Figure 4.18. Pinwise burnup results for Case 1. (No void, 40 GWd/tHM.)

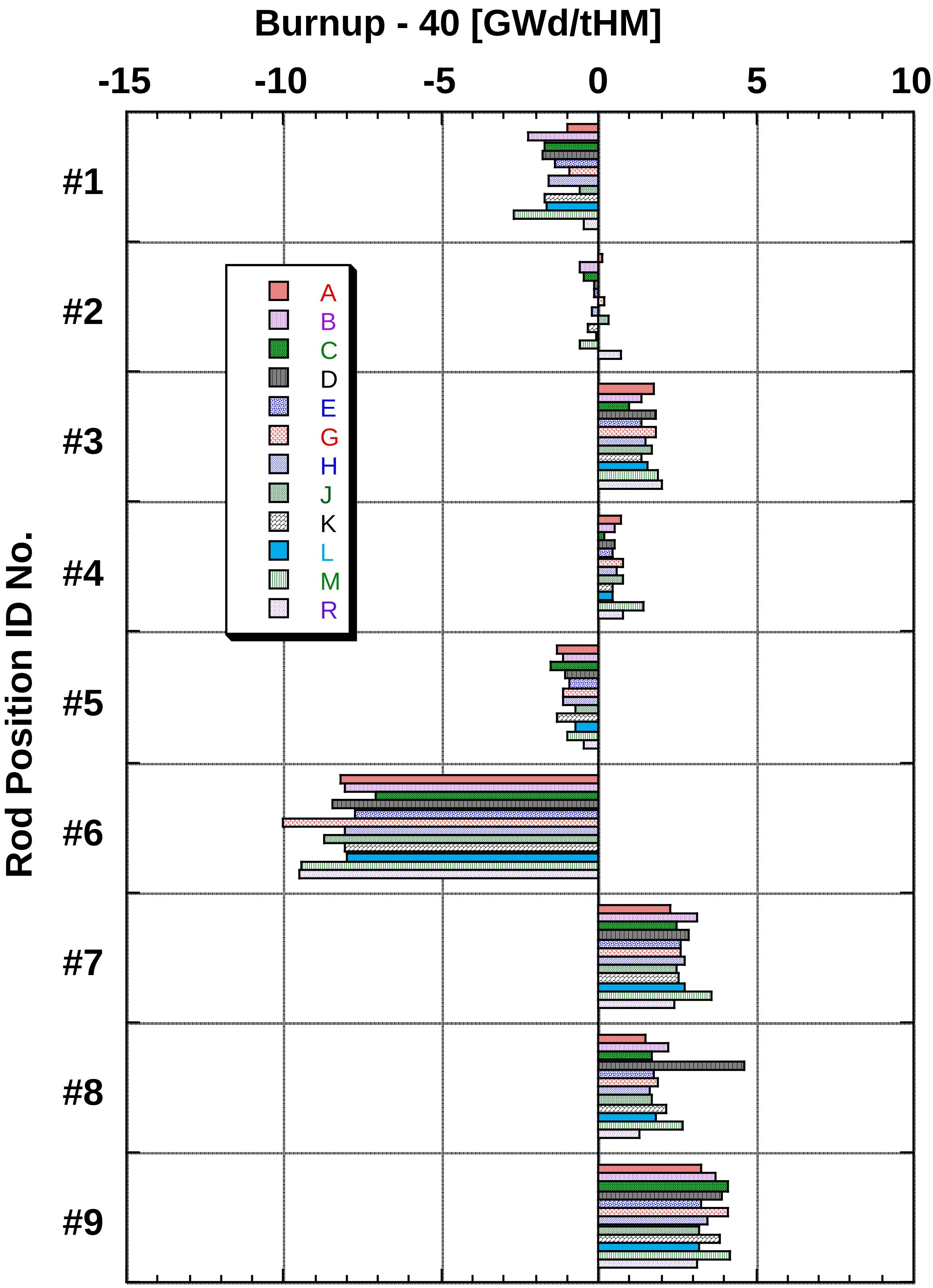

Figure 4.19. Pinwise burnup results for Case 2. (40% void, 40 GWd/tHM.)

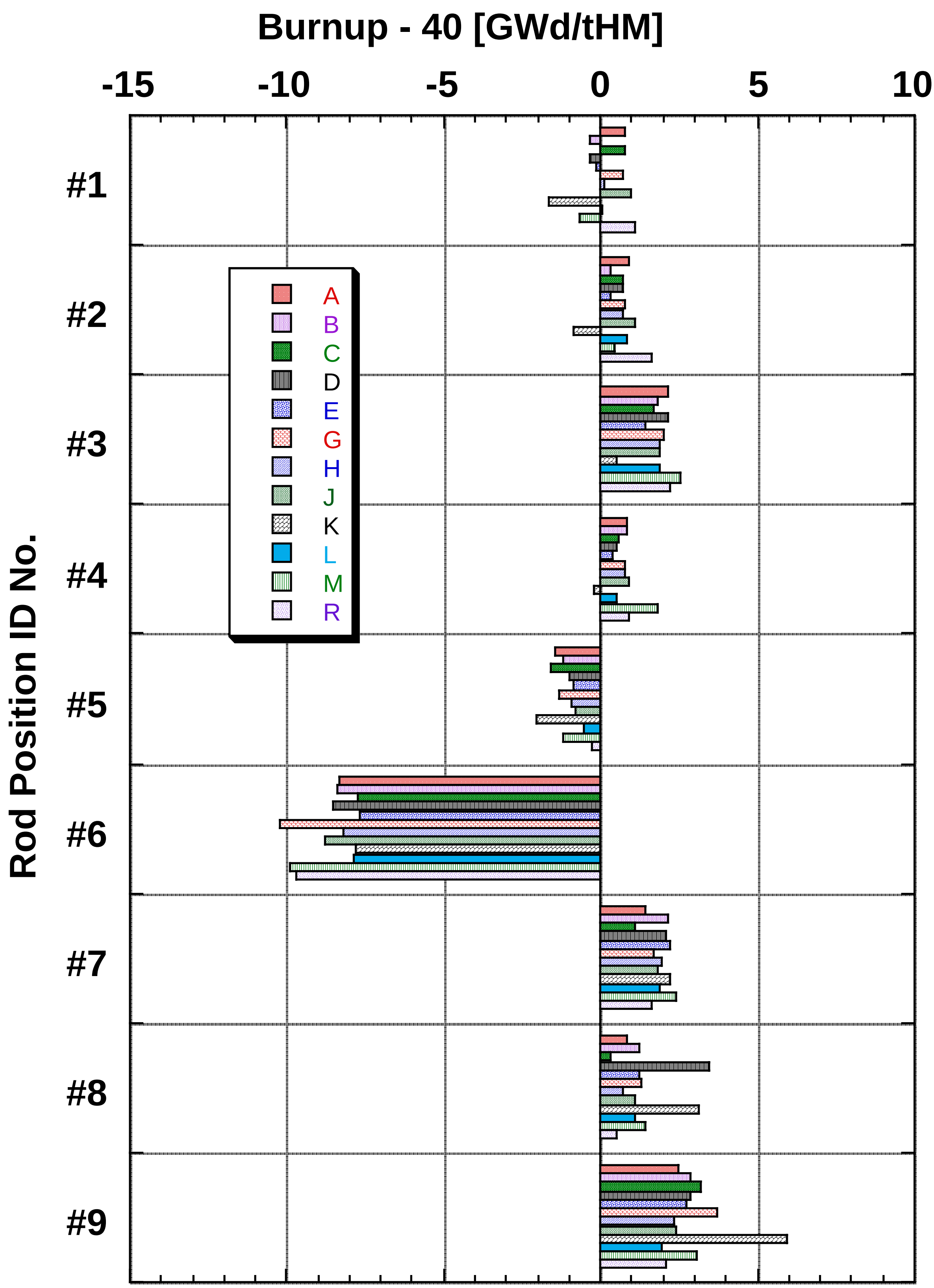

Figure 4.20. Pinwise burnup results for Case 3. (70% void, 40 GWd/tHM.)

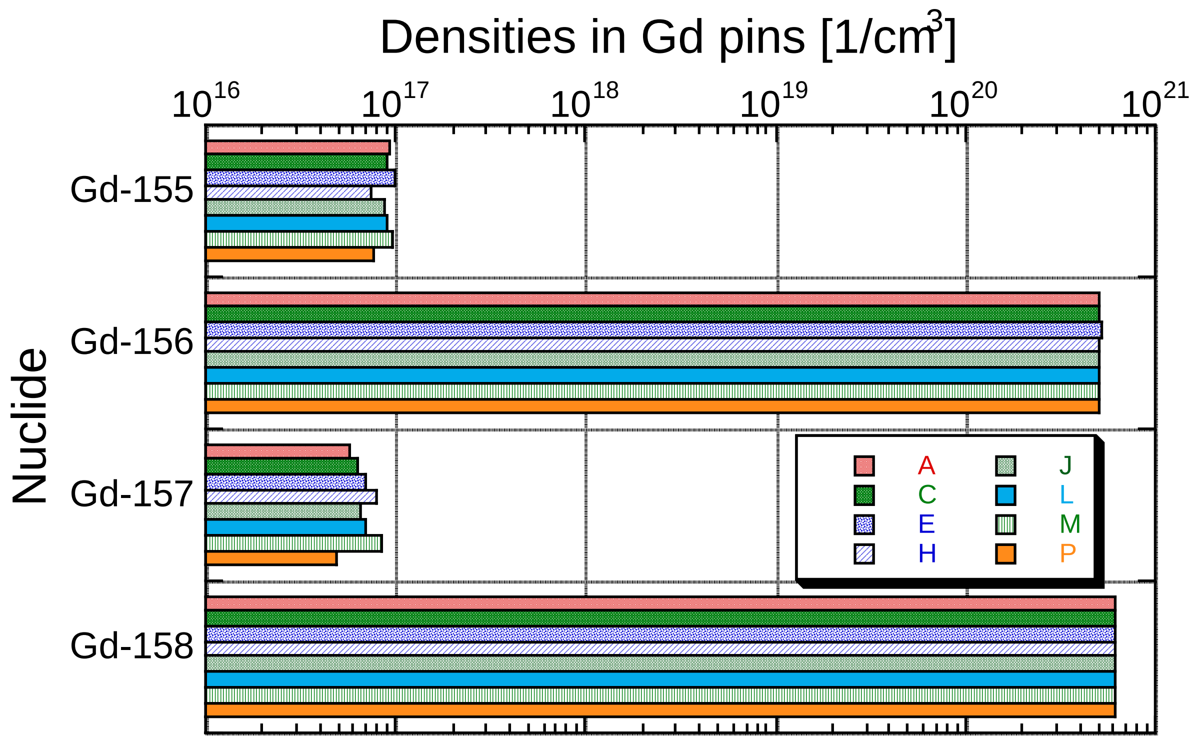

Figure 4.21. Gadolinium (Gd) densities in Gd pins for Case 1a. (No void, 40 GWd/tHM, Not cooling.)

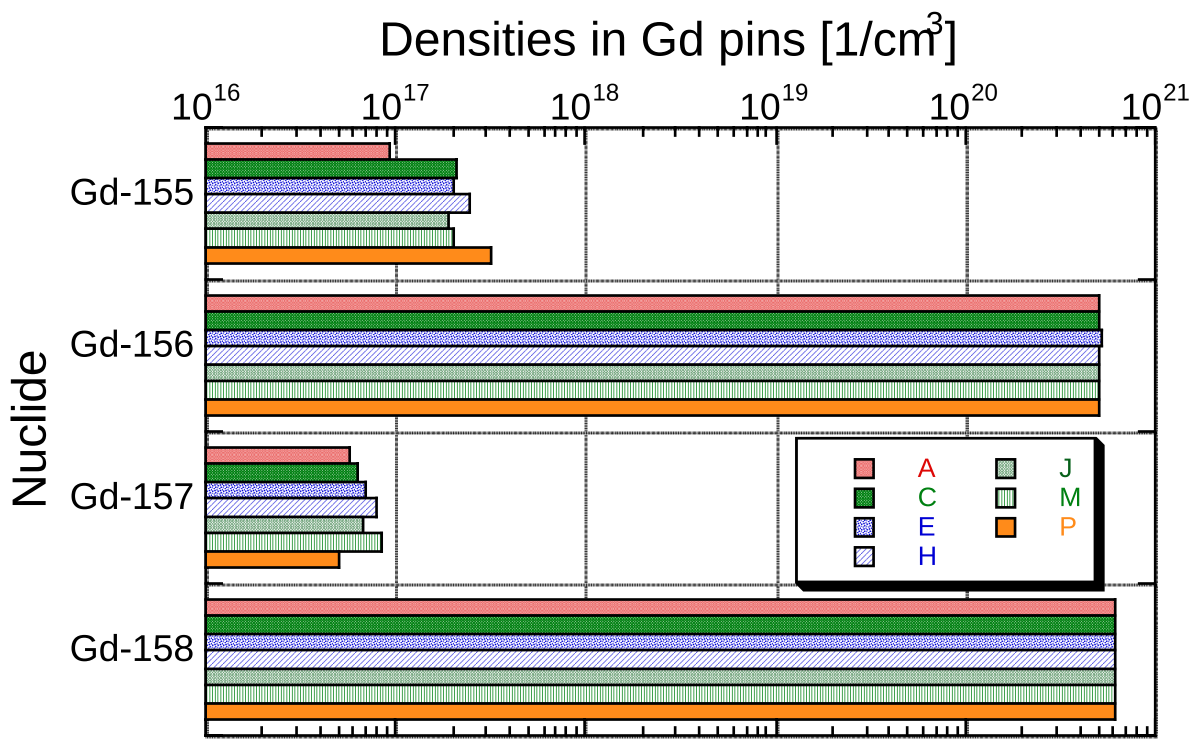

Figure 4.22. Gadolinium (Gd) densities in Gd pins for Case 1b. (No void, 40 GWd/tHM, 5 y cooling.)

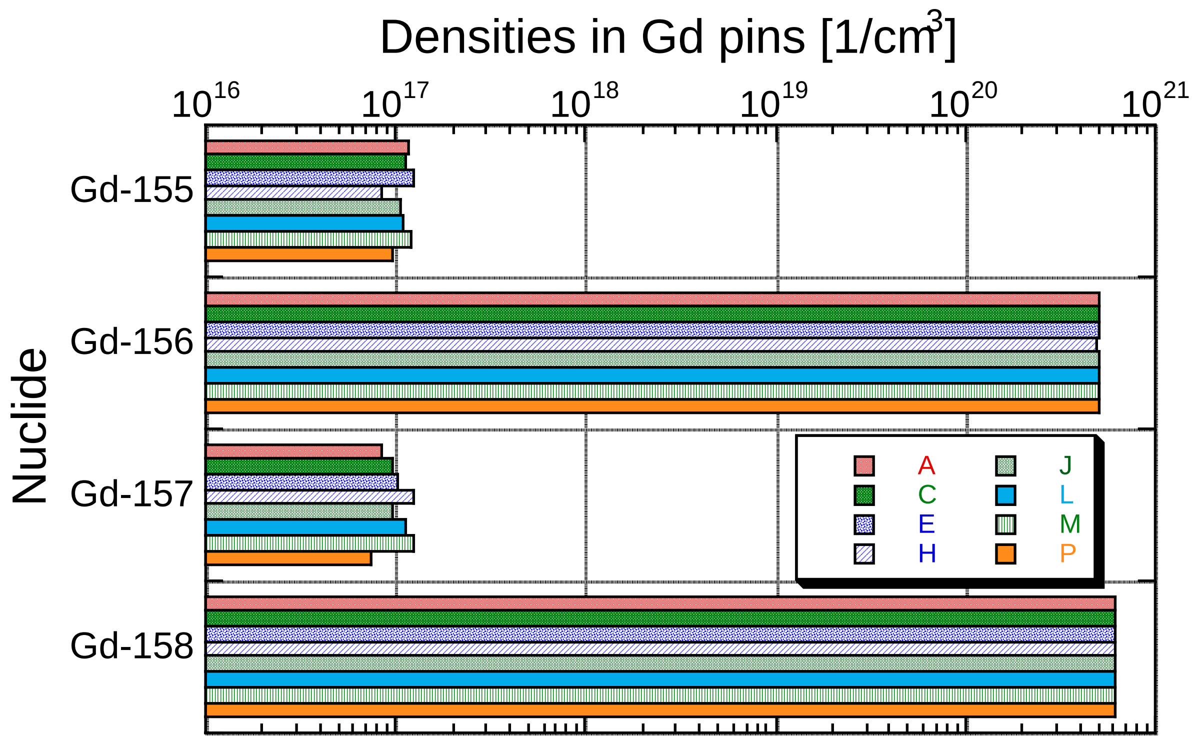

Figure 4.23. Gadolinium (Gd) densities in Gd pins for Case 2a. (40 % void, 40 GWd/tHM, Not cooling.)

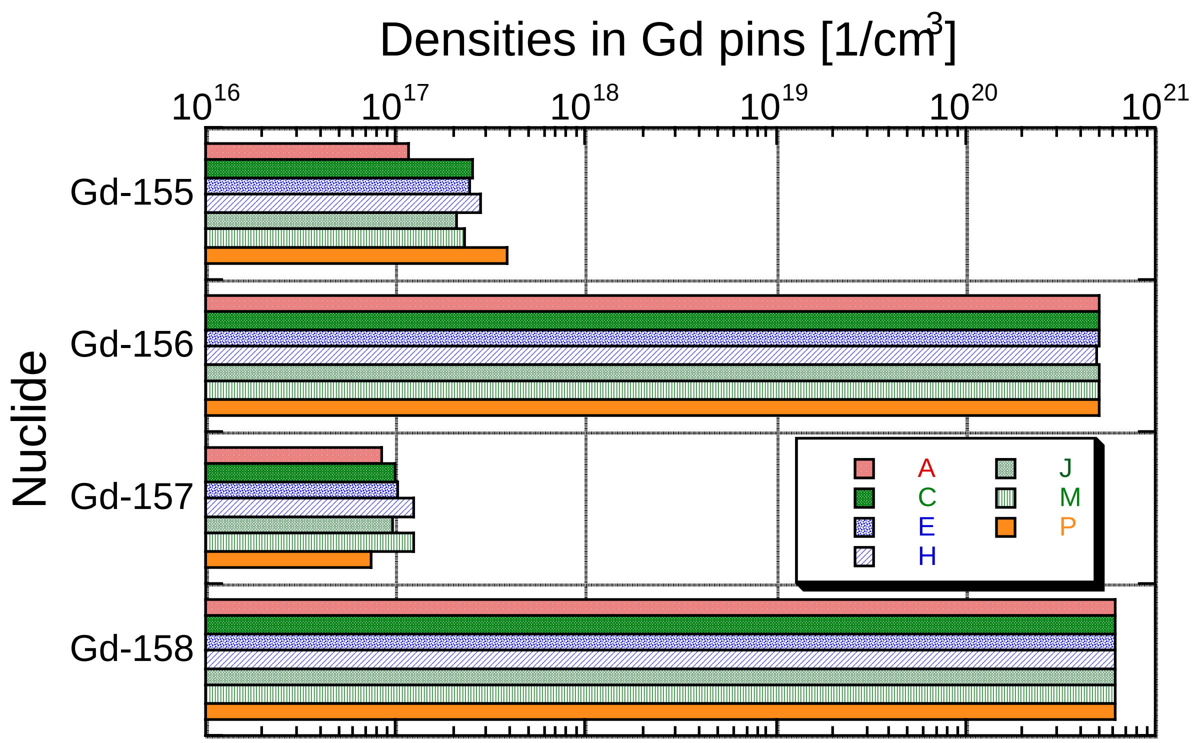

Figure 4.24. Gadolinium (Gd) densities in Gd pins for Case 2b. (40 % void, 40 GWd/tHM, 5 y cooling.)

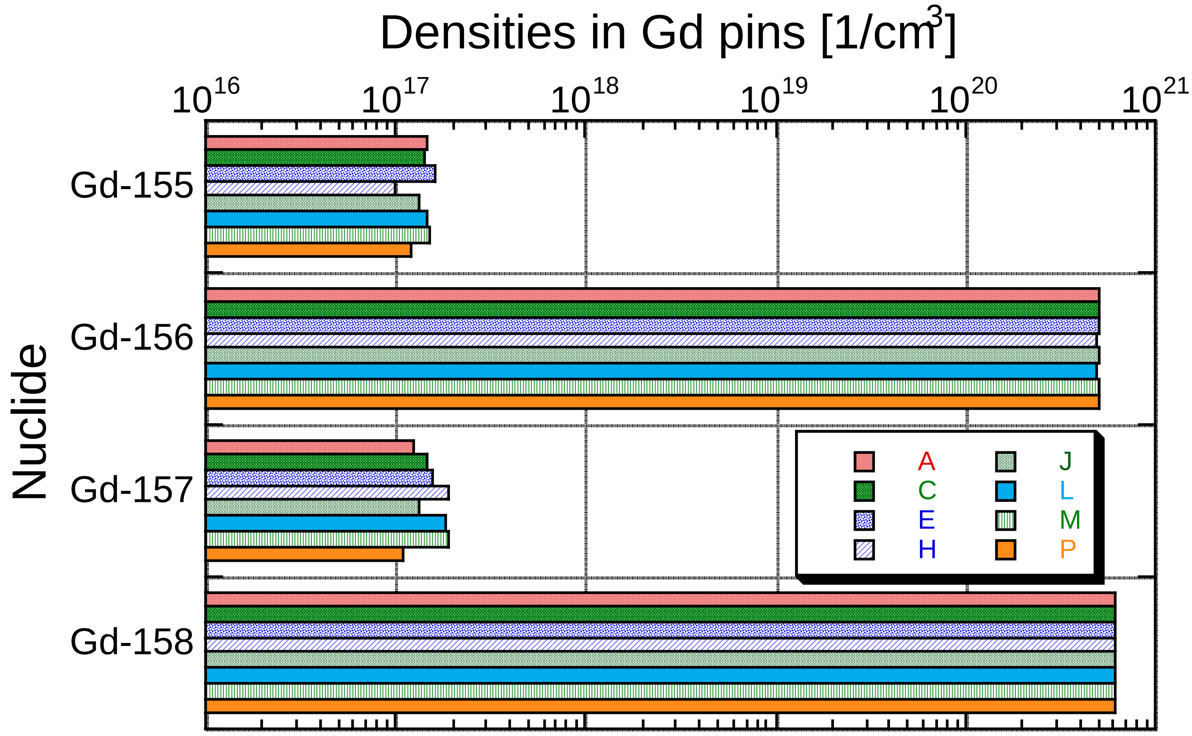

Figure 4.25. Gadolinium (Gd) densities in Gd pins for Case 3a. (70% void, 40 GWd/tHM, Not cooling.)

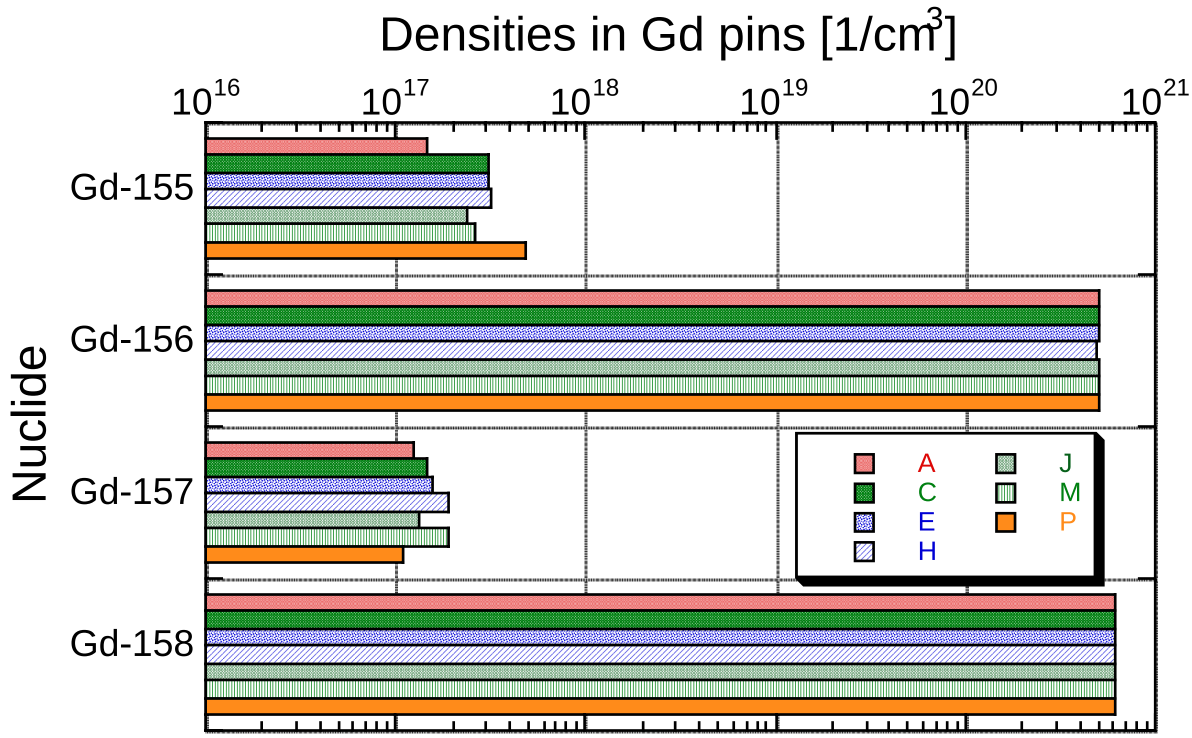

Figure 4.26. Gadolinium (Gd) densities in Gd pins for Case 3b. (70% void, 40 GWd/tHM, 5 y cooling.)

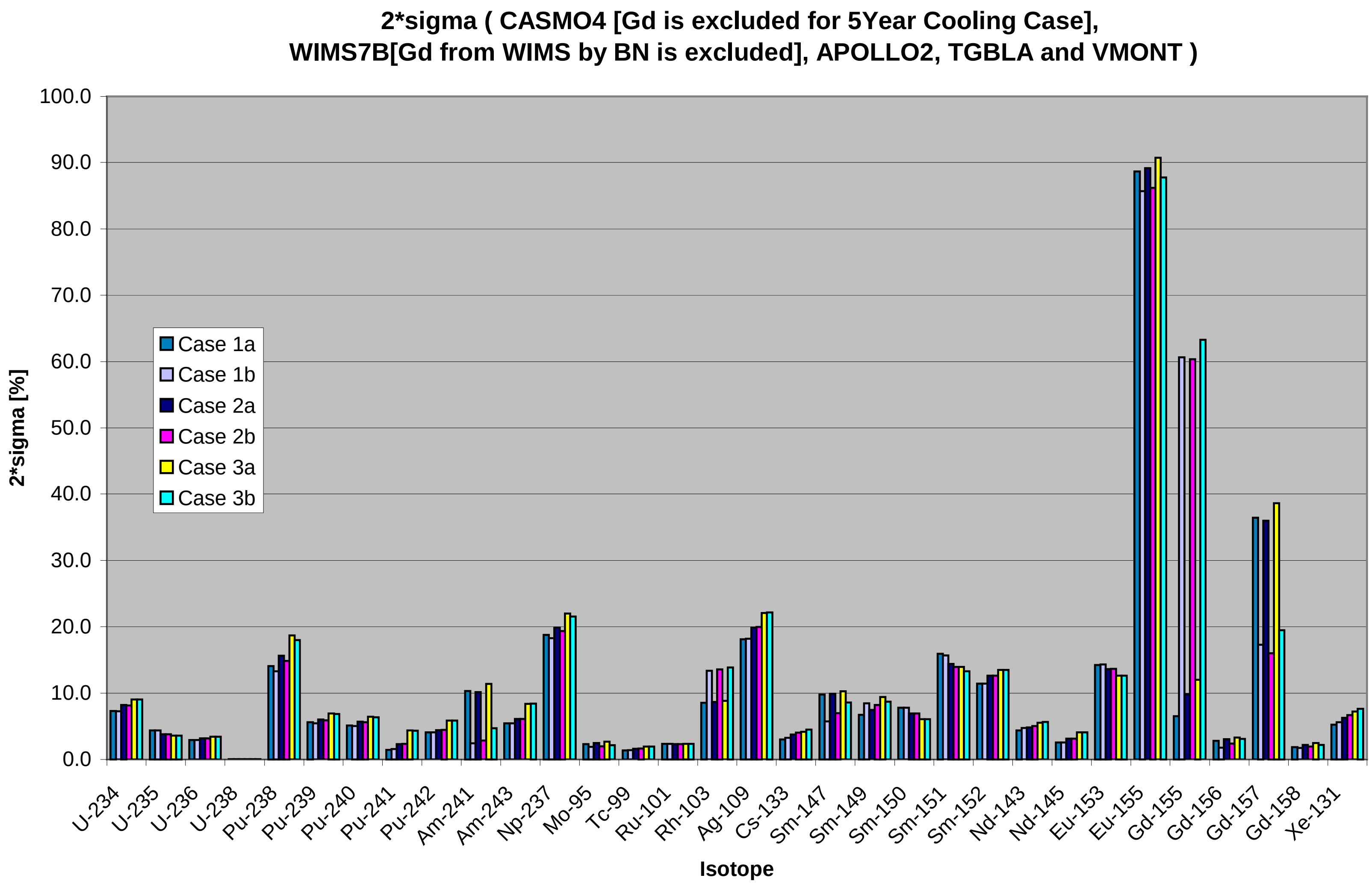

Figure 4.27. Two relative standard deviations of actinide concentrations calculated by participants [**A** (except for Gd, 5 y cooling case), **B**, **C**, **G** (except for Gd) **H** and **J**].

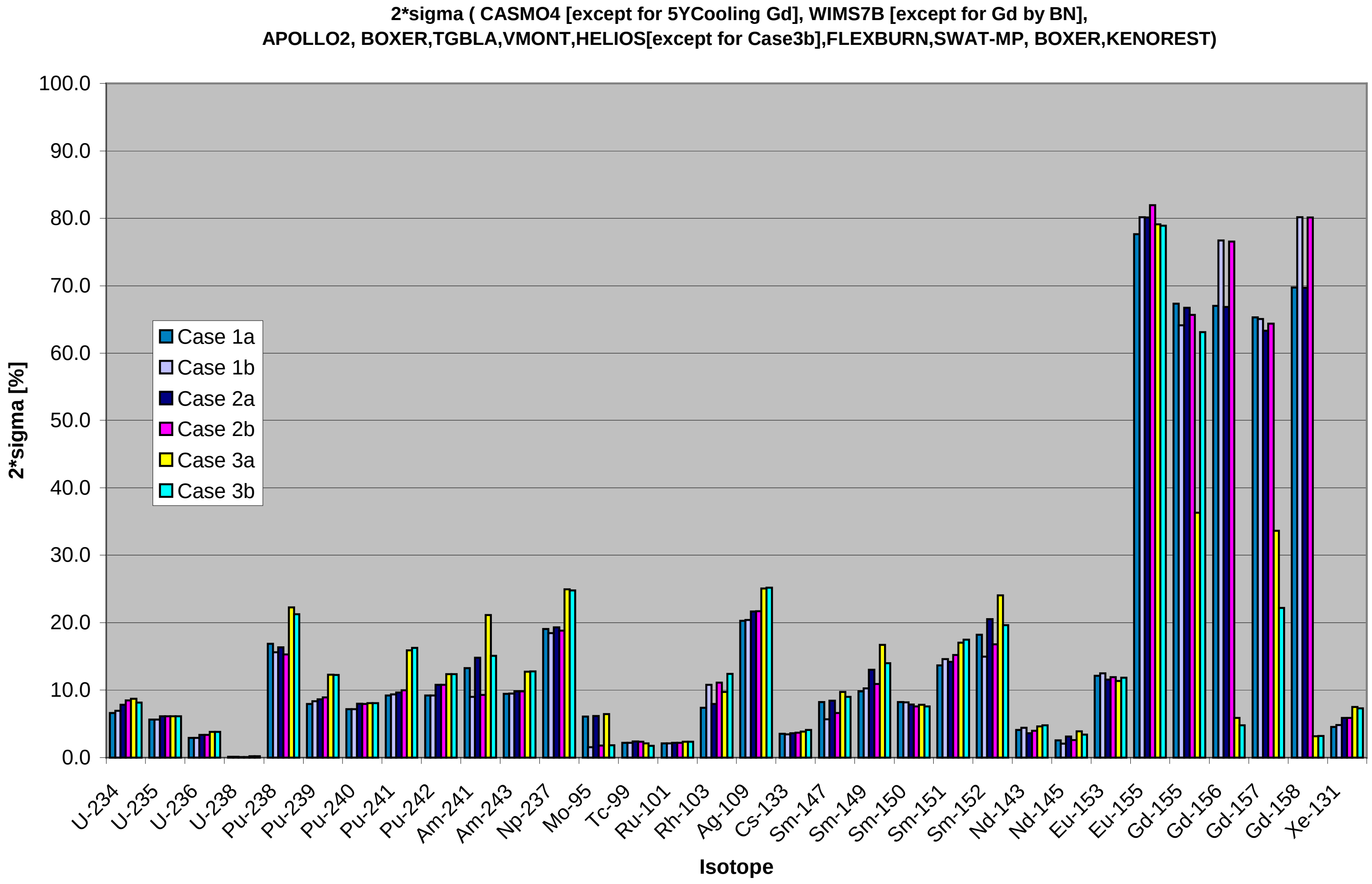

Figure 4.28. Two relative standard deviations of actinide concentrations calculated by participants [**A** (except for Gd, 5 y cooling), **B** , **C** , **E** , **G** (except for Gd), **H**, **J**, **K** , **L** , **M** , **R**].

5. Concluding Remarks

The OECD/NEA Expert Group on Burnup Credit Criticality Safety has designed benchmark problems to compare the predictive capabilities of the current computer code and data library combinations for the atomic number densities of an irradiated BWR fuel assembly model. In total 16 results were submitted from 13 institutes of 7 countries. The calculated atomic number densities of actinides were found for the most part within 10% relative to the average, except (1) ^{243}Am, and (2) ^{238}Pu, ^{239}Pu, ^{241}Pu, ^{241}Am and ^{237}Np for the 70% void cases. The concentrations of FP nuclides were also found to be within 10 % relative to the average, except (1) ^{155}Eu and gadolinium isotopes, (2) ^{149}Sm and ^{151}Sm concentrations for 70% void cases and (3) ^{109}Ag and ^{152}Sm, which are slightly greater than 10%. Some outliers were identified for individual cases.

k_∞ also agreed well, typically in ±2%Δk band, except one major deviation for the 70% void case and some minor deviations, which need further investigation.

Pinwise burnup results agreed well among participants. However, two participants' deviations from the average, common to the deviations of nuclide concentrations, were observed.

The nuclide concentrations among the fuel assembly design codes were compared, and the differences were found small: two relative standard deviations were less than 5 – 10% for many compared isotopes. Results from assembly calculation codes were also in good agreement except for several outliers.

Since the present benchmark (Phase IIIB) is a numerical benchmark and the object of study is fuel assembly, it is difficult to make clear the reason of discrepancy among the codes. However, the isotopes that showed a large difference among the codes in the Phase IB benchmark calculations also show a large difference in the present benchmark. This implies a common cause of discrepancies in the nuclear data or in calculation method itself. Based on the experiences gained from the Phase IB and Phase IIIB Benchmarks, the next step should be to check the one-grouped cross section data in a simple geometry, fission yield data and generation chain treatment in each code.

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References

1) M. Brady, M. Takano, M.D. DeHart, H. Okuno, A. Nouri and E. Sartori, “Finding of an International Study on Burnup Credit,” *Proc. of Intl. Conf. on the Physics of Reactors, PHYSOR 96*, September 16–20, 1996, Mito, Japan, Volume 4, L-41 – L-52 (1996).
2) J.T. Mihalczo and B.L. Broadhead, “Feasibility of Spent LWR Fuel Subcritical Measurements by the Californium Noise Method,” *ANS Trans*., **62**, 322–324 (1990).
3) T. Suzaki, M. Kurosawa, H. Hirose, T. Yamamoto, K. Nakajima, F. Kanaizuka, I Kobayashi and T. Kaneko, “Exponential Experiments of PWR Spent Fuel Assemblies for Acquiring Subcriticality Benchmarks Usable in Burnup Credit Evaluations,” *Proc. Intl. Conf. on Nucl. Criticality Safety,* September 17–21, 1995, Albuquerque, New Mexico, Volume I, 1B•11—1B•18 (1995).
4) R.L. Bowden, P.R. Thorne and P.I.D. Strafford, “The Methodology Adopted by British Nuclear Fuels plc in Claiming Credit for Reactor Fuel Burnup in Criticality Safety Assessments,” *Proc. Intl. Conf. on Nucl. Criticality Safety,* September 17–21, 1995, Albuquerque, New Mexico, Volume I, 1B•3—1B•10 (1995).
5) J.M. Conde and M. Recio, “Evaluation of Burnup Credit for Fuel Storage Analysis - Experience in Spain,” *Nucl Technol.* **110**, 22–32 (1995).
6) M. Brady, H. Okuno, M.D. DeHart, A. Nouri and E. Sartori, “International Studies on Burnup Credit Criticality Safety by an OECD/NEA Working Group,” *Proc. of Intl. Conf. on the Physics of Nuclear Science and Technology*, October 5–8, 1998, Volume 1, 624–630 (1998).
7) M. Takano, “OECD/NEA Burnup Credit Criticality Benchmark – Result of Phase-1A –,” *NEA/NSC/DOC*(93)22, *JAERI-M* 94-003 (1994).
8) M.D. DeHart, M.C. Brady and C.V. Parks, “OECD/NEA Burnup Credit Criticality Benchmark Phase I-B,” *NEA/NSC/DOC*(96)06, *ORNL*-6901 (1996).
9) M. Takano and H. Okuno, “OECD/NEA Burnup Credit Criticality Benchmark - Result of Phase IIA -,” *NEA/NSC/DOC*(96)01, *JAERI-Research* 96-003 (1996).
10) A. Nouri, “OECD/NEA Burnup Credit Criticality Benchmark, Analysis of Phase II-B Results: Conceptual PWR Spent Fuel Transportation Cask,” *NEA/NSC/DOC*(98)1, *Rapport IPSN/*98-05 (1998).
11) J.C. Neuber and T. Lamprect, "Proposal for Phase II-C: Benchmark on the Reactivity Effect of Axial Burnup Shapes," *WPNCS/EGBUC*9, Paris, September 2000.
12) H. Okuno, Y. Naito and Y. Ando, “OECD/NEA Burnup Credit Criticality Benchmarks Phase IIIA: Criticality Calculations of BWR Spent Fuel Assemblies in Storage and Transport,” *NEA/NSC/DOC*(2000)12, *JAERI-Research* 2000-041 (2000).
13) M.J. Bell, “ORIGEN – The ORNL Isotope Generation and Generation Code,” *ORNL*-4628 (1973).
14) (Eds.) Y.Nakahara, K.Suyama and T.Suzaki, "Technical Development on Burn-up Credit for Spent LWR Fuels," *JAERI-Tech* 2000-071(2000).

15) K. Okumura, T. Mori, M. Nakagawa and K. Kanako, "Validation of a Continuous-Energy Mote Carlo Burn-up Code MVP-BURN and Its Application to Analysis of Post Irradiation Experiment," *J. Nucl. Sci. Technol*. **37**, 128–138(2000).